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Performance of SCTP through switch to second path

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Abstract
Today the Internet plays an important role in our everyday life. Users hope that the network is always speedy enough to help them access the Internet without any delay. But the real situation is far from the ideal case. Due to increase the network traffic for multi-homing. The Stream Control Transmission Protocol (SCTP) can migrate to secondary paths when primary path becomes unavailable, through standard path failure detection strategy managing, but the matter of fact the standard SCTP Path Management has a delay so does not mark path inactive as soon as failure is detected, due to parameters values related to standard path failure detection strategy such as α, β and Path.Max.Retrans (PMR), these parameters have a major impact on the failover performance. For this reason we propose a method which requires alternation on current standard parameters, the new enhancement mark path failure detection strategy managing, in short time SCTP switches to secondary path when failure path detected. Therefore, we can achieve high performance, in throughput through proposed method, by using tools of OMNet++ simulation and finally will compare the performance of the SCTP, between the proposed method and default mechanism.

Keywords: RTO Calculation, SCTP Path. Max. Retrans, failure, OMNeT++

1. Introduction
SCTP provides additional features which are multi-homing and multi-streaming. These features make it suitable for the transport of many services which use the classical transport protocols to migrate to SCTP in order to take advantage of the new features offered by this protocol [1]. Multi-homing support is one of the major advantages of SCTP which is not supported in other transport protocols such as TCP or UDP [2]. SCTP multi-homing mechanism is based on the assumption that each endpoint has several networks interfaces and IP addresses. So between each pair of sender-receiver, multiple paths can be existed. One of these paths can be designated as the primary path to send packets during association setup. Another path is chosen as secondary path and it may be used for retransmission and avoids additional and unnecessary congestion at the primary path. Multi-homing is proposed to provide end-to-end network fault tolerance and faster recovery during network failures [3]. SCTP keep an error counter for the destination transport addresses at each path and each peer of sender receiver. The counter detects path failure by timeout [4]. When this value exceeds the protocol parameter PMR of that destination address, the path is considered unavailable or unreachable and a failover is performed. The primary path becomes unusable and the secondary path is chosen as the new primary path [5]. The next secondary path is selected from the backups. If the primary path breaks down, one of the alternate paths will be set as primary and the traffic between the hosts will continue [6]. But the fact of the matter the SCTP Switchover Management process is take large period of time can cause significant performance degradation and will not be acceptable in some situations. So for this reason we propose a new enhancement to the SCTP Switchover Management. The new enhancement of propose does not require major modification to the current Switchover Management. But we altered in some of the part to evaluate the total Time spent during failure of primary path occur and detect path failure as soon as possible. The first enhancement concern in RTO Calculation Behavior through α and β parameters, in this case we proposed that, when is old smooth round Trip Time of the path (SRTT.old) greater than or equal new round Trip Time (RTT.new), the value of smoothing factor α = 1, otherwise the value = 0, instead of 0.25 as

the constant value in current strategy. Also the value of delay variance factor β was changed to 0, when SRTT.old - RTT.new, greater than or equal old Round Trip Time Variation of the path (RTTVAR.old), otherwise β = 1 instead of 0.125 as the constant in current strategy. The second enhancement of current SCTP switchover management the total time between the failures of the primary path and until the path is regarded useless known as PMR we setting this parameter to four instead of five, is Which improves to the existing SCTP failover mechanism so we can obtained small delay when the primary path failure occurs. However the performance of the proposed the enhancement SCTP switchover management was evaluated by a set of simulations OMNeT++ the OMNeT++ projects provides component architecture for modeling environment. Components (modules) are programmed using C++, and then assembled into larger components [7]. Some model in Omnet++ is programmed in high level language such as NED.Omnet is a simulation framework not a simulator by itself, and Omnet++ is an important simulator programs which is used to simulate various network domain [8]. The remainder of the paper is organized as follows. Section II Overview of SCTP Path Management, while in section III, Standard SCTP Switchover Management with an Example. The section IV is Enhancement of SCTP Switchover Management. In section V Network Simulation Model, The objectives in section VI. Expected results of the proposed: switchover enhancement VII, and finally, the Conclusions in section VIII.

