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ADAPTIVE RESOURCE ALLOCATION ALGORITHM FOR WIRELESS MULTIMEDIA SERVICES

G.Sivaradje and P.Dananjayan
Department of Electronics and Communication Engineering
Pondicherry Engineering College, Pondicherry, INDIA – 605 014
Email: shivaradje@ieee.org

ABSTRACT

In this paper, an adaptive resource allocation scheme that provides high wireless network utilization is proposed by dynamically reserving only those resources that are needed. The algorithm exploits the structure of MPEG video stream and allocates bandwidth on a scene basis, wherein the mobile users change their bandwidth requirement only for scene boundaries. This will result in a high bandwidth gain, which will improve the overall network performance. The proposed scheme is dynamic and also facilitates bandwidth management. It automatically adjusts the amount of reserved resources, while the required QoS are also guaranteed. The algorithm is simulated and evaluated using model encoded video data.

1. INTRODUCTION

The wireless communication has entered into its fourth generation (4G), the wireless broadband-integrated service digital network (B-ISDN) access. The capabilities of wireless networks are improving at a steady pace. In a wireless network, bandwidth is perhaps the most precious and limited resource of the whole communication system. Therefore, it is very important to use this resource in the most efficient way.

A prevalent underlying theme is the techniques used to control the handoff of users as they move between shrinking cells, at greater speeds and with stricter requirements on both the Quality of Service (QoS) delivered to the user and the operational costs associated with the connection. The wireless network must provide the requested level of service even if the user moves to an adjacent cell. A handoff could fail due to insufficient bandwidth in the new cell, and in such case, the connection is dropped. The call dropping probability (CDP) is a very important connection level QoS parameter. In addition, users already in the system should have higher priority over new users. This is because, from the user point of view, receiving a busy signal is more bearable than having a forced termination. All these considerations including Variable Bit Rate (VBR) traffic make bandwidth management in wireless network a very complex task.

2. BANDWIDTH ALLOCATION

To define bandwidth allocation scheme, which provides an adequate QoS for VBR applications and minimizes the bandwidth wastage, the characteristics of the traffic generated by VBR must be investigated.

Resource allocation could be performed according to the peak cell rate of the VBR sources. Such an approach leads to under utilization of wireless resources due to the bursty nature of the sources. The wireless bandwidth will be wasted and the wireless network will experience high call blocking and forced termination probabilities. Resource allocation could be performed based on the source's mean cell rates. In such approach, video sources will suffer from unacceptable losses and delays. Using this proposed dynamic bandwidth allocation algorithm can reduce these problems.

2.1 Threshold parameter

The scene duration is computed differently as shown in Fig.1. Let {GOP (j): j= 1, 2...} be the GOP sequence in a MPEG stream. This sequence consists of the sizes of consecutive GOPs in a given MPEG trace. Suppose that the current scene is the i^{th} scene that started with the k^{th} GOP. The $(n+k+1)^{th}$ GOP of the sequence indicates the start of $(i+1)^{th}$ scene if

$$|\mathrm{GOP}(n+k+1)-\mathrm{GOP}(k)| \geq T*\mathrm{GOP}(k) \quad (1)$$

where T is a threshold ($T \geq 0$). $n+1$ in this case represents the length of the i^{th} scene. Notice that the number of consecutive GOPs in that scene measures the length of the scene. With this definition of scene, all the GOP sizes within a scene i are located between First_GOP (i) * (1 – T) and First_GOP (i) * (1 + T), where First_GOP (i) is the size of first GOP in scene i.

