Resource Reservation with Pointer Forwarding Schemes for the Mobile RSVP

Gwo-Chuan Lee, Tsan-Pin Wang, and Chien-Chao Tseng

Abstract—**In this letter, we propose a pointer forwarding scheme for the Mobile Resource reSerVation Protocol (MRSVP) to reduce the resource reservation cost on the wireless Internet. We show that the pointer forwarding scheme could significantly degrade the reservation cost when a mobile host performs locality movement.**

***Index Terms*—Internet, MRSVP, pointer forwarding, QoS, RSVP, wireless networks.**

I. Introduction

RESOURCE reserVation Protocol (RSVP) [4] is a protocol which can provide quality of service (QoS) guarantees for integrated services on the Internet. The RSVP establishes an *active reservation* to reserve needed resources on routers or hosts along the reservation path from the sender to the recipient. However, RSVP cannot be used directly due to the host mobility in a mobile computing environment. Mobile RSVP (MRSVP) [1], [2] overcomes the impact of mobility on RSVP by making advance resource reservations, namely *passive reservations*, in all neighboring subnets. Unfortunately, these excessive resource reservations may waste too much bandwidth and degrade the network performance. Therefore, the hierarchical Mobile RSVP (HMRSVP) [3] was proposed to achieve the same QoS guaranteed seamless handoff as MRSVP but fewer advance resource reservations. In particular, the HMRSVP scheme performs very well when a mobile host (MH) always performs locality movement.

In this letter, we propose a pointer forwarding scheme for the HMRSVP to degrade the resource reservation cost on the wireless Internet. We also model the pointer forwarding scheme with a locality-movement behavior and compare our approach with the resource reservation schemes for the muticast and unicast cases in the MRSVP [1].

II. HMRSVP with Pointer Forwarding

In this section, we describe the pointer forwarding scheme for the HMRSVP. The wireless Internet environment is assumed to be a tree topology as shown in Fig. 1. In this topology, three resource reservation schemes can be described as follows.

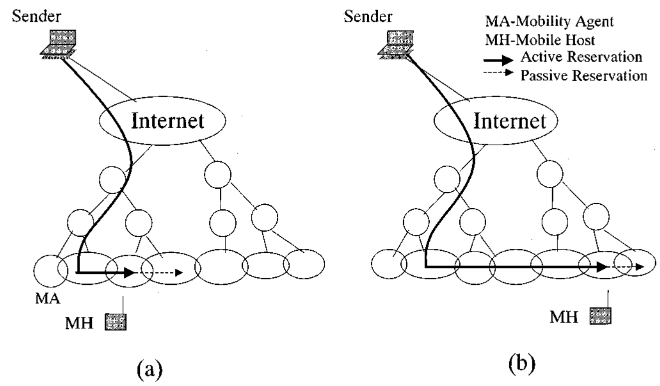

Fig. 1. HMRSVP$_{pf}$ scheme for the wireless Internet when an MH performs (a) locality movement and (b) nonlocality movement.

- HMRSVP$_m$ represents the multicast scheme for the HMRSVP on the wireless Internet. The HMRSVP$_m$ makes advance resource reservations on all the branches of the tree topology from the sender under the multicast approach.
- HMRSVP$_u$ represents the unicast scheme for the HMRSVP on the wireless Internet. The HMRSVP$_u$ makes advance resource reservations only two passive paths from a router or host to the two neighboring MA's of the current visited MA, in which the router or host is the least common ancestor of the two neighboring MA's.
- HMRSVP$_{pf}$ represents the pointer forwarding scheme for the HMRSVP on the wireless Internet. The HMRSVP$_{pf}$ makes advance resource reservations only a forward one-step path from an MH along the forwarding pointer chains as shown in Fig. 1.

III. Performance Analysis

A. Modeling the HMRSVP$_{pf}$ Scheme

To model the HMRSVP$_{pf}$ scheme, we assume that the structure of the wireless Internet is hierarchical and forms a tree topology as shown in Fig. 1. For demonstration, we assume the tree is a binary tree.

