International Journal of Advanced Science and Technology
Volume 7, June, 2009

A Quality of Service Strategy to Select Coding Schemes in General Packet Radio Service System

P. Calduwel Newton[1], DR. L. Arockiam[2], and Tai-hoon Kim[3]

[1]Lecturer, Bishop Heber College (Autonomous), Tiruchirappalli - 620 017
[2]Lecturer (SG), St.Joseph's College (Autonomous), Tiruchirappalli- 620 002
Tamil Nadu, India
[3]Department of Multimedia, Hannam University, Korea
calduwel@yahoo.com

Abstract

The internet is used for wide variety of applications in wired, fixed wireless and mobile wireless environment. The requirements of one application / environment will vary from another application / environment. The challenge for the service provider is Quality of Service (QoS). The wired network has less complexity compared to fixed wireless network with respect to QoS. Certainly, the challenge for the service provider is further increased in mobile wireless network. This paper proposes a QoS strategy to select an appropriate coding scheme for any application based on the characteristics of coding schemes and data rates provided by the General Packet Radio Service (GPRS). This paper also analyzes coding schemes with various internet applications and QoS parameters like reliability, delay and bandwidth. The outcome of our strategy and analysis will help to select an appropriate coding scheme and to reduce the complexities involved in the data transfer with respect to the above parameters in wireless mobile networks.

Keywords: *Quality of Service (QoS), Fixed wireless, General Packet Radio Service (GPRS), Wireless mobile networks, Coding scheme, Global system for Mobile Communications (GSM)*

1. Introduction

The penetration of internet in mobile networks is increasing day by day. The mobile network helps the customers to avail the benefits of the internet while on the move. Though the customers can enjoy benefits, it also challenges the service providers. The services provided in mobile environment has more complexity than in fixed wireless or wired environment. The ad hoc nature of the mobile networks poses more challenges in the protocols that they use. In other words, the protocols in each layer have to be enhanced in order to support mobility. Despite these difficulties, the service provider has to take measures to ensure Quality of Service (QoS).

The QoS is defined as the set of service requirements to be met by the network. Applications often require a certain level of bandwidth, delay or security to work properly. Analyzing further, these applications reveals that their requirements also depend on the user's situation [1] [2]. The QoS depends on various parameters such as reliability, delay, jitter, bandwidth, etc. The requirement of above parameters will differ from one application to another application. The applications are video, audio, file

transfer, web access, etc. These applications can also be classified as delay sensitive, error sensitive, bandwidth sensitive, etc. The very delay sensitive application cannot tolerate if the data transfer takes more time to reach the destination. The QoS mechanism must prioritize different applications, users or data flows in order to ensure certain level of quality.

One of the aims of QoS is to manage the service response provided to low-speed devices such as mobile wireless devices. The QoS can be ensured only when the achieved / actual performance is greater than or equal to the desired performance. With the growth of mobile services, it has become very important for an operator to measure the QoS and Quality of end-user Experience (QoE) of its network accurately and improve it further in the most effective and cost-efficient way to achieve customer loyalty and maintain competitive edge [3]. The service provider must take steps to introduce new mechanisms to achieve the desired performance. Otherwise, QoS cannot be achieved.

Motorola offers the industry's leading portfolio of GPRS and EDGE handsets, designed to be 100% compatible with CS1 and CS2-based GPRS networks and our faster, EDGE and CS3 / CS4 networks [4]. In other words, GPRS uses CS1 / CS2 and Motorola uses CS3/CS4. The data transfer speed depends on various paramters. One such parameter is the channel encoding used. This channel encoding is done using coding schemes. The General Packet Radio Service (GPRS) uses four coding schemes such as Coding Scheme-1, Coding Scheme-2, Coding Scheme-3 and Coding Scheme-4. In short, these coding schemes are called as CS1, CS2, CS3 and CS4. Each coding scheme has its own merits and demerits. This paper analyzes these schemes based on few QoS parameters in order to increase efficiency of data transfer.