2. Overview of SCTP Path Management

SCTP needs a path management functionality to take switchover decisions as well as implementing the path switchover, to detect path failure. SCTP provides two kinds of implementing mechanisms one for the primary path and another for the alternate paths [7]. To monitor the primary path, SCTP keeps an error counter that counts the number of consecutive timeouts. For the alternate paths, SCTP uses a heartbeat mechanism to monitor the availability of these paths [8]. The SCTP path management functionality defines two states for each path. The state value can be set to ACTIVE or INACTIVE. A primary path is set to INACTIVE if transmission of packets on the path repeatedly fails see Figure (1). However, a secondary path fails, if a heartbeat chunk transmitted to the destination on that path was not successfully acknowledged. Both of these mechanisms are reactionary to network failure [9]. The SCTP associations, secondary paths are monitored to detect any changes in the reachable state of a destination address, and also to update the Round Trip Time (RTT) measurement for each of these secondary addresses. Path monitoring is performed using HEARTBEAT chunks which are sent periodically to know which addresses defined in the association are reachable Show in Figure (2) [10]. When a heartbeat is received by an endpoint, the packet is processed and a heartbeat ACK packet is sent back. Each heartbeat packet contains a timestamp of when it was sent. When the heartbeat ACK packet is received, the time delay difference can be used to estimate the RTT for secondary paths [11]. In order to detect the primary path failure, SCTP uses a reactive strategy which is mainly based on a retransmission timer. The duration of this timer is referred to Retransmission Timeout (RTO) [12]. The RTO duration represents the delay between each retransmission on the path. The computation and management of RTO in SCTP is similar to how TCP manages its retransmission timer. However, SCTP differs from TCP by supporting multi-homing feature. In fact, when the destination is multi-homed, the endpoint will calculate a separate RTO for each different destination's transport address. The RTO value of the primary path is important for path switchover decision. If an SCTP sender doesn't receive a response for an SCTP data chunk from its receiver within the time of RTO, the sender will consider this data chunk lost [13]. When the number of consecutive timeouts on the primary path exceeds the SCTP threshold, the address will be marked as INACTIVE by the sender, and a new primary path will be selected among the alternate paths that are currently available more details in (section III). The SCTP parameters which are used to implement the switchover management strategy are:

- RTO.Initial: is the initial value of the RTO before any RTT measurements have been made.
- RTO.Min: is the lowest allowed value for RTO. If a calculated RTO is very small, then the value will be rounded up to RTOmin.
- RTO.Max: is the highest allowed value for RTO. Large RTO values will be rounded down to RTOmax.
- Path.Max.Retrans: is the number of maximum retransmissions on a path before it is considered unreachable. Until this value is exceeded a failover will not take place.
- HB.interval: the interval at which heartbeats are sent to monitor an SCTP endpoint [14].

3. Standard SCTP Switchover Management with an Example

we can see in Figure (3) multi-homed architecture which are peers connected by an IP network, from this assumptions host A have tow alternation paths to sent data to host B, through paths1 or paths2. SCTP before select one must be evaluates performance for all paths through the association based on RTT for each path. Always the RTT reflects the degree of congestion and packet loss rate on the path. After evaluation the performance, SCTP selects the best one as the Primary path and other as secondary path. In this architecture we assume SCTP select paths1 as the Primary path and the second path as backup, when host A sending data, if it doesn't receive a response, the sender will consider this data chunk lost, this indicate that path was failed, then SCTP is initialized to calculate RTO, assume SCTP is initialize with RTO as initial. So the calculation is:

$$RTO = RTO.\ Initial \tag{1}$$

When SCTP detect new packet lost immediately calculate RTO based on first RTT, if the first RTT equal 1000ms then SCTP calculate SRTT as equation:

$$SRTT = RTT.1^{st} \tag{2}$$

Where the SRTT of the path, equal 1000ms then SCTP calculate RTTVAR as equation:

$$RTTVAR = \frac{RTT1.^{St}}{2} \tag{3}$$

Where the RTTVAR of the path, equal 500ms, the values of SRTT and RTTVAR it will be old for each time SCTP gets a new measurement of RTT. We can calculate a new RTT for various packet sizes (ignoring propagation delay and latencies in transmission equipment) using the following new RTT equation:

RTT.new = ((packet size * bits per byte) / link speed) * 2 (4)