We also assume that an MH has a locality behavior of mobility, i.e., the probability an MH moves within an local area is larger than that within a nonlocal area. For simplicity and without loss of generality, we can then model the locality behavior of an MH in one direction using the HMRSVP$_{pf}$ scheme

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G.-C. Lee and C.-C. Tseng are with the Department of Computer Science and Information Engineering, National Chiao Tung University, Hsinchu, Taiwan, R.O.C. (e-mail: gclee@csie.nctu.edu.tw; cctseng@csie.nctu.edu.tw).

T.-P. Wang is with the Department of Computer Science and Information Management, Providence University, Shalu, Taiwan, R.O.C. (e-mail: tpwang@pu.edu.tw).

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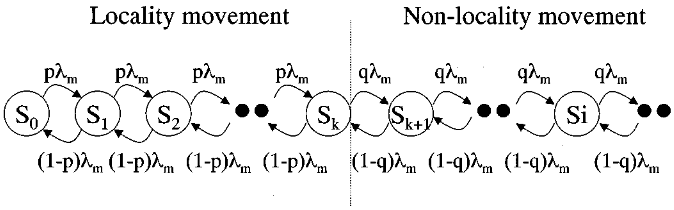

Fig. 2. The state transition diagram for the locality behavior of an MH in one direction using the HMRSVP_{pf} scheme.

as a Marchov chain with infinite states, as shown in Fig. 2. To describe this Marchov chain, we define the following parameters:

- S_i state that an MH stays in an MA with a forwarding pointer chain of length i;
- π_i stationary probability that an MH stays in an MA with the state S_i in the steady state;
- p mean probability that an MH may move right to its neighboring MA and perform locality movement;
- q mean probability that an MH may move right to its neighboring MA and perform nonlocality movement;
- λ_m the mobility of an MH;
- k mean length of locality movement for an MH.

We can obtain the balance equations from the Marchov chain of Fig. 2. Therefore,

$$\pi_i p\lambda_m = \pi_{i+1}(1-p)\lambda_m, \qquad 0 \le i \le k-1 \quad (1)$$
$$\pi_i q\lambda_m = \pi_{i+1}(1-q)\lambda_m, \qquad k \le i \quad (2)$$
$$\pi_0 + \pi_1 \cdots + \pi_\infty = 1 \quad (3)$$

where $p \ge q$ and $q < 1/2$.

From the above balance equations, the close form of each stationary probability π_i for all is can be derived as

$$\pi_i = \frac{P^i(P-1)(1-Q)}{(P^{k+1}-1)(1-Q)+P^k(P-1)}, \qquad 0 \le i \le k \quad (4)$$
$$\pi_i = \frac{P^k Q^{i-k}(P-1)(1-Q)}{(P^{k+1}-1)(1-Q)+P^k(P-1)}, \qquad k+1 \le i, \quad (5)$$

where

$$P = \frac{p}{1-p} \quad \text{and} \quad Q = \frac{q}{1-q}. \quad (6)$$

B. Resource Reservation Cost Analysis

We define the following parameters to compare the resource reservation cost of the HMRSVP_{pf} with those of the HMRSVP_m and HMRSVP_u. α represents the resource reservation cost if the reservation path length is one between two neighboring tree nodes, two neighboring MA's or from one tree node to one MA; θ represents the ratio of resource reservation costs, i.e., the cost $\mathrm{Cost}_{\mathrm{Passive}}$ of a passive reservation path with path length one divided by the cost $\mathrm{Cost}_{\mathrm{Active}}$ of an active reservation path with path length one along the same resource reservation path; θ can be referred to as reservation overhead; and l represents the tree level of the binary tree. The reservation costs for the three schemes thus can be evaluated as follows.