This paper is organized as follows. Section 2 expalins the motivation to write this paper. Section 3 proposes QoS strategy to select coding scheme to increase QoS. Section 4 analyzes proposed QoS strategy and shows the results. Section 5 states the conclusion. Finally, references are listed.

2. Motivation

Typically, wireless networks offer lower quality than wired networks. There are three major reasons for this quality issue. First reason is the lower bandwidth due to limitations in radio transmission (e.g. only 1-10 Mbps instead of 100 – 1000 Mbps). Second reason is the higher error rate due to interference (e.g. 10^{-4} instead of 10^{-12} in fiber optics). Third is higher delay / delay variation due to error correction and detection mechanism [5]. It seems that the success of wireless data at the moment is just prohibited because certain requirements for data rates and cost are not fulfilled [6]. Hence, there is need to use the available requirements effectively which is discussed in this paper.

Error correction and detection mechanism uses the concept of redundancy, which means adding extra bits for correcting and detecting errors [7]. These extra bits can also be called as redundant bits. The number of redundant bits (r) depends on the number data bits (d). For example, If d=4, then r=3 and If d=5, then r=4. The number redundant bits used in GPRS differ from one coding scheme to another coding scheme. The number redundant bits also increases overhead with respect to reliability, delay, bandwidth, etc. Therefore, care must taken to avoid unnecessary overheads in the selection of coding scheme.

The Global system for Mobile Communications (GSM) Association has defined 12 multislot classes for GPRS. Each class is associated with maximum number of uplink and downlink slots that can be allocated to a single mobile host. The slot is usually written us M +

N, where M is the maximum number of downlink slots and N is the maximum number of uplink slots. For example class 1 is "1+1" (one downlink slot plus one uplink slot); class 12 is "4+4" (four downlink plus four uplink slots). In addition each multislot has an active slot constraint. A mobile host cannot have more than K active slots simultaneously. This active slot constraint limits the data rate. The class 12 mobile node can have maximum 5 active slots. That is, only "4+1", "3+2", "2+3" or "1+4" slots can be used simultaneously [8]. The number slots used in the downlink and uplink will differ based on the amount of data to be transferred. Consequently, the coding scheme may also differ in downlink and uplink. The profiles of services are vastly different, the qualities of service demanded by these services also differ greatly [9]. Due to the diversified nature of the requirements and available services, care must be taken to improve QoS.

The CS-1, CS-2 and CS-3 use convolution codes and block check sequences of differing strengths so as to give different rates [10]. The performance evaluation of deploying coding schemes from CS1 to CS4 is necessary. The coding schemes will differ in their data rates and in offering benefits [11]. A QoS prediction technique can also be used to overcome QoS issues in GPRS. It is used to predict reason(s) for deterioration in the QoS [12]. After a data transfer or a group of data transfer is over, the QoS requirements have to be validated. That is, periodically QoS requirements should be validated for correctness. A flow may not get expected QoS requirements all the time [13]. For mobile network operators, knowledge of their strengths and weaknesses provides the basis for identifying options to maximize revenue and business potential [14].

The GPRS has four different coding schemes, namely CS1, CS2, CS3, and CS4. CS1 has more error correction bits than CS2. CS4 has minimal error correction bits than CS3. In practice, CS4 is rarely used because it can lead to frequent retransmissions of lost packets and overall underperformance. Communication between the base station and any given mobile host is full-duplex but can be asymmetric; that is the down link and the uplink capacities need not be the same [8]. Hence, the system can select the coding scheme based on the amount of data to be transferred through down link and uplink.

Generally, the downlink has more frequency than the uplink. Both links can send user data as well as control data. There are some situations in which the amount of user data may be larger than the control data and vice versa. That is, the downlink may have more data to carry than the uplink. Thus, the selection of coding scheme may differ for downlink and uplink. As a result, a QoS strategy to select the coding scheme becomes important.

3. A QoS Strategy

This section explains a QoS strategy to select the coding scheme in General Packet Radio Service. Table 1 show that the data rates have increased from CS1 to CS4. The number of redundant bits is also increased from CS1 to CS4. The typical data rates of GPRS with the coding scheme are given in Table 1 [5].