Assume a packet with a 20-byte IP header, 32-byte SCTP header, and 38550 bytes of user data and a 1,544,000 bits/sec link between two nodes. Using the new RTT equation therefore the new RTT equal ((38602 * 8) / 1,544,000) * 2 = 400ms then SCTP calculates SRTT.new as equation:

$$SRTT.new = (1- \alpha) \times SRTT.old + \alpha \times RTT.new \quad (5)$$

Where α is the constant and their recommended value equal 0.25 then SCTP calculate SRTT.new equal (1-0.25)*1000 + 0.25*400 = 437.5 + 75 = 512.5ms Show in Figure (4) then SCTP calculate RTTVAR.new as equation:

$$RTTVAR.new = (1-\beta) \times RTTVAR.old + \beta \times (SRTT.old - RTT.new) \quad (6)$$

Where β is constant and their recommended value equal 0.125 then SCTP calculate RTTVAR.new equal (1-0.125)*500 + 0.125*(1000 – 400) = 750 +100 = 850m see Figure (5) the new RTO through equation:

$$RTO = SRTT.new + 4 \times RTTVAR.new \quad (7)$$

The SCTP chose new RTO depend on if the new RTO is greater than RTO. Min and less than RTO. Max illustrated in table (1). So the new RTO equal 850+4*512.5 = 2.9s, then the new RTO. Every time a transmission timeout occurs for an address, the RTO for this address will be doubled as equation:

$$RTO = RTO \times 2 \quad (8)$$

Until reach RTO. Max, then SCTP using the default PMR value of 5 it would take 2.9+5.8+11.6+23.2+46.4+60 = 149.9s, for switchover to occur. So really the current SCTP implementation behaves allowing more time for switchover causing poor performance of the network Illustrated in Figure (6).

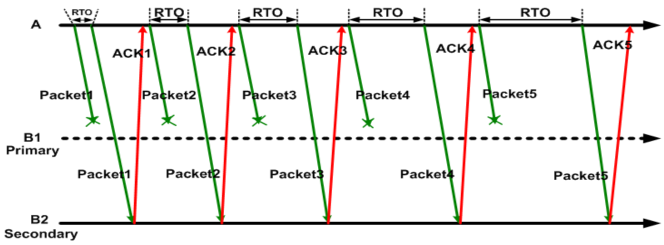

Fig 1: Primary path as INACTIVE

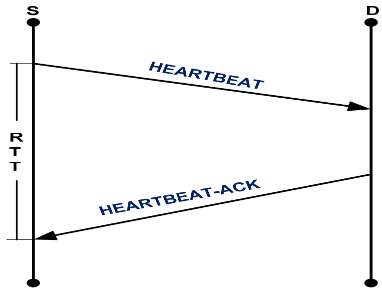

Fig 2: Secondary paths monitoring

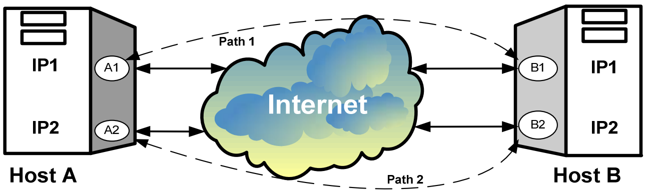

Fig 3: Multi-homed architecture

Table 1: The default values from for SCTP parameters

Parameter	Recommended Value
RTOinit	3000 ms
RTOmin	1000 ms
RTOmax	60000 ms
RTOmin	1000 ms
α	0.25
β	0.125
HB.interval	30000 ms
MPR	5 attempts

