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Service Oriented Real-Time Buffer Management for QoS on Adaptive Routers

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Abstract: To increase the quality of service in adaptive routers, researchers propose a Service Oriented Buffer Management algorithm. Researchers use different buffers for different service packets and the buffer controller maintains the buffer size according to flow of incoming packets. The buffer controller increases or decreases the buffer size at each input and output port by monitoring the rate of incoming packets and the size of buffer is fixed based on a flow threshold which is dynamic one. The value of flow threshold is computed using Dynamic Flow Approximation algorithm. The proposed system reduces the packet dropping rate and increases the throughput.

Key words: Adaptive routers, buffer management, packet dropping, QoS, dynamic

INTRODUCTION

The development of information technology induced people to use mobiles, internet and other tools. Peoples are using internet and web technologies to explore information's about any topic and uses voice chat and video conferencing, etc., whatever the service they are using all those information are transferred through the network layer. The network layer transfers the information in form of data flow which constitutes of data packets. The network layers consider all type of packets as flow packets.

The packets transmitted are destined to particular machine or instrument or device may pass through various networks. Each network has its own routers or switches which is the entry point to that particular network. A network may consist of few other intranets and which consists of number of computers or devices. So that, there may be huge number of data packets arriving at the router of that network, all those packets have to be queued in a temporary storage medium and forwarded towards destination. The temporary storage medium where the router or switch stores the packet is called buffers. The router may have any number of input and output ports where it can receive or send packets. For each port, it has a unique queue allocated.

Once the incoming rates of packets are increased then the router could not store the packets in buffer and that all will be discarded or dropped if the router is not adaptive one. The adaptive router can handle the incoming traffic with intelligent manner and reduce packet drop. How the router is handling the traffic is called buffer management.

The buffer is a linear storage medium, you can visualize that as a queue. The size of buffer is constant one initially but it can be increased or decreased at runtime according to algorithm used by the routers. Once there is not enough space in the buffer to store the incoming packets then they will be dropped. Queue Management algorithm is a particular calculation method to determine the order of sending data packets stored in the queue. So that, there must be an intelligent queue management in the router for better service.

There are various parameters which influences the quality of service of any network service or protocol. In the case, the packet drop ratio of router highly influences the quality of service. Once the drop ratio increases then it reduces the throughput and efficiency of the network and vice versa. For the better service and increased throughput there must be a high quality buffer management implemented on the adaptive router.

Back ground: In Dynamic Buffer Management algorithm proposed by Umamaheswari (2012), buffer slots can dynamically be re-allocated for various applications to improve performance. That reallocation is based on the number of hotspots using EBLA (Extended Buffer Loan Algorithm). Beckerm (2012) introduces Adaptive

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Backpressure, a novel scheme that improves the utilization of dynamically managed router input buffers by continuously adjusting the stiffness of the flow control feedback loop in response to observed traffic conditions. They modified the router's flow control mechanism little bit and heuristically limit the number of credits available to individual virtual channels based on estimated downstream congestion, aiming to minimize the amount of buffer space that is occupied unproductively.

A two-levels of adaptive buffer for virtual channel router in NoCs (Concatta, 2011) is proposed which use the two-level adaptive buffer for a virtual channel router where the buffers units and the virtual channels are dynamically allocated to increase router efficiency in a NoC, even under rather different communication loads. With the proposed architecture the buffer and virtual channels in the input channels of the routers can be adapted at run time.

Michelogiannakis *et al*. (2012) introduces Adaptive Backpressure, a novel scheme that improves the utilization of dynamically managed router input buffers by continuously adjusting the stiffness of the flow control feedback loop in response to observed traffic conditions. They have done this using a simple extension to the router's flow control mechanism; it limits the number of credits available to individual virtual channels based on estimated downstream congestion, aiming to minimize the amount of buffer space that is occupied unproductively. This leads to more efficient distribution of buffer space and improves isolation between multiple concurrently executing workloads with differing performance characteristics.

Nicopoulos *et al*. (2006) and Neishaburi and Zilic (2009) proposed adaptive buffer allocation with virtual channel. Nicopoulos *et al*. (2006) dynamically allocates virtual channels and buffer slots according to network traffic conditions. Each input channel manages its virtual channels according to the number of header flits that arrive in the input channel that is for each new packet that reaches the input channel, a new virtual channel is allocated.