Table 1. GPRS data rates in kbps

Coding Scheme	**1 Slot**	**2 Slots**	**3 Slots**	**4 Slots**	**5 Slots**	**6 Slots**	**7 Slots**	**8 Slots**
CS1	9.05	18.2	27.15	36.2	45.25	54.3	63.35	72.4
CS2	13.4	26.8	40.2	53.6	67	80.4	93.8	107.2
CS3	15.6	31.2	46.8	62.4	78	93.6	109.2	124.8
CS4	21.4	42.8	64.2	85.6	107	128.4	149.8	171.2

The following steps illustrate the proposed QoS strategy. They are,

Step 1: Identify the data rates offered by the coding schemes
Step 2: Find error correction capability / amount of redundant bits in the coding schemes
Step 3: Analyze the coding schemes based on QoS parameters
Step 4: Relate the coding schemes with QoS parameters based on relative terms such as low, medium and high (Low, medium and high refer sensitivity to QoS parameters)
Step 5: Identify / analyze the application(s) based on Step 4.

The coding scheme, CS1 has more error correction bits. Here, the error correction bits can also be called as redundant bits. The more number of redundant bits ensure that CS1 has more error correction capability. It provides more reliability than other coding schemes such as CS2, CS3 and CS4. The limitation of CS1 is that it takes more time to reach the destination which in turn affects the bandwidth. The reliability refers the amount of erroneous packets. For example, high reliability means the amount erroneous packets must be very less. But, the throughput of CS1 will be lesser than other coding schemes as it has more number of redundant bits. The coding scheme, CS4 has no error correction capabilities. As CS4 uses minimum number of redundant bits, it provides higher throughput. The limitation of CS4 is that number of retransmissions if it is used in poor channels. In each coding scheme, there will be tradeoff between reliability and throughput.

4. Analysis and Results

This section analyzes the various applications and suggests the coding scheme for them. The analysis can be done in various ways like, application-wise, one or more parameter-wise, etc [13]. The applications used in the internet can be classified into many ways. The following are important classifications. They are,

- Delay-sensitive applications (e.g. Telephony)
- Bandwidth-sensitive applications (e.g. Video)
- Error-sensitive applications (e.g. E-mail)

Some of the applications will be sensitive to one or more parameters. For e.g. video conferencing is more sensitive to delay and bandwidth. The detail QoS requirements for various applications are given in [15].

Table 2. Relationship between coding scheme and QoS parameters

Coding Scheme / Parameter	CS1	CS2	CS3	CS4
Reliability	High	Medium	Medium	Low
Delay	Low	Medium	Medium	High
Bandwidth	Low	Medium	Medium	High

Table 2 summarizes the steps 1-4 of the proposed strategy in the previous section and relates the coding schemes with the QoS parameters. The reliability of the coding schemes is as follows. That is, CS1 offers high reliability, CS2 and CS3 offer moderate / medium reliability and CS4 offers low reliability. The high reliability refers that CS1 can be used by an application which is highly sensitive to reliability. In other words, CS1 can be used by an

application which cannot tolerate errors. Likewise, CS1 offers low delay, CS2 and CS3 offer medium delay and CS4 offers high delay. Here, low delay means CS1 can be used by an application which is low sensitive to delay. In other words, CS1 can be used by an application which can tolerate more errors. The Step 5 of the proposed strategy is discussed in Table 3. It shows the appropriate coding scheme for the various applications based on QoS parameters such as reliability, delay and bandwidth.