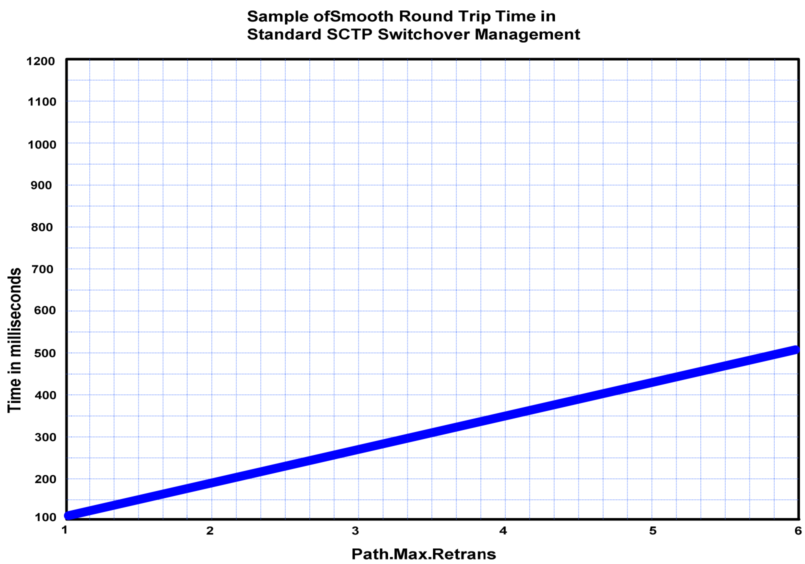

Fig 4: Current SCTP Switchover. "SRTT.new ".

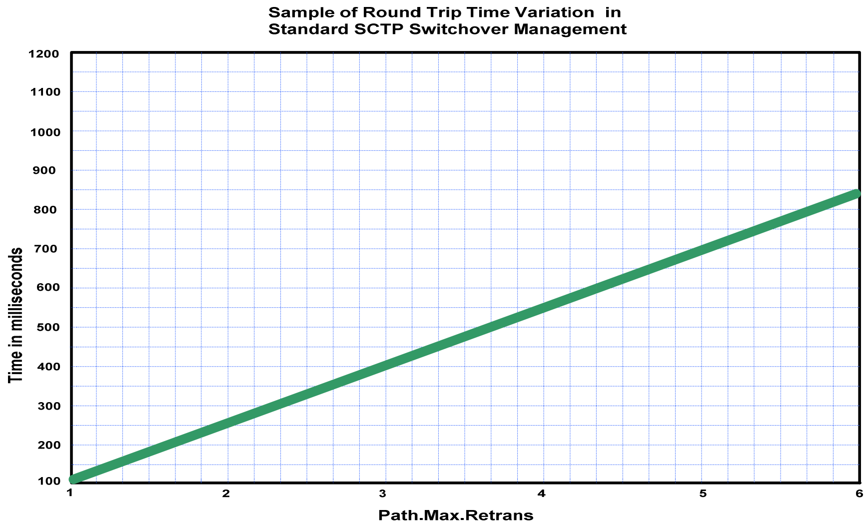

Fig 5: Current SCTP Switchover. "RTTVAR.new".

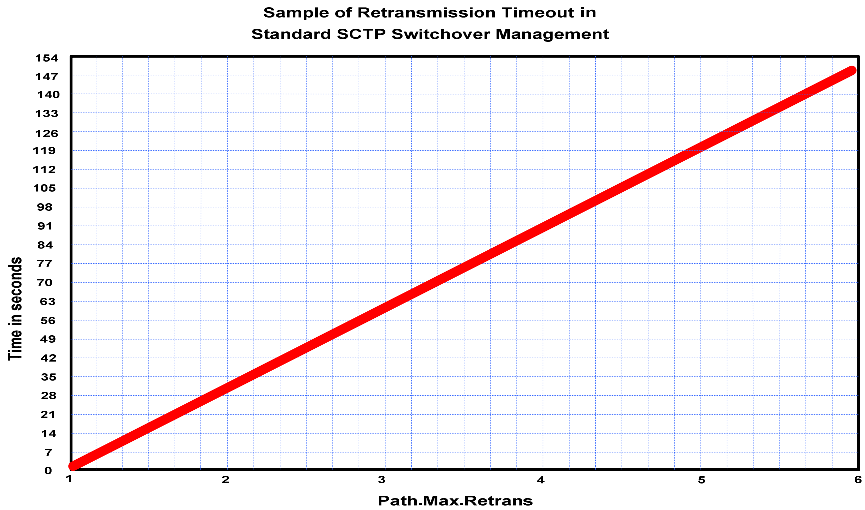

Fig 6: Current SCTP Switchover. "Switchover Occurrence ".