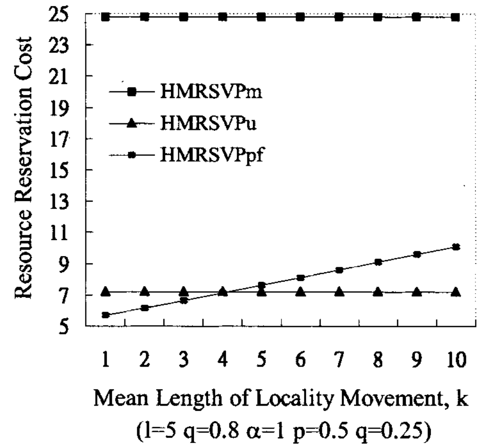

Fig. 3. Comparison of resource reservation costs for all schemes.

- The reservation cost for the HMRSVP_m

$$C_{\mathrm{HMRSVP}_m} = \mathrm{Cost}_{\mathrm{Active}} + \mathrm{Cost}_{\mathrm{Passive}} = (l-1)\alpha + (2^1 - 1 + 2^2 - 1 + \cdots + 2^{l-1} - 1)\theta\alpha \quad (7)$$
$$= (l-1)\alpha + (2^l - l - 1)\theta\alpha. \quad (8)$$

- The maximum and minimum reservation costs for the HMRSVP_u

$$C^{\max}_{\mathrm{HMRSVP}_u} = \mathrm{Cost}_{\mathrm{Active}} + \mathrm{Cost}_{\mathrm{Passive}} = (l-1)\alpha + (1+(l-1))\theta\alpha \quad (9)$$
$$= (l-1)\alpha + l\theta\alpha \quad (10)$$
$$C^{\min}_{\mathrm{HMRSVP}_u} = \mathrm{Cost}_{\mathrm{Active}} + \mathrm{Cost}_{\mathrm{Passive}} = (l-1)\alpha + (1+2)\theta\alpha \quad (11)$$
$$= (l-1)\alpha + 3\theta\alpha. \quad (12)$$

Therefore, we obtain the C_{HMRSVP_u} in the following.

$$(l-1)\alpha + 3\theta\alpha \le C_{\mathrm{HMRSVP}_u} \le (l-1)\alpha + l\theta\alpha. \quad (13)$$

- The reservation cost for the HMRSVP_{pf}

We use the $C_{\mathrm{HMRSVP}_{pf}(k,i)}$ to represent the resource reservation cost for an MH when the mean length of locality movement is k and the forwarding pointer chain length is i. The $C_{\mathrm{HMRSVP}_{pf}(k,i)}$ can be given by

$$C_{\mathrm{HMRSVP}_{pf}(k,i)} = \mathrm{Cost}_{\mathrm{Active}} + \mathrm{Cost}_{\mathrm{Passive}} = ((l-1)\alpha + \alpha i\pi_i) + \theta\alpha. \quad (14)$$

Next, we use the $C_{\mathrm{HMRSVP}_{pf}(k)}$ to represent the reservation cost for the same locality movement except that the i is replaced by the mean length of the forwarding pointer chain. Thus, we can obtain

$$C_{\mathrm{HMRSVP}_{pf}(k)} = ((l-1)\alpha + \alpha L_{pf}) + \theta\alpha \quad (15)$$

where

$$L_{pf} = \sum_{0 \le j \le \infty} j\pi_j \quad (16)$$

is the mean length of the forwarding pointer chain.

IV. Numerical Results

For comparison, we use the average of the $C^{\max}_{\mathrm{HMRSVP}_u}$ and $C^{\min}_{\mathrm{HMRSVP}_u}$ to represent the C_{HMRSVP_u} from Figs. 3–6.

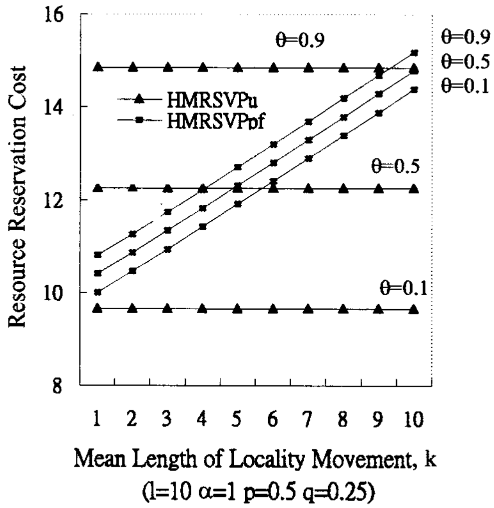

Fig. 4. Resource reservation costs with different values of the reservation overhead θ.