Neishaburi and Zilic (2009) combined (Nicopoulos *et al*., 2006) with the loan process of buffer slots from other channels in the router to sustain performance in the presence of faults. The router architecture enables two-levels of adaptability both dynamic virtual channel allocation and sharing buffer slots among input channels. There is only one buffer for the entire router shared among all channels and a linked list controls the buffer status. The buffer stores flits and pointers for the next flit.

Shim *et al*. (2009) proposed static virtual channel allocation policy that statically allocates channels to flows at each link when oblivious routing is used and ensure deadlock freedom for arbitrary minimal routes when two or more virtual channels are available.

A dynamically-allocated virtual channel architecture with congestion awareness for on-chip routers (Lai *et al*., 2008) in low rate, this structure extends virtual channel depth for continual transfers to reduce packet latencies. In high rate, it dispenses many virtual channels and avoids congestion situations to improve the throughput. Researchers modify the VC controller and VC allocation modules while designing simple congestion avoidance logic. In preemptive virtual clock: a flexible, efficient and cost-effective QoS scheme for networks-on-chip (Grot *et al*., 2009), they discussed a new QoS scheme which enables efficient reclamation of idle network bandwidth without per-flow buffering at the routers and with minimal buffering at the source nodes. PVC averts priority inversion through preemption of lower-priority packets.

Krifa *et al*. (2008) proposed an optimum buffer management policy which uses the theory of encounter-based message dissemination which is based on global knowledge about the network. They introduce a Distributed algorithm that uses statistical learning to approximate the global knowledge required by the Optimal algorithm in practice. Hay and Giaccone (2009) provide a general framework for devising optimal routing algorithms to such networks under different objective functions and various real-life constraints. The key insight is to model the DTN as an equivalent time-independent graph; this allows the usage of well-known algorithms and techniques to achieve optimal results. These algorithms can be also used as approximation for less certain settings or as benchmarks to evaluate other routing algorithms. In addition, researchers extended the framework to deal with long-lived DTNs in which contacts are periodic.

MATERIALS AND METHODS

The proposed method uses service oriented buffers for each input and output queues. There may be various service packets arriving at various channels of the router. The voice packet, video packets and data packets are arriving at single channel with varying priority. For example the voice and video conferencing packets are more prior other than normal textual contents.

Figure 1 shows that there are three different queues namely voice, video and text data queues, each will store packets of that particular type. There are various components present in the proposed architecture, each has particular responsibility and they are buffer controller, dynamic threshold manager and scheduler. The buffer in the methodology is a shared medium, i.e., any

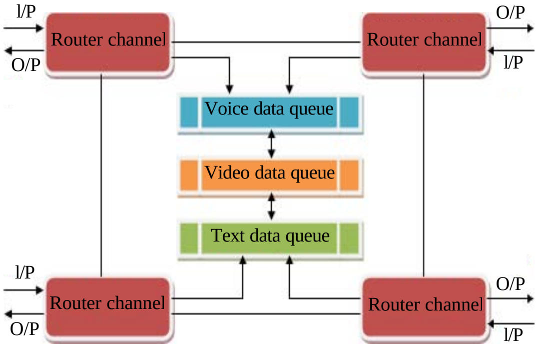

Fig. 1: The buffer architecture of the proposed method

type of packet can be placed in any type of queue under the circumstance that there are huge space available. The size of buffer is controlled by the value generated by DNC (Dynamic Threshold Controller). The packet handler is responsible for placing the packets in respective queues in both input and output port of the router (Fig. 2).

Dynamic threshold controller: The threshold value is the key which controls the size of the buffer used in adaptive router. It generates three different threshold values, i.e., for each buffer, it generates different threshold. The threshold value computed is based on the flow and the size of buffer is computed using this threshold value. The Dynamic threshold Controller (DNC) always monitors the flow at each port of the router and each kind of packets. Whenever, the flow varies in notifying rate it computes a new threshold value for that particular queue for that port. The buffer depth or size is dynamic in nature and it is assigned in design time. The optimum buffer size in the protocol is 3 and will be changing dynamically by computing flow approximation.