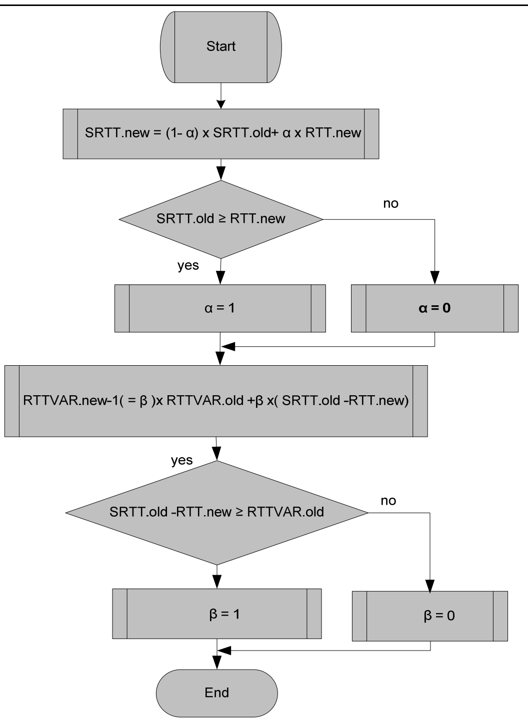

Fig 7: The flow for chart Enhancement of SCTP Switchover Management

The The pseudo code of Enhancement of SCTP Switchover Management:

Initially:
SRTT.new = (1- α) x SRTT.old+ α x RTT.new;
RTTVAR.new = (1-β) x RTTVAR.old+ β x (SRTT.old-RTT.new);

If (SRTT.old ≥ RTT.new) {
α = 1;
/ / SCTP gets a new calculation of SRTT
}

else if {
α = 0;
/ / SCTP gets a new calculation of SRTT
}

If (SRTT.old -RTT.new ≥ RTTVAR.old) {
β = 0;
/ / SCTP gets a new calculation of RTTVAR
}