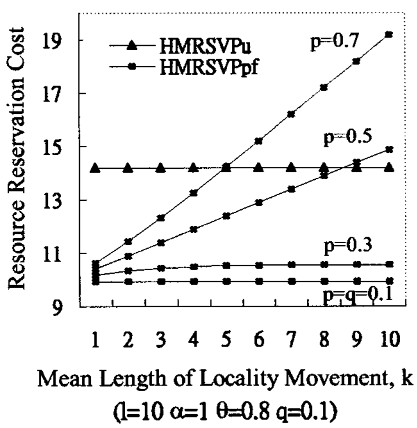

Fig. 5. Resource reservation costs with different values of the locality movement probability p.

Fig. 3 depicts the performance results of the resource reservation costs for all the three schemes. First, it shows that the cost of the HMRSVP$_m$ scheme is significantly higher than those of the HMRSVP$_u$ and the HMRSVP$_{pf}$ schemes. Therefore, we discuss only the HMRSVP$_u$ and the HMRSVP$_{pf}$ schemes form Figs. 4–6. In addition, Fig. 3 shows that the resource reservation cost is relatively high when the mean length of locality movement k is high in the HMRSVP$_{pf}$ scheme. In other words, our HMRSVP$_{pf}$ scheme performs well at high locality movement, i.e., small k, for a mobile host. Moreover, the figure shows that there is an intersection point, which could be a *resetting point*, for the HMRSVP$_u$ and the HMRSVP$_{pf}$ scheme. It means that the HMRSVP$_{pf}$ scheme should perform a resetting operation as discussed in [5], [6] at low locality movement, i.e., large k; otherwise, the HMRSVP$_{pf}$ scheme will perform worse than the HMRSVP$_u$ scheme.

In Fig. 4, the resource reservation cost is relatively high when the reservation overhead θ is high for both the HMRSVP$_u$ and HMRSVP$_{pf}$ schemes. The phenomenon is consistent with our

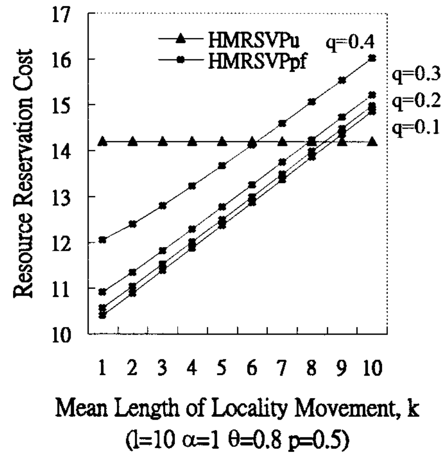

Fig. 6. Resource reservation costs with different values of the nonlocality movement probability q.

intuitive result. In addition, this figure also points out that the value of k for the resetting point increases when the reservation overhead θ is high. This phenomenon shows that the performance of our HMRSVP$_{pf}$ degrades less significant than the HMRSVP$_u$ if the overhead increases.

In Figs. 5 and 6, we observe that the reservation cost grows with the increasing of the probability p or q in the HMRSVP$_{pf}$ scheme. This is because the increasing of the locality movement probability p or the nonlocality movement probability q will degrade the degree of locality movement for mobile hosts. It demonstrates that the HMRSVP$_{pf}$ scheme can achieve a low cost if a mobile host has a locality-movement behavior.

V. Conclusions

The pointer forwarding scheme can be implemented simply for the hierarchical MRSVP on the wireless Internet. We show that it performs well when a mobile host has a locality behavior of mobility. Consequently, the HMRSVP$_{pf}$ scheme is most suitable for the real world of future wireless networks because mobile hosts always move locally at a region in most time.

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