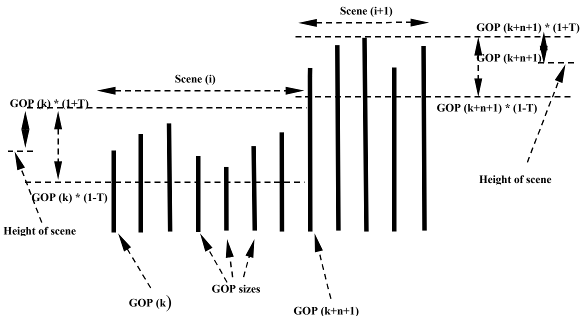

Fig. 1 Scene Duration

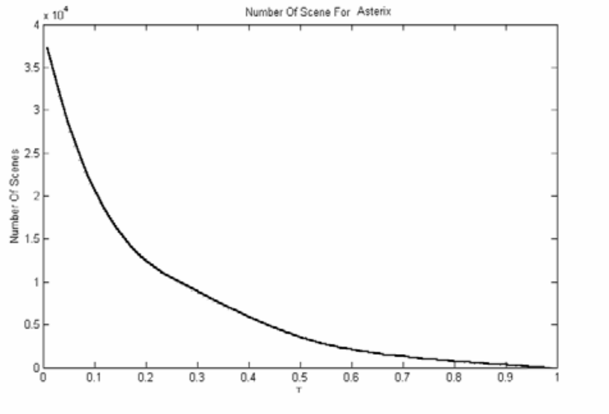

Fig. 2 Number of scene for Asterix IBP trace

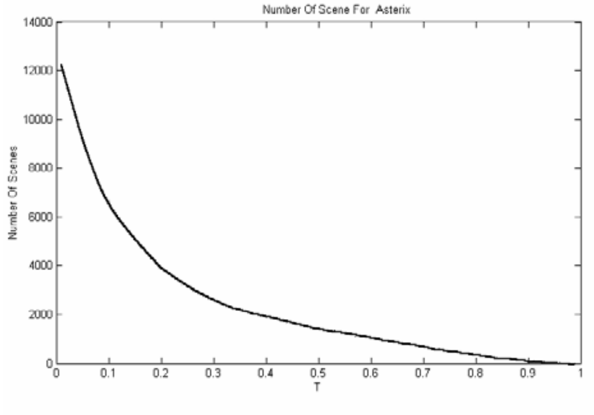

Fig. 3 Number of scene for Asterix IP trace

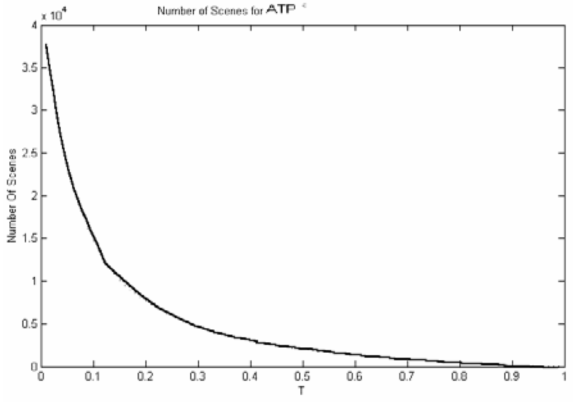

Fig. 4 Number of scene for ATP IBP trace

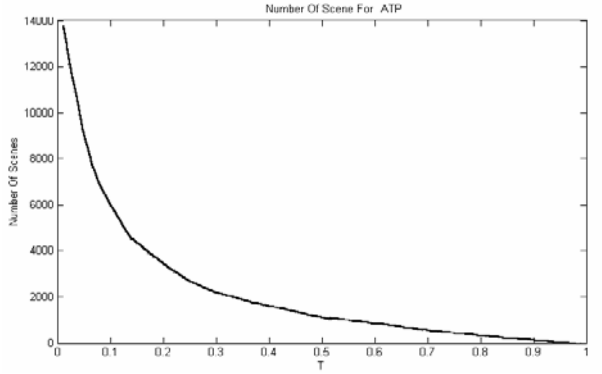

Fig. 5 Number of scene for ATP IP trace

Clearly, the value of threshold parameter, T influences the shape of the scene length distribution. It determines the amount of correlation between successive scenes; the larger these value, the less correlated the scenes. The value of the T parameter influences also the number of scenes in a particular trace. Larger values of T produce smaller number of scenes as indicated from the Fig.2 to Fig.5 for different traces.

2.2 Influence of the *t* parameter

Our ultimate goal is allocate bandwidth dynamically on a per scene basis. For this purpose, it is important to characterize the elements of the scene. As this characterization depends on the *T* parameter, the study of the influence of the *T* parameter on the characterization is of great importance.

Let us recall that the *T* is the parameter that determines the height of the scenes. The value of *T* influences the shape of the scene length distribution. It determines the amount of correlation between successive scenes; the larger these value, the less correlated the scenes. The value of the *T* parameter influences also the number of scenes in a particular trace. Larger values of *T* produce smaller number of scenes.

Our goal is the characterization of the GOPs within a scene. The idea is to see if from the study of the MPEG traces, the mean and the variance of the GOPs within a scene is approximated or even calculated by knowing only the size of the first GOP of that scene. This will allow the characterization of the entire scene based on the size of the first GOP, which can be used to allocate bandwidth for the scene.

