Signaling traffic management in short peak signaling traffic loads

N. Curic-Segaric, I. Ljubic, K. Delac
Carrier Services Department
Croatian Telecom, Inc.
Complete Address: Kupska 2, Zagreb, 10000, Croatia
Phone: (385) 1-4912 366 Fax: (385) 1-4912 300 E-mail: ncs@ht.hr

Abstract - C7 signaling network in national and international part was designed initially for PSTN traffic. Incumbent carrier is telecommunication operator that provides, besides services for fixed network, STP and SCCP services for mobile operators. It is faced with the problem of signaling traffic management. Because of high number of mobile customers and their migration from their own national network to other mobile networks, and because of marketing promotions and activities from mobile operators and service providers that are based on SMS traffic, there is a lot of traffic generated in short time frames. Since this type of traffic is running via signaling network of incumbent operator in national and international part we are faced with signaling traffic management issue. This paper focuses on available tools for signaling traffic management in this critical short-term traffic overload.

I. INTRODUCTION

Existing signaling network architecture cannot respond fast to network expansion in case of traffic load. The traffic load amount can grow several times higher than average and during the peak traffic load capacity is not sufficient. Available tools for traffic routing are fixed and are based on bilateral agreements between two operators – owners of the network. Primary and secondary routes are implemented and, very rarely, third route. Upon determination of available routes, operators define Message Transfer Part (MTP) and Signaling Connection Control Point (SCCP) routing. This static routing (one routing table) limits fast response ability to new traffic demand.

The main goal for all parties in the chain is to deliver the traffic with minimum activities and without losses.

II. SIGNALING NETWORK ARCHITECTURE AND ROUTING TOOLS

International signaling traffic is run via signaling network established between incumbent operators. On our side, international signaling gateways carry voice and signaling traffic. This means that transmission bearer carrying voice and signaling channels terminates on the same switch. In international part, E1 carrying signaling link terminates on 64k DXC in order to split voice channels from signaling channels. This way the signaling link terminates on stand alone STP. Besides STP functionality, switches also have SCCP functionality.

Typical signaling diagrams that are in place for SCCP traffic for mobile operators are shown in Fig.1

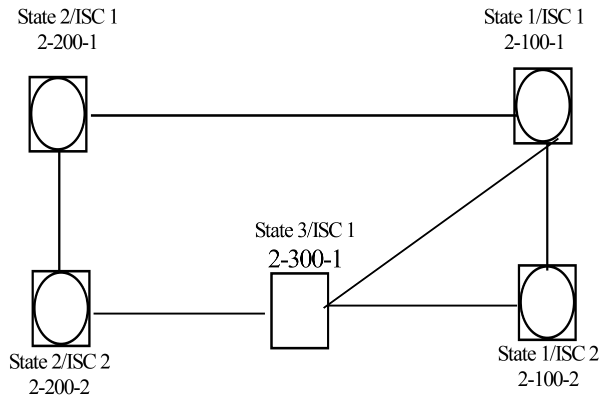

Fig. 1. Typical signaling diagram

Terminating points are connected either via direct signaling link or by using STP point to exchange traffic. MTP traffic routing is based on criteria to deliver the traffic out of your own network via shortest way. The advantage of this method is avoiding of utilization of signaling link between two national switches [1]. Also, STP operator allows transit but just as a second choice. This condition will probably be changed soon due to operators announcement about charging the signaling traffic. Table 1 represents MTP routing for signaling diagram defined in Fig. 1.

TABLE I
MTP TRAFFIC ROUTING

Relation	1st choice	2nd choice
State1/ISC1-State2/ISC1	direct	State3/ISC1
State1/ISC1-State2/ISC2	State2/ISC1	State3/ISC1
State1/ISC2-State2/ISC1	State2/ISC1	State3/ISC1
State1/ISC2-State2/ISC2	State2/ISC1	State3/ISC1
State2/ISC1-State1/ISC1	direct	State2/ISC2
State2/ISC1-State1/ISC2	State1/ISC1	State2/ISC2
State2/ISC2-State1/ISC1	State2/ISC1	State3/ISC1
State2/ISC2-State1/ISC2	State2/ISC1	State3/ISC1

For technical reasons - to increase utilization and economic reasons, in peak traffic load it is necessary to define load-sharing algorithms in signaling nodes [2].

Load sharing possibility is based on MSU structure that consists of routing label shown in Fig. 2.