Table 3. Quality of service requirements with coding scheme

Application	***Reli-ability***	***Delay***	***Band-width***	***Coding Scheme***
E-mail	*High*	*Low*	*Low*	*CS1*
File Transfer	*High*	*Low*	*Medium*	*CS1 / CS3*
Web Access	*High*	*Medium*	*Medium*	*CS1 / CS3*
Remote login	*High*	*Medium*	*Low*	*CS1/ CS3*
Audio	*Low*	*Low*	*Medium*	*CS3*
Video	*Low*	*Low*	*High*	*CS4*
Telephony	*Low*	*High*	*Low*	*CS4*
Video Conference	*Low*	*High*	*High*	*CS4*

There are three scenarios involved in this analysis. First, e-mail application needs high reliability. It refers that it cannot tolerate the errors. It also shows that it can tolerate delay and bandwidth problems to a greater extent. In this scenario, only CS1 can provide better service than other coding schemes. Second, web access application needs high reliability, medium delay and medium bandwidth. In this scenario, either CS1 or CS3 can be chosen. The limitation of this scenario is the selection of the coding schemes (CS1, CS3). The web access application places constraint on more than one QoS parameters. That is, it places constraints on reliability, delay and bandwidth. This issue is out of the scope of this paper. Third, video conference application need low reliability, high delay and high bandwidth. As video application can tolerate errors to certain extent, it can use CS4. As CS4 uses minimum number of redundant bits, it can provide better service on delay and bandwidth requirements.

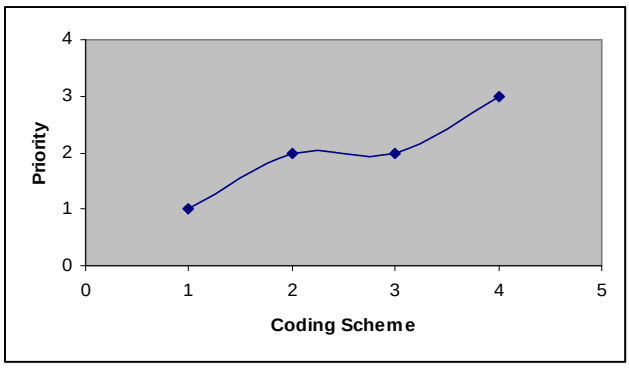

Figure 1. Coding Scheme vs. Reliability

Figure 1 and 2 show the results in graphical form. It gives you an idea about how the coding scheme gives priority based on the parameters such as reliability and delay. Here, priority 1 means high priority, priority 2 means medium priority, priority 3 means low priority. According to Figure 1, CS1 gives high priority, CS2 and CS3 gives medium priority and CS4 gives low priority to reliability. According to Figure 2, CS1 gives low priority, CS2 and CS3 gives medium priority and CS4 gives high priority to delay. In other words, Figure 2 is an inverse of Figure 1. The coding schemes can be selected based on the priority. No coding scheme is less important than the other. Likewise, graph can be drawn for bandwidth vs. coding scheme.