The value GOP (n) – GOP*(n) for every n is calculated as the difference between each GOP size and the mean size of the scene to which the GOP belongs. Let us recall that

$$GOPD(n) = GOP(n) - GOP^*(n) \text{ for all } n \qquad (2)$$

GOPD depends on the value of *T* parameter. For values of *T* below 200%, the shape of the histogram of {GOPD} suggests the use of normal fit. Values above 200% are not important for us. Since the entire MPEG stream will not have any scenes, and hence will not profit from the scene-based bandwidth allocation (SBA). Indeed, for *T* above 200%, the majority of studied streams are composed of a single scene.

The normal distribution f_{GOPD} is fully characterized by the mean μ_{GOPD} and the variance $\{\sigma_{GOPD}\}^2$ of the empirical sequence {GOPD}. Since GOPD (n) depends on the *T* parameter, the values μ_{GOPD} and σ_{GOPD} depend also on the *T* parameter. As said before, since GOPD (n) represents the mean GOP size of the scene to which GOP (n) belongs, μ_{GOPD} is equal to zero for all *T*. σ_{GOPD} is computed for different values of *T* {from *T* = 0% to 200% step 1%}.

3. ALLOCATION ALGORITHM

Our bandwidth allocation algorithm is based on the idea that the GOP sizes within a scene are close. Allocation of bandwidth requirement for each scene depending on the GOP sizes mean and variance within the scene is proposed. The proposed approach requires less capacity than the traditional scheme while guarantying the same and even better user QoS requirements.

Based on our definition of a scene, Eqn. (1), the sizes of the GOPs within a scene could be considered close. The GOP size fluctuates around an average value that represents the level of activity of the scene. The GOP sizes within a scene can be modeled by a normal distribution with mean μ and variance σ^2 (N (μ, σ)). μ Varies from one scene to another while σ is invariant to scene changes and depends only on the *T* parameter.

First_GOP (i) + σ_{GOP}, $T * \sigma_{GOP}$ can be used as an approximation for (μ, σ) for the scene i to compute the required capacity and as confirmed by simulation the predetermined Cell Loss Ratio (CLR) is still respected. The following algorithm (SBA) can be used to allocate bandwidth dynamically for each scene and can be used either in a mobile terminal or in the mobile station depending on the transfer direction.

The algorithm begins by allocating the required capacity (for pre-specified CLR) for the first scene depending on the scene's first GOP size. Then, it checks the following GOP sizes to detect the beginning of the new scene using Eqn. (1). Moreover, depending on the first GOP of the new scene it allocates a different amount of bandwidth. This capacity will remain constant until the beginning of another scene, and can be, for e.g., used by neighboring base stations to reserve bandwidth for the mobile terminal in case it immigrates to another cell.

4. ALGORITHM

The code for the algorithm implemented is as follows:

```
Initialization:
        Set the value of T.
        Set the value of CLR.
        Find the Stream variance
                Set N = 1
                First_GOP = GOP (N)
                First_GOP size
                        $\mu$ = First_GOP + $\sigma_{GOP}$
                        $\sigma = T * \sigma_{GOP}$
Allocate the capacity.
        Send the GOP (N)
                N = N + 1
Loop:
        While not end of stream do
        S = GOP (N)       // the n^th GOP size
        If | S – First_GOP | > T * First_GOP
Then
        // Another scene starts
        First_GOP = S
                $\mu$ = First_GOP + $\sigma_{GOP}$
Allocate the capacity
        End if
                Send the GOP (N)
                        N = N + 1
        End While
```

5. SIMULATION AND RESULTS

In simulation results shows how the dynamic bandwidth allocation surpasses the traditional scheme. In this work, the performance of the algorithm in terms of the used capacity with the ones calculated supposing a Gamma distribution MPEG source and a lognormal distribution MPEG source are compared. Only the results obtained supposing a gamma distribution MPEG source are presented. Similar results were found while using a log normal distribution as a model for the MPEG sources.