else if {
β = 1;
/ / SCTP gets a new calculation of RTTVAR
}

Fig 8: The pseudo code Enhancement of SCTP Switchover Management

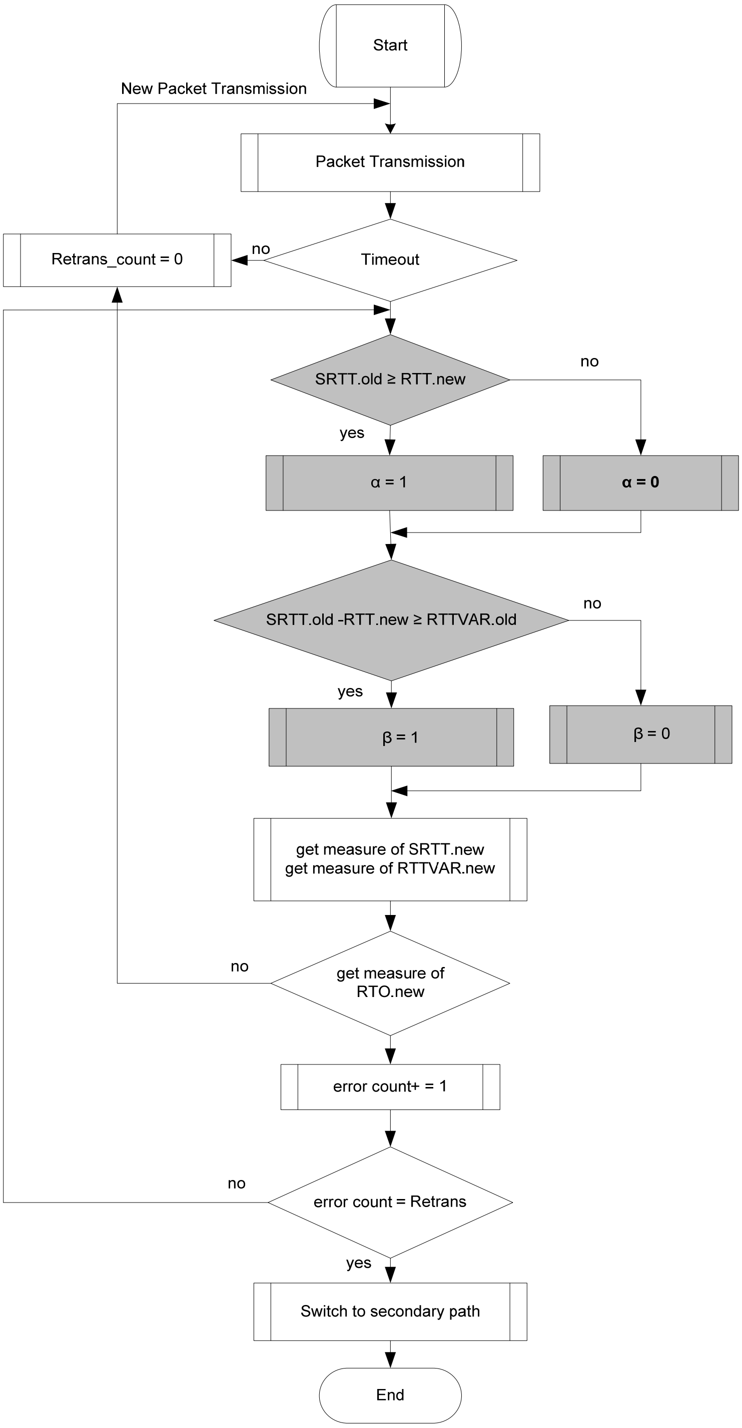

Fig 9: The flow for chart enhancement through standard mechanism

4. Enhancement of SCTP Switchover Management

In this paper, we propose an improvement of the standard path failure detection strategy used by SCTP by changing the criteria of switchover. The first alteration concern in RTO Calculation in SCTP, in particular that equation SRTT.new = (1- α) x SRTT.old+ α x RTT.new (5), we can obtain less time for SRTT.new when restricted that equation according to the following conditions, when the SCTP gets a new measurement of RTT, the new measurement of RTT must be compared with SRTT.old as: if SRTT.old ≥ RTT.new, then α = 1, else α = 0, and equation RTTVAR.new = (1-β) x RTTVAR.old+ β x (SRTT.old -RTT.new) (6), also the new calculate of RTTVAR, depends on take the differentiate between SRTT.old and RTT.new and compared with RTTVAR.old as: if SRTT.old -RTT.new ≥ RTTVAR.old, then β = 0, else β = 1 The new parameters of α, β were changed to variables values instead of constant values as it is was in SCTP switchover management. Figure (7) and figure (8) showed the new enhancement. The new enhancement makes switchover management more flexible under worst conditions due to more than one option for α and β values. in second alteration we reduced the number of unnecessary retransmissions during failover this means we make change in PMR to ideal number this because when the PMR is too small may cause false failovers due to temporary congestion in the network So we chose ideal number as: PMR – 1, the new number of PMR may make the reach-ability less than to RTO.Max, is Which improves to the existing SCTP failover mechanism so we can obtained small delay when the primary path failure occurs. The enhancement through standard mechanism illustrated figure [9].

5. Network Simulation Model

Simulations were carried using the OMNeT is an extensible, modular, component-based C++ simulation library and framework, primarily for building network simulators, includes wired and wireless communication networks, on-chip networks and queuing networks. [15]. The INET framework for the widely used OMNeT++ simulation environment supports discrete event simulation for IP-based networks [16]. Also has been extended to support external interfaces. These interfaces allow setting up hybrid scenarios where simulated nodes communicate with real external IP-based nodes [17]. The simulated network was set up in OMNeT++ to simulate the SCTP multi-homing environment each endpoint is defined as an SCTP-HOST and an association connection was set up between these two hosts. Duplex links were set up between the hosts in different endpoints. Each link has a bandwidth of 1Gbit/second and a propagation delay to 30 ms, the router queue is set to 20 packets. The path MTU is set to 3500 Bytes and one of these links were set to be the primary path. A heartbeat is sent out to all the nodes at 60-second intervals, using the default SCTP *RTO* parameters and parameter and PMR as default. The failover time in this case as the standard due to no changing in the parameters. The second case we will change the source code of the SCTP module on INET framework in order to make the module support the new enhancement. The RTO parameter is initially set to 1000 ms, which is also the minimum value for the parameter, while the RTO max parameter is restrict for parameter PMR set to 4. Finally we compared between two cases.

