ATM Switch: Impact Of Heuristic Approach To Static Bandwidth Allocation

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Abstract

In this paper, the performance evaluation of two Asynchronous Transfer Mode (ATM) scheduler strategies, static bandwidth allocation with and without heuristic approach are presented. Several experiments were carried out by using the ON-OFF distribution source model based on the ATM Various Bit Rate (VBR) service category. The strategy with the heuristic approach improves the buffer cell loss ratio (CLR) performance significantly. Several numerical results are presented to show the effects of the heuristic approach to bandwidth allocation.

Keywords: ATM, Bandwidth Allocation, VBR, Heuristic Approach.

1. Introduction

Real time video, such as video conferencing and video-on-demand, is expected to be one of the major services supported by the ATM-based ISDN [1]. The main service used for transmitting video streams is variable bit rate (VBR) transmission. Cell loss ratio (CLR) and cell average delay are the evaluation parameters in ATM QoS requirement that assess a bandwidth strategy’s performance. Although network performances in terms of cell loss ratio and average cell delay from [3] are better for bandwidth allocation strategy called Bandwidth Allocated Proportional to Expected Queue Length with Threshold Value, this is true only when the buffer space exceed 500 cells. For real-time applications, generally these types of traffic cells are not queued in the buffer, as this would introduce cell delay. However, if traffic shaping is required, cells may need to be buffered and large buffer space is better to avoid due to their stringent delay requirement [4].

Bandwidth allocation is defined as allocating bandwidth to all the connections at contention point, which usually is called a switching unit. In order to increase network throughput, bandwidth needs to be managed and allocated fairly and this is the responsibility of the ATM switch. Two bandwidth allocation strategies have been developed in this research. They are static bandwidth allocation from [2] and an enhancement strategy with heuristic approach.
Only the results for VBR Video/Data buffer and VBR Video traffic are given in the discussions. The comparison is done to evaluate the performances of static bandwidth allocation, which adopts the heuristic approach and the one without heuristic approach.

2. System Description and Model Development

The simulation model utilized from this research is shown in Fig 1. Two bandwidth allocation strategies have been developed; they are Static Bandwidth Allocation and Static Bandwidth Allocation with heuristic approach. The first strategy is taken from [2], while the second strategy is the modification of previous strategies implemented in [2] with the purpose to improve the network performances.

![Simulation Model](image)

To investigate the proposed algorithm and its efficiency, a single virtual path with 622 Mbps is investigated. Typically there could be diverse services using this path and so a number of source models are needed. The ON-OFF source model is used to represent some of the VBR services in the ATM networks, which are VBR Video, Connection Oriented Data, VBR Video/Data and Connectionless Data. Source model is where the ATM cells are generated. The cell stream from a number of sources is then input to the ATM switch buffers model. The buffer smooths the arrival of cells to the ATM networks and so takes care of cell scale congestion. This buffer is the limited resource, which is critical to the performances of the simulation model. DTS model is where several bandwidth allocation strategies operate and where bandwidth is calculated and allocated to the buffers. A total number of two million time slots are executed for the entire duration of the simulation.

Static Bandwidth Allocation is a strategy that guarantees bandwidth to high priority traffic classes. This allocation does not change with time. Thus, it provides no congestion control. In this study, VBR Video/Data buffer is allocated 300 Mbps, Connectionless Data buffer is allocated 20 Mbps and VBR Video buffer is allocated 300 Mbps. This pattern of bandwidth allocation is fixed for every cycle length. Thus, this strategy does not have bandwidth allocation recalculation mechanism. The amount of bandwidth allocated to buffer is calculated as below:

\[
\text{VBR Video/Data Bandwidth Allocated} = \frac{300 \text{Mbps} \times 200 \text{ Slots.}}{622 \text{Mbps}}
\]

\[
\text{Connectionless Data Bandwidth Allocated} = \frac{20 \text{Mbps} \times 200 \text{ Slots.}}{622 \text{Mbps}}
\]

\[
\text{VBR Video Bandwidth Allocated} = \frac{300 \text{Mbps} \times 200 \text{ Slots.}}{622 \text{Mbps}}
\]