The capacity gain is calculated as follows:

$$Gain = 100 * \left(1 - \frac{Dynamic\_capacity}{Static\_capacity} \right)$$

where, Dynamic Capacity is the total capacity allocated by our dynamic algorithm and Static Capacity is the total capacity allocated by the static approach. To clarify the meaning of the Gain variable, let us take the following example: assume that bandwidth is allocated to an MPEG stream for 30 minutes. Knowing that the considered MPEG source can be modeled by a Gamma distribution source the static scheme allocates the capacity C for this film (to have a certain CLR). Suppose also that our dynamic allocation algorithm has identified three scenes that last five, 15 and 10 minutes respectively and allocates the capacity C1, C2 and C3 for the three scenes, respectively. The following capacities are:

Static Capacity = 30 * C
Dynamic Capacity = 5 * C1 + 15 * C2 + 10 * C3

In addition, the Gain represents the percentage of the Static Capacity that the dynamic approach did not use. If for example, Gain is equal to 70% then if the static approach uses a particular amount B of bandwidth to have a certain CLR; our algorithm uses only 30 % of B to have the same CLR. The capacity gain can be calculated for different values of *T* and different values of CLR and for different MPEG traces.

Although already available traces are used, our algorithm remains valid for online traces. This is the case because, any information already available on the used traces are not used. The variance that is considered as a known value is only used. However, it is found that the Gain is not always positive. The Gain is negative for higher values of *T* and considerably higher values of CLR, which means the dynamic scheme requires more bandwidth than the static one. For smaller values of *T* (approximately equal to 10%) and smaller values of CLR the gain is positive, which means the dynamic scheme requires less bandwidth than the static one. The comparison scheme between two schemes has been shown below.

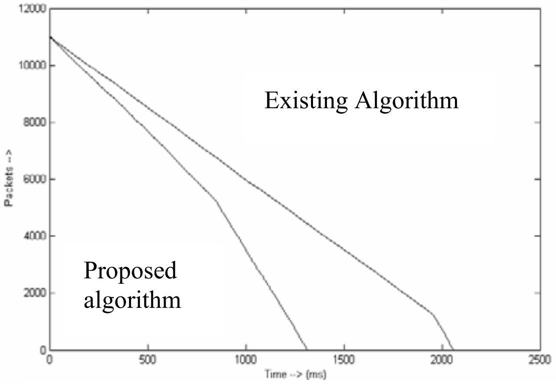

Fig. 6 shows the comparison between our proposed algorithm and the existing algorithm providing an increase in the data transmission rate

6. COMPARISON RESULTS

Static channel capacity		2900KBps
Dynamic channel capacity		
	IBP traces	1990KBps
	IP traces	2230KBps
Gain		
	IBP traces	31.38%
	IP traces	43.44%
Increase in gain		12.06%

7. CONCLUSION

The dynamic bandwidth allocation algorithm proposed in this paper can significantly improve bandwidth utilization in wireless networks. It automatically adjusts the amount-reserved resources, while guarantying the required QOS. The proposed scheme is dynamic and it requires some communication between the mobile terminal and the base station. However, the amount of extra information generated by the mechanism is acceptable in comparison to the capacity gain obtained. It is also worth noting that the proposed scheme can be applied to any type of video coding as long as the scene is defined in the same notion.

REFERENCE

1. G.Sivaradje, P.Danajayan, "Dynamic Resource Allocation for Next Generation Wireless Multimedia Services" Proceedings of ICCS2002 International Conference on Communication Systems, Singapore, Pp 752- 754, November 2002.
2. S.Shiokawa, S.Tasaka, "Bandwidth allocation considering priorities among multimedia components in mobile networks", IEICE Trans. Comm., Vol.E84-B, No.5, May 2001.
3. K.L.Eddie Law, Nortel, "The bandwidth guaranteed prioritized queuing and its implementations", IEEE INFOCOM '97 , pp.636-646 , 1997.
4. D.A. Levine, I.F. Akyildiz, M. Naghshineh, The shadow cluster concept for the resource allocation and call admission in ATM – based wireless networks, IEEE/ACM Transaction on Networking 5(1) (1997).
5. N.Wakamiya, M. Murata, H. Miyahara, "On video coding algorithm with application level QoS guarantees", Computer Communications 23 (2000) 1459-1469.
6. M. Progler, C. Evci, M. Umehira, Air interface access schemes for broadband mobile systems, IEEE Communications Magazine, September, 1999.
7. http://www.etsi.org/smg/utrs/utra.htm
8. Y.Iraqi, R. Boutaba, A novel distributed call admission control for wireless mobile multimedia networks. Third ACM International Workshop on Wireless Mobile Multimedia (WoWMoM-2000), Boston, 11 August 2000.