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Search & Compare (S&C) - Reservation Protocol in High-Speed Optical Networks

M. Markovic, J. Dubovan, M. Dado
University of Zilina, Faculty of Electrical Engineering, Department of Telecommunications and Multimedia, Univerzitna 8215/1, 010 26 Zilina, Slovak Republic, +421 41 513 2229, e-mail: miroslav.markovic@fel.uniza.sk, jozef.dubovan@fel.uniza.sk, milan.dado@uniza.sk

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Introduction

The Search & Compare protocol uses outband signalling. It is the reason why the Wavelength-division multiplexing (WDM), i.e. multiple WDM channels, can be utilised and signalling channel may be multiplexed in the same fibre [1–8]. Our new proposed reservation protocol was created for Optical burst switching (OBS) networks, which combine the best of optical circuit switching and packet switching without optical buffering or packet-level parsing [6, 8]. This fact can help us to build terabit optical routers and realize IP over WDM transmission . Currently, there are several reservation protocols, such as Resource Reservation Protocol - Traffic Engineering (RSVP-TE), Intermediate-node Initiated Reservation (IIR) [2], Robust Fast Optical Reservation Protocol (RFORP) [6, 7] and S-RFORP [1]. RSVP-TE reservation protocol is primary designed for multiprotocol label- switched (MPLS) networks, which support synchronous optical networks (SONET), synchronous digital hierarchy (SDH) and dense wavelength-division-multiplexed (DWDM) networks [3, 5]. It is also possible to use RSVP-TE for generalized MPLS (GMPLS). All of these protocols have positive and negative features. The best one is S-RFORP. However, this reservation protocol has one disadvantage. S-RFORP is used in intra-segment, node by node discovery and reservation. This means discovery or reservation time of a segment depends on the number of active nodes, i.e. the more nodes in the segment the worse the discovery and the reservation time [1].

Table 1. Input simulation parameters

Number of segments	3
t_s, t_c, t_v, R_{ts}	<0,1>
Number of active nodes in I. Segment	37
Number of active nodes in II. Segment	8
Number of active nodes in III. Segment	9

The S&C is a reservation protocol which uses the parallel-segment based and parallel link reservation. Like S-RFORP [1] this protocol has two phases - discovery and reservation.

S&C Discovery time

As you can see in Fig. 1, the same signalling is both in the inter-segment and in S-RFORP [1]. The main difference between S-RFORP and S&C is in intra-segment signalling.

The steps of the S-RFORP discovery phase are:

- Discovery phase starts in the source node (Seg. 1 head) of the first segment;
- Source node sends parallel discovery initialization message to all head nodes in all segments (Fig. 1);
- Head node ("Node H") in the segment inserts its free wavelengths (λ_1, λ_2, λ_3, λ_4) into the discovery message;
- Head node sends the discovery message to another node ("Node a");
- "Node a" compares its free wavelength (λ_1, λ_4) with wavelength from the discovery message (λ_1, λ_2, λ_3, λ_4) and generates a new discovery message as a conjunction (see Fig. 2);
- The previous step is repeated until the discovery message arrives into the tail node ("Node T");
- The tail node generates the discovery results message (information about discovery wavelength) and sends it to the destination node.

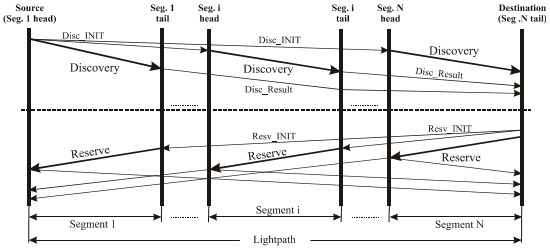

Fig. 1. S&C inter-segment signalling is same as in S-RFORP

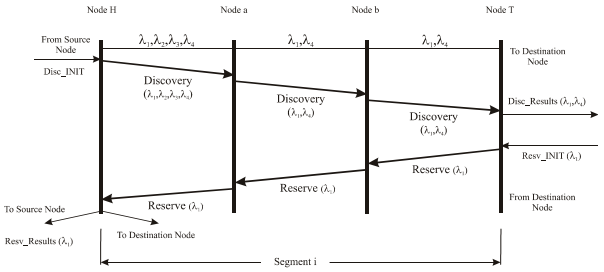

Fig. 2. S-RFORP intra-segment signalling

S&C Intra-Segment Discovery

The main element of the intra-segment discovery is "MASTER NODE". This node stores all available free wavelengths used in all nodes in the segment (data are stored in the discovery table). In this case it is not necessary to wait for node by node discovery because all information is available in the discovery table and primary alternative wavelengths (see Fig. 3) are selected.

