A REVIEW OF SELECTIVE REPEAT ARQ SCHEME FOR CHANNEL ERROR CORRECTION IN POINT TO MULTIPOINT SERVICE

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Abstract— Channel error correction for data broadcast remains a priority operation in ensuring correct communications for either point-to-point or point-to-multipoint broadcast. Selective repeat ARQ is an oft used error correction protocol where high bit rates are involved. This paper presents a historical perspective to the developments of this error correction scheme and gives a pointer to the future directions regarding amelioration schemes that can be used to improve on the standard SR-ARQ algorithm. Buffer management at the receiver end has been used traditionally to control the number of retransmissions. However fixed buffer schemes with some modification of throughput computation are still being explored and investigated in this review.

Index Terms— error correction, point-to-multipoint, selective repeat ARQ, throughput.

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1 INTRODUCTION

The evolution of broadcast technologies has seen a corresponding growth in the types and functionalities of techniques used to mitigate channel noise. With different broadcast topologies presenting their unique challenges, the medium or channel of communication retains the number one spot as primary source of noise in any broadcast communication. Some well-established effects of noisy channels include signal fading, data loss, error-prone transmissions such As in satellites[Yoshimoto 1993][Two of the well-known broadcast topologies include point to point and point to multipoint which as inferred from their names represent one-to-one and one-to-many broadcast schemes respectively. Although there are advantages to either one of the two topologies, this paper focuses on point-to-multipoint broadcast which has for an example, satellite communications. Disadvantages also exist for either one of the broadcast schemes and these include bandwidth, noise, as documented in Mohan and Qian (1988). However common to either scheme is the channel noise problem and the opportunities this fact presents for researchers and scientists to mitigate the noise effect on transmitted data. Noise is a necessary phenomenon but an unwanted artefact of any communication medium and methods of dealing with the noise constitute the focus of this paper.

The noise question in broadcast communications continues to be a vital one, requiring novel answers which are driven by new solution techniques []. For satellite communications, a number of techniques have been identified from literature [Friedman, Zhang, and Ephremides] [] [], a spectrum of solution techniques have already been considered which includes. These techniques can broadly be divided into two,

namely; Forward Error Correction (FEC) and Automatic Repeat Request (ARQ). A hybrid architecture combining the two previously mentioned techniques has also been used especially where multicast (point-to-multipoint) broadcast communications is used [Friedman et al].

FEC utilizes a number of techniques for error correction in the channel also which includes BCH, Golay, Reed Solomon etc. These methods usually selected based on the noise threshold detected in the channel or the type of noise profile that predominates on the channel. Such noise threshold and profile being subject to the frequency of. Communication being transmitted with attendant bursty or non-bursty noise model considerations being made [Friedman et6 al 1996].
Automatic repeat request on the other hand has been broadly subdivided into two parts namely go--back-n and selective-repeat ARQ. All types of this generally named technique utilize some form of soft feedback in effecting error correction via

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retransmissions. The major difference between the two protocols involves the type of retransmissions used in answer to instances of failed transmission of data []. While go-back-N requires that all the previously transmitted frames prior to failure be retransmitted, the SR-ARQ only requires that the damaged frame be recent until acknowledgement is received from the receiver that the frame has been correctly transmitted []. Due to the nature of selective repeat ARQ admitting high data or bit rates, attendant loss of information or data is possible. Such data loss, in the form of error bits makes even the SR-ARQ protocol to become problematic at extremely high data rates which are accompanied with greater probability of error.

The rest of the paper is arranged as follows; Section 2 addresses the utiliozed methdodology which is the review of literature pertaining the paper subject, Section 3 touches on some of the constitutive equations describing throughput in point to multipoint networks. Section 4 concludes the present discussion while the full list of references comes last.

2 METHOD

2.1 Literature Review

The methodology applied here is to present the existing schemes that exist for SR-ARQ. This paper presents the known and well established methods and also the state of the art. All this is done to give readers and interested researchers a sense of the progress already made and directions for future work.