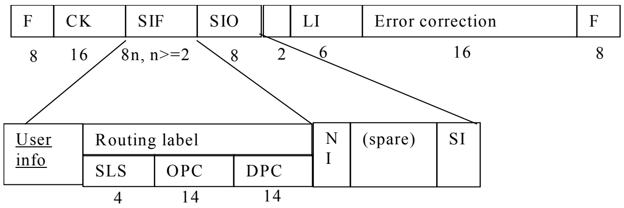

Fig. 2. MSU Structure

Message routing over the respective signaling link is based on values of the following fields: Network Indicator field (NI), Service Information Octet (SIO) field, Signaling Link Selection (SLS) field and Destination Point Code (DPC) field [4].

Routing of the MSU is performed in such a way that the messages with the identical NI, SLS and DPC parameters are routed over the same signaling link if there is no failure on the link.

II.A. Signaling Message Handling

The signaling message handling distinguishes following processes (Fig.3) for routing messages to the appropriate signaling link and for distribution of received messages within the local signaling point to the correct User Part(UP) [3].

The signaling message handling consists of:

- signaling message discrimination
- signaling message distribution
- signaling message routing
- signaling message conversion

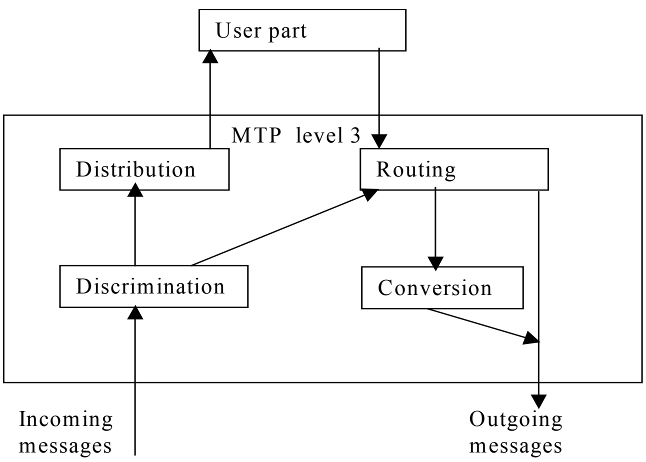

Fig. 3. Signaling Message Handling

Signaling Message Discrimination

When message arrives to the local signaling point it is necessary to discriminate the message. Comparison is performed between DPC and signaling point code of the switch that performs discrimination procedure. If the codes are the same distribution procedure is activated, otherwise routing procedure is activated.

Then the Network Indicator, which is a part of SIO field is analyzed to determine if the message is destined to the network in which is node defined.

Incoming messages have OC value which is compared with OPCs defined by the system. If this OPC is not on the system list, the message will be discarded. If there is no list all messages are accepted by the system.

Signaling Message Distribution

Signaling Message Distribution delivers incoming messages from the Signaling Message Discrimination to the appropriate User Part depending on the value of SI field.

If SI=0000 message will be delivered to signaling network management part. If SI=0001 or 0010 then it is a test message.

For all other SI values message is delivered to appropriate user part.

Signaling Message Routing

Every User Part has Routing Label which consists of OPC field, DPC field and SLS field (Fig.2).

The routing of outbound messages consists of the following steps:

1. An OPC field is checked first. If it doesn’t exist the message is discarded.
2. Secondly, the existance of DPC configuration is checked. If it doesn't exist message is discarded. Othervise, the signaling link will be reserved and will carry the message.
3. Check whether the outgoing and incoming bearers are the same type. If the types match, signaling link that will carry the message is specified. Otherwise, signaling message conversion will take over the message.

In order to define the route (routing object) it is necessary to differentiate the following elements:

1. route type (SS7 or IP)
2. route number
3. link ID or stream ID, depending on the route type

Routing object is used for sending outgoing messages to correct route and link towards a specific destination, based on the current route priority and the SLS value.

To determine which route to use for a given destination and SLS in the selected local node for a outgoing message, the SLS map is used.

In Signaling End Point (SEP) a Signaling Link Set (SLS) map is defined as matrix with all available routes and SLS values taking into account route priority (Fig.4).