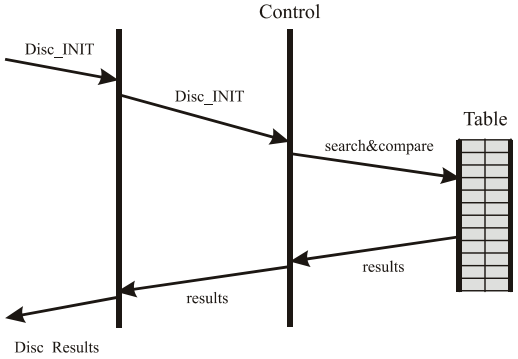

Fig. 3. S&C discovery process in intra-segment

The main principle for selecting the primary and alternative wavelength from the discovery table is the same as with S-RFORP protocol, i.e. the first row corresponds to the first node in the segment and it is compared with the second row, the second row is compared with the third one, etc. This procedure is repeated until the algorithm compares all rows in the table (number of rows is equal to number of active nodes in the segments).

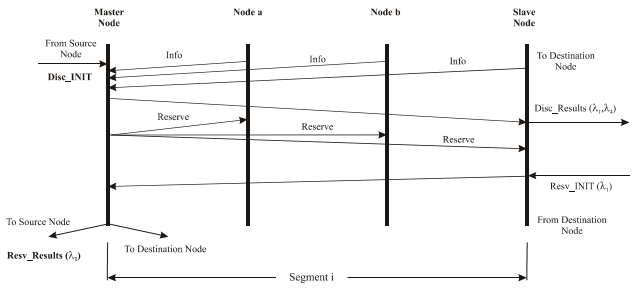

Fig. 4. Intra-segment signalling in S&C protocol

When the discovery process finishes, master node generates a new message called "Disc_Results" (see Fig. 4), which is sent into the destination node (Seg. N tail - see Fig. 1). This process is much faster than the serial discovery in S-RFORP protocols.

Time analysis – discovery time in S&C

The discovery time is a sum of two variables only - search time and compare time. Both times depend on master node search speed (see Fig. 3). The discovery time in S&C D_{tsc} is defined as

$$D_{tsc} = t_s + t_c , \quad (1)$$

where t_s – is the search time in the table; t_c – is the compare time in the table.

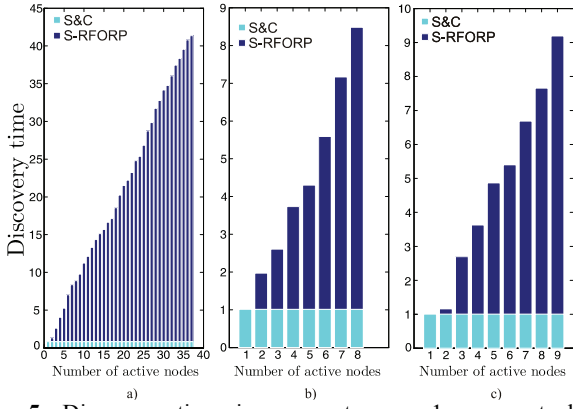

Fig. 5. Discovery time in segments a – 1. segment; b – 2. segment; c – 3. segment

As can be seen in figs. 5 and 7, reservation protocol S-RFORP depends on the number of active nodes in the segment. In the first segment 37 nodes are located. It can be seen in figs. 5a and 7a that discovery and reservation times increase with rising number of active nodes but reservation protocols S&C need the same amount of time.

Reservation

Reservation process starts with receiving a message called "Resv INIT" (see Fig. 6). The next step is offer checking – received wavelengths (from "Resv INIT") with actual free wavelengths in the segment (table in master node).