Dynamic flow approximation algorithm:

```
Step 1: start
Step 2: for each port $P_i$ of router R
            Initialize Buffer Size $BS_i$ to a constant A for each Buffer
            A-a constant selected by a router initially
            End
Step 3: for each port $P_i$ of router R
          Initialize threshold $Th_i$ to a constant
          $Th_i$ a constant selected by a router initially
          End
Step 4: for each port $P_i$ of router R
          Compute flow $F_i = NP/T_i$
          NP-number of packets arrived
          $T_i$- time frame in seconds
          If $F_i > (BS_i \times (m/100))$
             $BS_i$-Buffer Size of particular queue
              $BS_i = (F_i \times m \times 100)$
m-is a constant used by router. The value of m is between 1.1-1.5
      End
 End
Step 5: Stop
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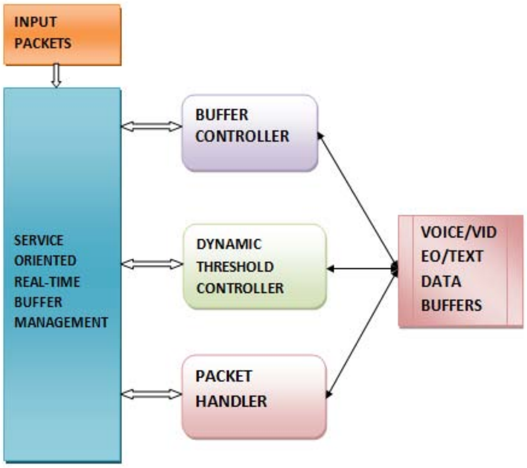

Fig. 2: Proposed system architecture

Buffer controller: Buffer controller assigns the place for the incoming packets and controls the size of the buffer. Whenever, a new packet comes into the port, it gets a request from the packet handler and this will assign a location for the new packet. The place this assigns is depending on the free space available in the respective queue. For example, if there is a new voice data packet but there is not enough space in the voice queue then it will look for the space in video data queue and assigns it to that queue. The same will be done for all other kind of packets also:

Algorithm:

```
Step 1: start
Step 2: receive request from packet handler
Step 3: find out nature of packet $P_i$
Step 4: check space availability in respective queue $Q_i$
Step 5: if $BS_i < NP$ then
          Assign $P_i$ to Queue $Q_i$
          Increment NP by one $NP = NP+1$
          Else
          Check space availability in other queues $Q_x$
          if $BSx < NP$ then
                Assign $P_i$ to Queue Qx
                Increment NP by one $NP = NP+1$
                End
          End
Step 6: Stop
```

Packet handler: The packet handler waits for the incoming packet and requests the buffer controller to assign space for the new packet. Once the buffer controller assigns a space for the new packet it stores the packet in particular queue assigned and wait for the next packet. On the other end, the packet scheduler which is default with the router will schedule the packets in output queue according to the algorithm implemented with the router.

RESULTS AND DISCUSSION

The service oriented real time buffer management produces good results with increased efficiency. It reduces the overall packet drop and it reduces the overall power consumption and increases the life time. The proposed method increases the throughput of the router. The dynamic and sharing nature of the buffer uses the space completely and by placing the packets in other queues reduces the packet drop in the router.

Figure 3 shows the packet drop ratio of the proposed method. Researchers handled the flow rate efficiently to reduce the packet drop even in the worst case. If the flow rate increases suddenly the proposed system manages the buffer with other buffer space exists or buffer reallocation intelligently (Fig. 4).

The power consumption to allocate the buffers and initialization and handling process will take more in other systems normally. In the case, researchers have reduced the power consumption in huge scale by reducing the probability of buffer reallocation. In the methodology, the invocation probability of buffer reallocation process is very less because the methodology uses the space exist in other buffers for better buffer management, the buffer reallocation process will be called only at the time when there will be no space exist at all the buffers. This reduces the power consumption of overall system and increases the performance.

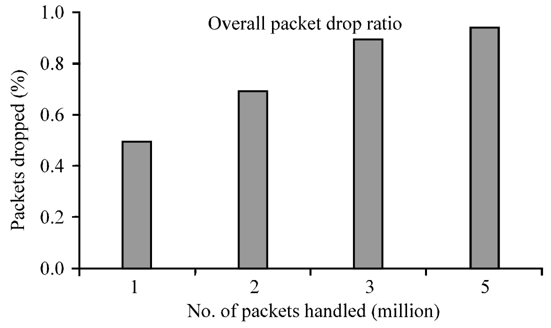

Fig. 3: The packet drop ratio

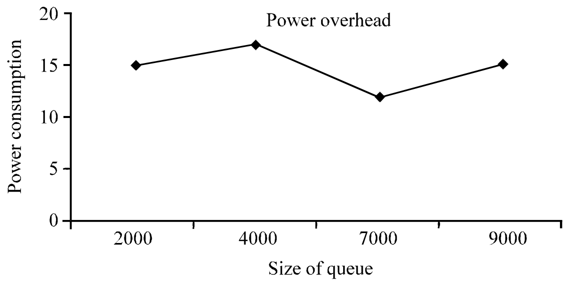

Fig. 4: The ratio of power consumption due to the increase of buffer size

Figure 5 shows the throughput ratio achieved by the algorithm and compared with other methods. It is clearly shows that the researchers have achieved higher throughput better than other methods. It shows that the number of packets arrived and number of packets re-routed towards the destination.

The power results were obtained using the maximum frequency of each architecture. As previously commented for the same average latency, the performance could be reached with buffer depth 4 in adaptive router and 9 in homogenous routers to the four mentioned traffic patterns.

Figure 6 shows the results of latency for the proposed, adaptive and homogeneous router. The homogenous router presents all channels with a fixed buffer size of 4. The adaptive router uses a buffer depth allocator with a equal to 0.125 and in this case, the buffer depth is monitored and changed at run time when 128 packets pass through a router, each channel calculates a new buffer depth based in the traffic of the channel and the buffer depth increase up to 9 but for our protocol initial buffer depth is 3 and reaches up to 6 according to flow approximation.

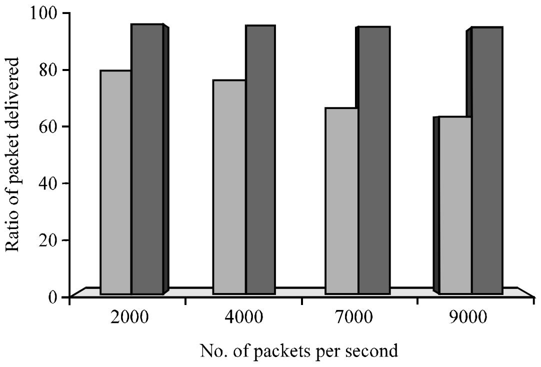

Fig. 5: The throughput ratio of different algorithms

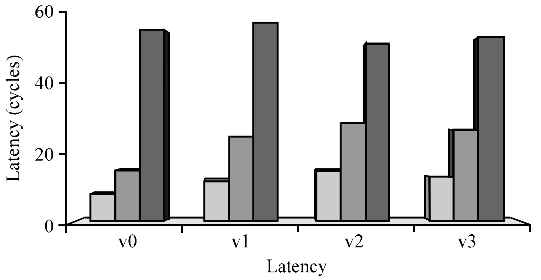

Fig. 6: Latency of proposed and adaptive homogenous routers

The service oriented real time buffer management reduces the power consumption 36% average and it uses smaller buffer depths to provide the same performance. For the same average latency, the frequency of proposed method is higher than the adaptive router and also the area of consumption is also less.

CONCLUSION

The proposed system uses dynamically varying threshold which is controlled by threshold controller which controls the size of buffer at each port. This phenomenon makes the router to handle packets without packet dropping. Also, various kind of packets uses various buffers because the incoming ratio of voice and video packets is higher than ordinary textual data packets. Using same buffer for both packets will reduce the throughput due to the size of buffer. To overcome this, researchers have used dynamic threshold to control the size of buffer and sharing methodology of buffers to increase the throughput and reduce the packet drop ratio.

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