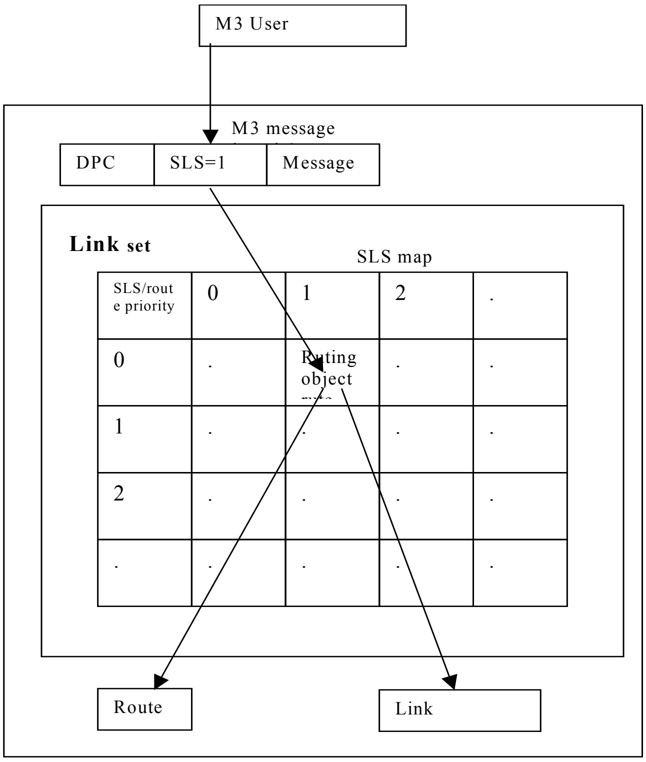

Fig. 4. SLS map – signaling message routing

In case of distribution traffic for load-sharing at the originating signaling point and intermediate signaling transfer points, following issues should be considered:

- use of signaling link selection (SLS) codes so that traffic will be distributed over all available routes evenly. On international level of the signaling link this is not in use. The choice of a particular link for a given signaling link selection code is made at each signaling point independently. As a result, message routes for a given user transaction in two directions may take different paths.
- when the number of links in a link set is not a power of 2 (i.e. 1, 2, 4, 8), SLS load sharing does not achieve even distribution of traffic across the individual links. In most cases it is not the power of 2 because of lack of signaling terminals.

There are two kinds of load sharing according to ITU standard: load sharing within a link set and load sharing between link sets.

II.B MTP load sharing

In this example we have the possibility to implement MTP load sharing traffic distribution all over available routes (link sets) and links within link set to specified destination.

Load sharing option between link sets in end nodes is not considered in network example shown in Fig. 1 due to nonexistence of second direct signaling route and there is no approval of STP part for that. This option is set on direct routes when there is a symmetrical network between end points (four end points and two routes). Maximum number of routes that can be used in load sharing mode is 5. Load sharing should be implemented in a way that all routes are equally loaded, regardless of the number of links on the route.

Here is an example of load sharing shown in table 2 when there are 4 routes and five signaling links.

Main criteria for route priority determination is existance of direct route to the destination point. Second criteria is signaling capacity, the minimum STPs between origination and destination point and finally screening and policing functions in STPs. The last one is more and more implemented in STPs, not just because of reliability but because of commercial conditions as already mentioned. SLS map is changing every time when there is some change on route or link. The highest route priority is 1 and the lowest is 5.

Signaling End Point indicates that there is even load on link sets but not on links within one route. Also in this case SEP analyses bits 3 and 4 within SLS as follows:

- all SLS with 00xx are mapped to link set 1
- all SLS with 01xx are mapped to link set 2
- all SLS with 10xx are mapped to link set 3
- all SLS with 11xx are mapped to link set 4

TABLE 2
SIGNALING END POINT SLS MAP

Link set	1st link set (xx00)		2nd link set (xx01)	3rd link set (xx10)	4th link set (xx11)
Link	1	2	3	4	5
	0(0000)				
			1(0001)		
				2(0010)	
					3(0011)
		4(0100)			
			5(0101)		
				6(0110)	
					7(0111)
Incoming SLS	8(1000)				
			9(1001)		
				10(1010)	
					11(1011)
		12(1100)			
			13(1101)		
				14(1110)	
					15(1111)
	0(0000)				

Load sharing between links is limited to maximum of 16 links due to SLS field limitation to 4 bits. If each SLS value is used in turn even load sharing will be achieved.

Load sharing is done in two steps, even load sharing between all available routes and then even load sharing between all available links.

II.C SCCP load sharing

Table 3. represents SCCP routing.