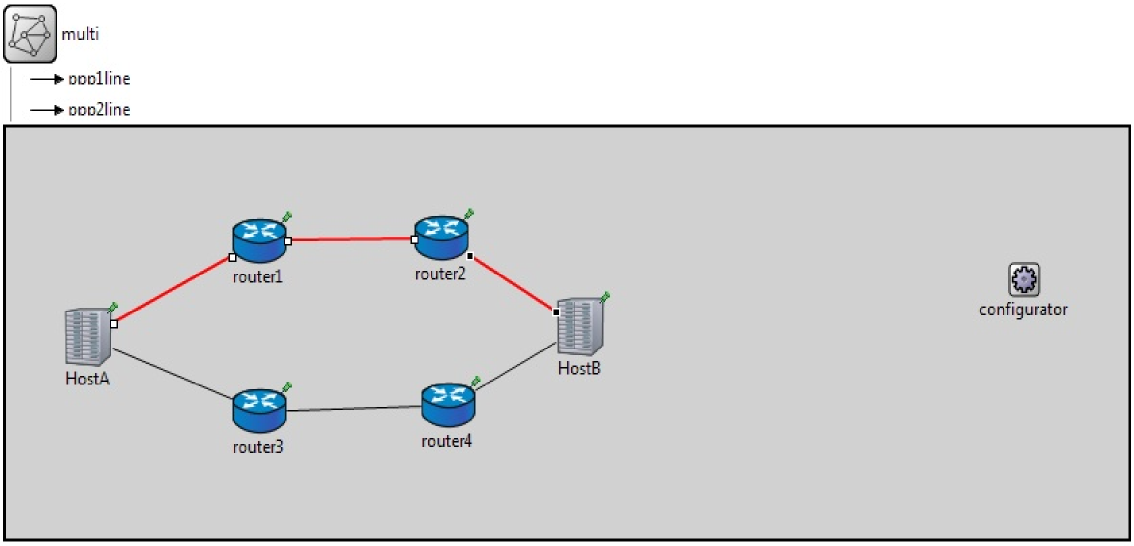

Fig 10: Network topology- testing congestion control through Modification Congestion Avoidance

6. Objectives

The authors would like to study the behavior of SCTP on switchover in a multi-homed environment in order to identify the limitations of current SCTP switchover management such as switchover delayed and Offer solutions to enhance switchover performance to allow SCTP to detect the path switchover earlier than the standard mechanism. Also one of the main objectives of the study to overcome the shortcoming related to current RTO Calculation, Considering that RTO selection has significant impact on switchover may cause degradation in network quality as path failure. We would also like to increase the performance in networks and avoiding service interruption. Our assumption is that the solution could be based on optimized values of SCTP parameters According to the considerations and conditions.

7. Expected results of the proposed "switchover enhancement"

The SCTP detects path failure through protocol parameters PMR and RTO. The first enhancement concern in RTO Calculation Behavior through α and β parameters. The current RTO Calculation, make α and β have a major impact on the RTO delay due to confirmation of α and β are 0.25 and .0125 respectively as the constant. So mathematically when we implemented the default values of α and β we found that the new SRTT and new RTTVAR have high delay are 512.5ms, and 850ms respectively these results lead to high delay in RTO equal 2.9s. Also other factor has a major impact on the failover performance is PMR; SCTP will mark the path as inactive. When the number of consecutive transmission timeouts on a path exceeds 5 attempts in this way more time is allocated before switchover occur amount up to 149.9s. So the expected results of the proposed we can get minimum delay in new SRTT due to $\alpha = 0$ or 1 depend on the previous case of SRTT.old with RTT.new, also we can get minimum delay in new RTTVAR due to $\beta = 1$ or 0 depend on previous case of RTTVAR.old with differential value of SRTT.old and RTT.new, Therefore the minimum delays of new SRTT and new RTTVAR can be achieved in the proposal method, really the minimum delays of new SRTT and new RTTVAR lead to minimum delay in RTO. Moreover we expected few of time for switchover this because the proposed use 4 as value of PMR, so we expected the best throughput in various path failure situations.

8. Conclusions

We proposed in this study a new enhancement to the current SCTP switchover management. The proposal is divided into two parts first part we change α and β parameters to variables values based on new measured of RTT, to estimate the RTO timer. Moreover the new enhancement has ability to make data traffic more flexible, in case of network congestion which is an excellent indicator of path performance. The second enhancement of current SCTP switchover management in the total time between the failures of the primary path and until the path is regarded useless known as PMR we setting this parameter to four instead of five, the choice of new setting of PMR require careful about Spurious timeout due to temporary congestion. However SCTP switchover management still needs more modifications to improve it's time delay for switchover. Therefore, we propose a further work is to design an algorithm to dynamically change the PMR value according to the measurement of path conditions. We also need to discover a method to choose the best path as the primary path.

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