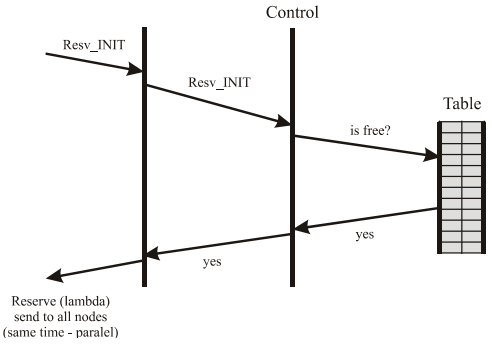

Fig. 6. S&C reservation - positive response from master node

If master node finds in the offer a free wavelength, it generates a new message called "Reserve" and sends it to all nodes at the same time (in parallel to all nodes in the segment - see Fig. 4).

Time analysis – Reservation time in S&C

The total time is calculated using the worst case results, i.e., if the reservation process is parallel, total time is calculated as a sum of the verification time and reservation time of the slowest node in the segment R_{tsc}

$$R_{tsc} = t_v + R_{ts}, \quad (2)$$

where t_v – is the verification time; R_{ts} – is the necessary time for reservation of the slowest node in the segment.

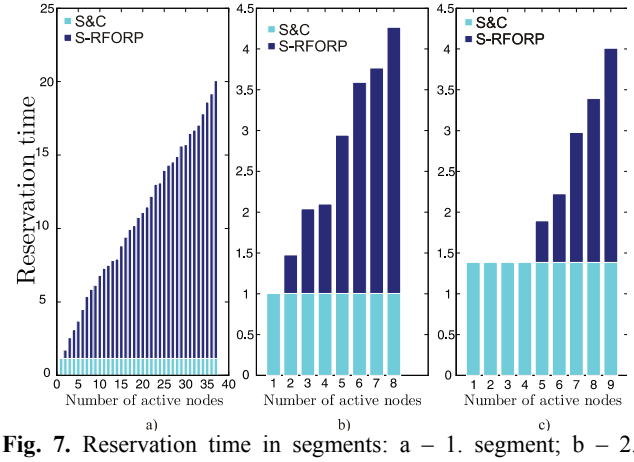

Fig. 7. Reservation time in segments: a – 1. segment; b – 2. segment; c – 3. segment

Blocking probability

As shown before, the main task of reservation protocol is to reduce the time which is important in discovery and reservation phases. Another very important parameter is blocking probability. As can be seen in Fig. 8, blocking probability in S-RFORP protocol is dependent on the number of active nodes, but the new S&C protocol is not.

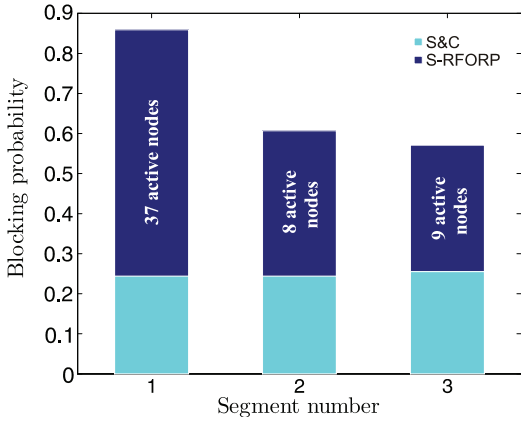

Fig. 8. Blocking probability for each segment

Fig. 9, Fig. 10 and Fig. 11 map dependence of blocking probability on intensity (in our case, intensity is dependent on traffic load and number of active nodes).

When intensity increased, blocking probability of both protocols had exponentially increasing character, but S&C did not increase as fast as S-RFORP. As a result, the S&C protocol has better potential for utilisation of node resources as S-RFORP.