TABLE 3
SCCP TRAFFIC ROUTING

Originating point	1st choice	2nd choice
State1/ISC1	State2/ISC1	State2/ISC2
State1/ISC2	State2/ISC2	State2/ISC1
State2/ISC1	State1/ISC1	State1/ISC2
State2/ISC2	State1/ISC2	State1/ISC1

SCCP load sharing is used when there are at least two SCCP points [5].

Here we have the possibility to implement load sharing but the contribution is not significant due to MTP routing.

Load sharing function deals with MSU. Since MSU length varies a lot from 15 bytes to 50 bytes we are able to achive even load from MSU point of view, but not on the byte level. Also there are other factors that effect final load sharing behaviour such as [6]:

1. Configuration aspect
   - network node configuration (terminate node or STP)
   - addressing method (MTP based, SCCP based)
   - service type (SCCP, TUP/ISUP,…)
   - weighting of service type message
2. Definition aspect
   - SCCP load sharing definition (network configuration) [7]
   - MTP load sharing definition (network configuration)
   - MTP load sharing algorithm
3. Method used for analysys

If there is no load sharing, the SLS is associated to the corresponding signaling link anyway. If there is no specific SLS, the signaling link to which the missing SLS is allocated will never be used.

II. TRAFFIC LOAD ON SIGNALING LINKS

On national level, from commercial and technical point of view, it is possible to react immediately, i.e. to expand the signaling network and to implement load sharing. Facility is in place and maximum traffic load is agreed between parties. Persons on duty are authorized to expand the traffic in case of crossing the threshold.

On international part temporary procedure for expanding the traffic is in place. This procedure is based on expected traffic peaks, for example during the tourist season. Traffic load during normal periods is shown in Fig. 5.

Traffic load shown in Fig. 5 is measured on two signaling links and is stable. There is only one traffic peak in receiving direction to ISC1 (OPC) from DPC. Obviously this traffic was rerouted from congested route via STP point with DPC. Since this was not agreed, traffic was redirected to some other route.

Thereby traffic was increased five times on one link. There was a possibility to split that traffic on two signaling links, but routing in that node was not set to cope with this situation.

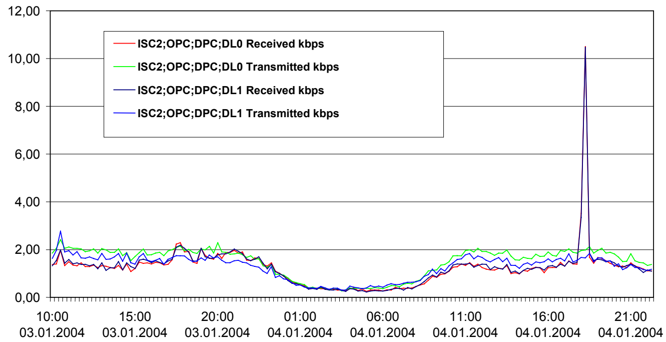

Fig. 5. Signaling link historic report 15 min interval

Period: 03.01.2004 10:00 - 04.01.2004 22:15

Fig. 6 indicates traffic load on one signaling link that shows significant traffic load on receiving direction. Since all direct signaling relations have been checked the only conclusion is that this DPC generates a lot of traffic. Also this DPC changed the routing via another link shown in Fig.5 without authorization. It would have been possible to overcome this problem if traffic policing implementation has been activated in transit node for this relation.

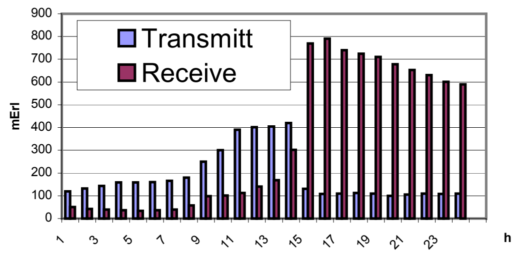

Fig. 6. Signaling link historic report 1 h interval

Period: 03.01.2004 0:00 - 23:50

If we look at the MSU type structure we can conclude that 95% of the traffic in critical period is SCCP traffic (Fig. 5.) generated from mobile networks.

According to the ITU Recommendation maximum traffic load on signaling link is 0.2Erl. With the implementation of stand alone STP this load level is changed between 0.8 Erl to nearly 1Erl.

Due to implementation of stand alone STP on one side and existance of combined STPs for voice and signaling (witch spend great amount of processor time processing voice traffic) on the another side, there are different criteria of traffic load on international signaling network. This is the reason why it is very difficult to define emergency procedure in case of significant traffic load on mutual signaling links.