The Static Bandwidth Allocation with Heuristic approach is an enhancement of the previous strategy [3] and only implemented for the highest priority traffic type. A new buffer called Dual Leak Bucket (DLB) is introduced. The DLB consists of two buffers, primary and secondary. When the primary queue length exceeds the capacity of the buffer, the following cells will be inserted into the secondary buffer based on FIFO
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discipline. The cells in secondary buffer will be transferred to the primary queue once there is an empty slot. To minimize the system overhead, cells in secondary buffer will be copied into primary buffer based on three criteria. The first criterion is at the inter cycle period. In other words, it is defined as the time when a cycle has finished and prior to entering into the next cycle. Second, when the secondary buffer is full. Third, there is no cell to be transmitted in the primary buffer. The heuristic approach algorithm is elaborated in Fig 2:

```c
/*decide which buffer to insert the cell*/
Choose_Buffer()

//check buffer size
If (queue[index] < buffer_size[index]){
    Copy(); // copy cells to primary
//switch back to primary buffer if no cell in
//secondary buffer
    If(queue[0] < buffer_size[0] & queue[4] = = 0)
        Index = 0 // 4 denotes secondary buffer
    else
        Index = 4
}

/*copy cells to the primary buffer */
Copy(){
//if buffer size > queue length)
    If((buffer size - queue length) > secondary queue length)
        Copy all cells from secondary queue
    else
        Copy cells based on the empty space in primary buffer
} else /* do nothing */
}
```

Fig 2: Heuristic Approach In Bandwidth Allocation

3. Results and Discussion

In this experiment, the buffer sizes for VBR Video/Data and VBR Video are varied from 200 cells to 1200 cells, whereas Connection Oriented Data infinite buffer size and Connectionless Data remains 100 cells. The output parameters are cell loss ratio and average cell delay. The network performance has been plotted out illustrating the output parameters versus buffer size. The simulation was carried out on a Pentium III 1000 MHz system using Visual C++ 6.0.

The cell loss ratio performances in VBR Video/Data buffer for these two types of static bandwidth allocation strategies are depicted in Fig 3. It is obvious that the static bandwidth allocation strategy with heuristic approach has a better cell loss ratio performance than the traditional static bandwidth allocation strategy overall. There are differences of cell loss ratio between the static bandwidth allocation with heuristic and without heuristic approach when the buffer’s size is small, 0.0120753 and 0.0051269 for the VBR Video/Data traffic when the buffer is set to 200 and 400 respectively. The traditional static bandwidth allocators produce higher cell loss ratio, which is equal to 0.0120753 and almost double of the cell loss ratio as compared to the bandwidth allocator with heuristic approach when the buffer size is 200 which is shown in Fig 3. However, the differences between these two strategies become smaller when the buffer size is increased.

Although the cell loss ratio for VBR Video Buffer is always within the range of 0.018 till 0.025 for both strategies, the strategy with heuristic approach performs better than the traditional strategy. From the Fig 4, it can be concluded that the static bandwidth allocation produces the more consistent cell loss ratio.

The comparison of the average cell delay performance in VBR Video/Data buffer for both strategies is illustrated in Fig
It is observed that the average cell delay for strategy with heuristic approach is always higher. This is caused by the cells of the strategy with heuristic approach that require to queue and wait before they can be transmitted when the scheduler is congested. As shown in Fig 5, when the buffer size is 200, the cell delay of the strategy with heuristic approach is 0.000198, which is 0.000085 seconds longer than the strategy without heuristic. However, the delay for both strategies becomes smaller as the buffer size increases.

Average cell delay for the VBR Video Buffer performances in the static bandwidth allocation with heuristic approach and traditional static bandwidth strategy which are shown in Fig 6 are similar to the average cell delay for VBR Video/Data buffer. As mentioned earlier, this is due to the large number of VBR sources in the network.

![VBR Video/Data Buffer's Cell Loss Ratio](image1)

**Fig 3: VBR Video/Data Buffer’s Cell Loss Ratio**

![VBR Video Buffer’s Cell Loss Ratio](image2)

**Fig 4: VBR Video Buffer’s Cell Loss Ratio**
Fig 5: VBR Video/Data Buffer’s Average Cell Delay

Fig 6: VBR Video Buffer’s Average Cell Delay
4. Summary

The analysis of all graphs proves that a total amount of 400 buffer cells and above are suitable for cell loss ratio, whereas 800 buffer cells and above will produce a more stable average cell delay. Judging from the performances evaluation results, it can be concluded that the static bandwidth allocation with heuristic approach is more efficient than the traditional static bandwidth allocation strategy. Finally, it can be observed that network performances are highly dependent on the bandwidth allocation strategies.

References