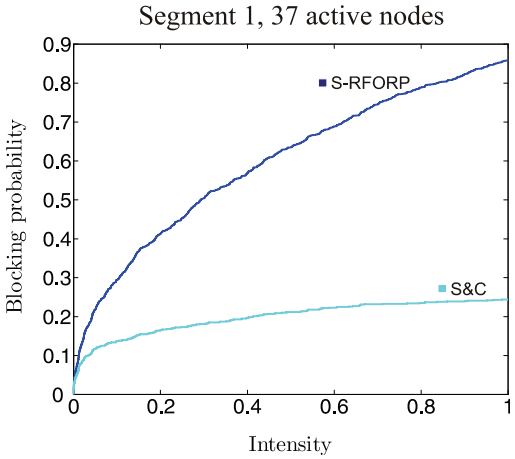

Fig. 9. Blocking probability versus intensity in 1. segment

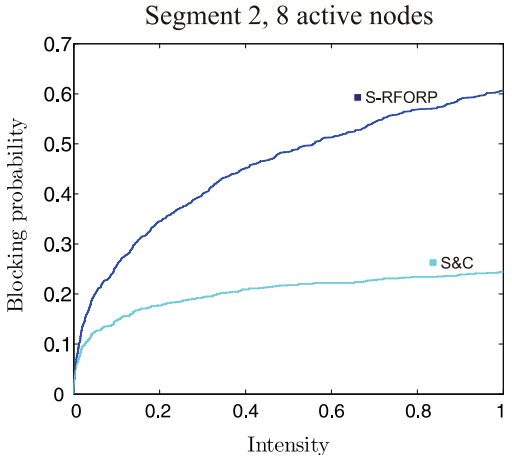

Fig. 10. Blocking probability versus intensity in 2. segment

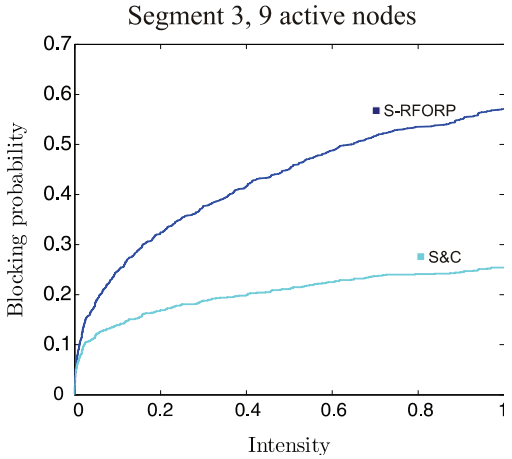

Fig. 11. Blocking probability versus intensity in 3. segment

Conclusions

The main target of proposing this new reservation protocol was to reduce discovery and intra-segment reservation times. It was shown in this paper (see figs. 5, 7 and 10) that S&C does not depend on the number of active nodes in a segment. It depends on the master node speed

only (see on Fig. 10, 8). If this node is faster than all the other nodes in the segment and there are many nodes in the segment, S&C reservation protocol is more powerful than S-RFORP. S&C also uses node resources better that manifests itself in lower blocking probability.

Acknowledgements

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M. Markovic, J. Dubovan, M. Dado. Search & Compare (S&C) - Reservation Protocol in High-Speed Optical Networks // Electronics and Electrical Engineering. – Kaunas: Technologija, 2011. – No. 8(114). – P. 39–42.

In this paper we deal with a new reservation protocol for high-speed optical networks called Search & Compare. This reservation protocol is improved Segment-based Robust Fast Optical Reservation Protocol (S-RFORP). S&C protocol contain is composed of two parts: inter-segment and intra-segment. The first part of this paper deals with the design of reservation protocol and the second part with the detailed analysis. Ill. 11, bibl. 8, tabl. 1 (in English; abstracts in English and Lithuanian).

M. Markovic, J. Dubovan, M. Dado. Rezervacijos protokolo taikymas didelės spartos optiniuose duomenų perdavimo tinkluose // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 8(114). – P. 39–42.

Analizuojamas naujas rezervacijos protokolas, taikomas didelės spartos optiniuose duomenų perdavimo tinkluose, vadinamas „surask ir lygink". Analizuojamas rezervavimo protokolas patobulino S-RFORP protokolą, susidedantį iš tarpsegmentinių ir vidinių segmentinių dalių. Pirmojoje straipsnio dalyje pateikiamas rezervacijos protokolo projektavimas, antrojoje – detali analizė. Il. 11, bibl. 8, lent. 1 (anglų kalba; santraukos anglų ir lietuvių k.).