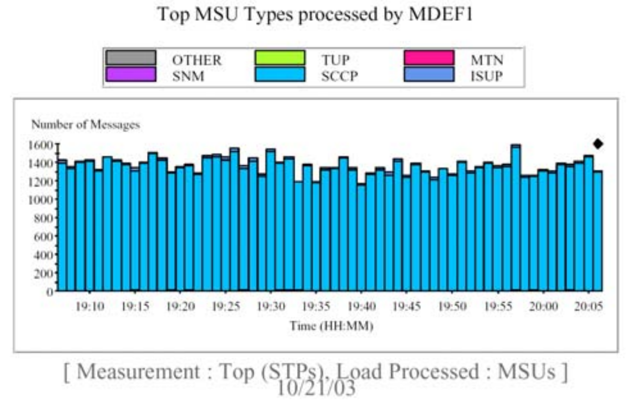

Fig. 7. MSU Types – measurement sample within 2 h expresed in number of mesages

Octet structure of MSU indicates that avarage SCCP message is approximately 50-60 octets long compared to ISUP message that has in avarage about 15 octets (Fig.7 and Fig. 8).

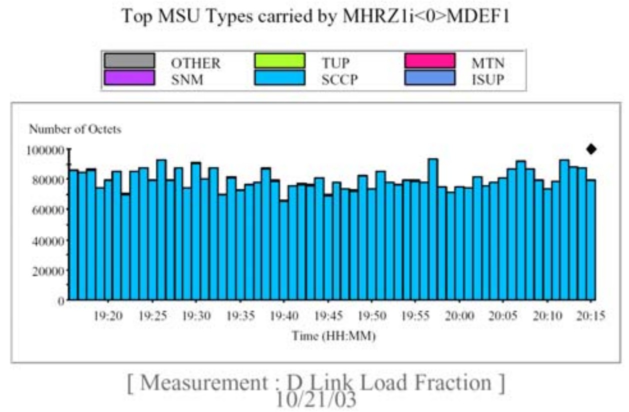

Fig. 8. MSU Types – measurement sample within 2 h expresed in number of octets

IV. Application of the Network Management Tools in Critical Peak Traffic Overload

According to the above mentioned, major part of the signaling traffic is related to SCCP traffic. We are able to measure traffic overload but unfortunately we are not able to react immediately in order to deliver all traffic to certain destination. The first step in meeting this demand is to expand C7 network immediately. Usually we are facing with transmission obstacles. Second step is to adjust the routing table in accordance with this new demand. At the time of signaling network expansion, no one can estimate the volume of the traffic that should be delivered. It is therefore the practice to double the number of signaling links. Due to load sharing and better utilization of all links in a link set and all over the routes the goal is to expand the network in even number of links and routes. Load sharing options over all links in a link set and over all direct routes should be also adjusted.

So far these activities satisfied traffic needs, but recently we have noticed that these urgent measures are not sufficient and the traffic is growing much faster than expected.

The idea regarding overcoming this problem is to utilize other routes and STPs. With the proper ways of negotiations and announcement of all parties about their spare capacity on the existing links, there is a possibility to include these routes in traffic management during critical situations. The main assumption of this method is to define traffic load levels on main route related to different routing tables, which should be implemented dynamically, i.e. certain traffic load relates to respective routing table.

IV. Conclusion

In spite of defined planning methods it is very difficult to dimension signaling network for short term traffic overloads. Due to political and economical reasons there are a lot of migrations of mobile customers that generate short term overload. The idea is to utilize existing signaling network in the best possible way. We currently have in place temporary signaling network extension procedure as an urgent procedure to overcome this problem. This means that we have availability on transmission level and redundancy in signaling terminal equipment. On the other end there are signaling routes that are underutilized.

Solution with few routing tables and at least three different routes could be the best way to deliver the traffic and utilize the network. That calls for cooperation of several operators. In order to accomplish this, all involved parties should define their thresholds and diversify maximum traffic load that can be delivered via their facilities. This solution could be compatible with new commercial trends on signaling market where there is a possibility to charge signaling information unit per MSU or per byte. This additional revenue or cost from the other side could be a mayor driver in implementation of common solutions without implementing new signaling capacities.

References

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[7] ITU-T Recommendation Q.751.2, Network element management information model for the Signaling Connection Control Part