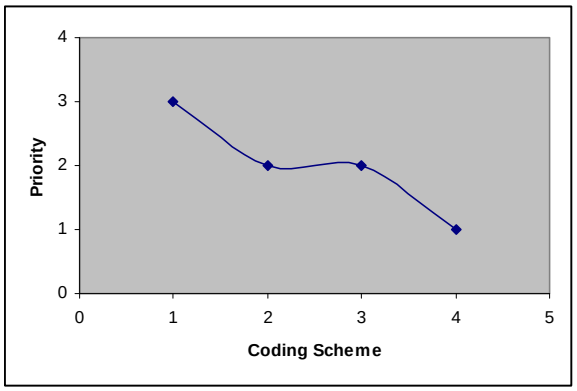

Figure 2. Coding Scheme vs. Delay

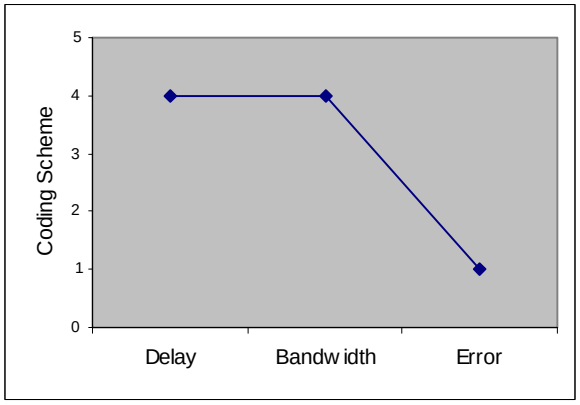

Figure 3. Coding Scheme vs. QoS Parameters

Figure 3 shows what the appropriate coding scheme for an application is. The X-axis shows the delay-, bandwidth-, and error-sensitive applications. The Y-axis shows the coding schemes. Figure 3 shows that the delay-sensitive applications (e.g. telephony) and bandwidth-sensitive applications (e.g. video) can use coding scheme, CS4. The error-sensitive applications (e.g. e-mail) can use coding scheme, CS1. The results clearly show that each coding scheme has pros and cons. It can be selected based on the requirements of the customer.

5. Conclusion

This paper discussed various coding schemes and its relationship with QoS parameters (reliability, delay, etc.) and applications (e-mail, video conference, etc.) used in the internet. The coding scheme, CS1 is suitable for unreliable medium and CS4 is suitable for applications which have a reliable medium. In other words, CS1 is suitable for the applications which are error-sensitive and CS4 is best suitable for applications which are delay-sensitive and bandwidth sensitive. Section 3 and 4 explained the suitable coding scheme for various internet applications with respect to reliability, delay and bandwidth parameters.

Certainly, the outcome of this paper will reduce the complexities such as number of erroneous packets, more propagation delay and insufficient carrying capacity of the channel by following our strategy. In other words, the proposed QoS strategy will help to increase the efficiency of the data transfer by decreasing the number of erroneous packets, propagation delay and insufficiency in the carrying capacity of the channel. This is possible by the appropriate selection of coding scheme that is discussed in this paper. The outcome of this paper is based on theoretical analysis; measures can be taken for an experimental analysis. Though this paper has contributed to increase the efficiency, it has a weakness as well. That is, if an application places constraints on more than one parameter, coding scheme must be selected carefully. As a future enhancement, strategy can be implemented to solve this weakness.

Acknowledgement

This work was supported by the Security Engineering Research Center, granted by the Korea Ministry of Knowledge Economy.

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Authors

Mr. P. Calduwel Newton is basically a physically challenged person presently working as a Lecturer in Computer Science at Bishop Heber College (Autonomous), Tiruchirappalli, Tamil Nadu, India, where he graduated in the year 1997. He took his Master's Degree in Computer Science in the year 1999 from Pondicherry University, Puducherry and he did his M.Phil. in Computer Science at Bharathidasan University, Tiruchirappalli in the year 2004.

Currently, he is pursuing Ph.D. in Computer Science at St.Joseph's College (Autonomous), Tiruchirappalli. He is a resource person for Indira Gandhi National Open University (IGNOU) and other Distance Education Centres of premier Universities. He has delivered lectures on computer network-related topics and motivational talk in various institutions.

He has presented 21 papers in the International, National and State Level conferences. Out of 21 papers, 3 papers are published by IEEE Computer Society and 2 papers are published in International Journals. He has presented papers in Malaysia, Korea and Australia. His research interests are: wireless mobile networks, Quality of service, route optimization and other related topics.

Dr. L. Arockiam is working as a Lecturer (SG) in the Department of Computer Science, St.Joseph's College (Autonomous), Tiruchirappalli, Tamil Nadu, India. He has published many research articles in the International / National Conferences / Journals. He has also presented 2 research articles in the Software Measurement European Forum in Rome. He has chaired many technical sessions and delivered invited talks in National and International Conferences. He has authored a book on "Success through Soft Skills". His research interests are: Software Measurement, Cognitive Aspects in Programming, Web Mining and Mobile Networks.

Prof. Tai-hoon Kim, M.S., Ph. D (Electricity, Electronics and Computer Engineering), currently, Professor of Hannam University, Korea. His research interests include Multimedia security, security for IT Products, systems, development processes, operational environments, etc. He has 14 Years of experience in Teaching & Research. He has already got distinctive Academic Records in international levels. He has published more than 100 Research papers in International & National Journals and Conferences.