One of the first mentions of the Selective repeat Automatic repeat request (SR-ARQ), was made in the 1980 paper of Shu and Lin. Here an improvement to the traditional go back N technique was introduced to take care of the drawback of go back n under high data rates and increased noise. Another improvement work was undertaken by Chandran and Shu Lin in 1986 to study the effect of buffer size on throughput efficiency. The important work by Weldon Jr (1982), gave a well-documented history, which offered explanation on the main points and individuals in the development of the ARQ technique. The central feature that gave it its uniqueness was its utilization of feedback and soft feedback in its operation. Investigations into this soft feedback for correction of error retransmissions was mentioned to have been pioneered by Chang (1956), Harris(1959), Metzner & Morgan(1960), Shannon(1961). More practical ARQ techniques employing stop and wait strategies were implemented by Reiffen (1961), Cowell and Burton (1962), Stuart (1963), Bernice and Fey (1964), Balkovich and Muench (1969) and other researchers who examined different aspects of the stop and wait strategy such as undetected error probability, propagation delay and throughput. The stop and wait strategy was oft utilized because of its simplicity [Weldon Jr, 1982]. However, with this simplicity came the obvious practical drawback of delay and long retransmission times.

Yoshimoto et al (1993) compared the performance of go back n and SRARQ in terms of queue length and waiting time which are characteristics of both methods, but it was identified that SRARQ showed better performance over go back n. in the 1996 paper of Friedman et al, real experiments were conducted to analyse the behaviour of various error correction protocols for satellite broadcast networks. Here Forward error correction (FEC) and automatic repeat request (ARQ) were analysed separately and then as a hybrid of the two techniques. The results obtained showed Hybrid technique being advantageous in such systems where both satellite relay and ground based relay was employed for data transmission. Other hybrid implementations of the error correction scheme used both go back n and sr-arq such that the drawbacks of go back n was addressed by using Sr-ARQ in the intra block data error correction[Sugimachi et al. 1999][Hashiyada et al, 2002]. Maeda et al also applied this hybrid go back n with SR-ARQ in the intra block scheme for error correction. The modifications to the primary ARQ algorithm started to also appear about this time with the paper by Narayan & Stuber (1997) being an example. This paper applied an already mentioned technique called Turbo coding. This technique was used to encode the data and make it more robust to noise or bit changes.

Since the stated beginnings and years of continuous improvements, several variants of the core algorithm has continued to be researched and developed by different researchers. Weldon Jr [1982] synopsis of the developments leading up to his own improvements in 1982 comes to mind. One very important fact with the SR-ARQ scheme is its assumption of infinite buffer size which is not obtainable in reality [Weldon Jr 1982]. Workable improvement sought to increase the buffer size dynamically until the point where the throughput showed no further improvements from buffer size increase. Therefore with finite buffer sizes, new schemes have been looked at to improve on the traditional SRARQ scheme. Some of these include repeating the retransmission of NACKED blocks multiple times with the number of repeats increasing as the receive buffer approaches overflow [Weldon], Benelli proposed a finite length SR-ARQ strategy named ARQ1. ARQ1 attempts to coordinate the transmission of negatively acknowledged messages to facilitate proper recovery at the receiver side [Benelli].

Central to all improvements in the SR-ARQ protocol is the improvement of throughput measure of the communication channel. This otherwise stated means ensuring retransmissions are timely done and correctly received[Weldon Jr] while noise effect is suppressed or reduced to an acceptable minimum. History of such improvement can be found in schemes utilizing computational algorithms, advanced coding of data and hybrid error correction protocols to gain higher throughput in light of fixed operational parameters such as bandwidth and buffer size.

The origin of most useful communication remains terrestrial sources. However in order to assist the effective transmission of data from source to user, intermediate relay points such as satellites are used for multicast networks. This fact however introduces undue delay between transmission and reception of data and also raises the incidence of noise entering the data from along channel sources []. Utilization of satellites therefore remains a most viable transmission option, not to mention one of the most excellent means for point-to-multipoint communications because of the wide coverage and reach [Friedman et

al].

3   CONSTITUTIVE EQUATIONS

Measuring the effectiveness of such communications is usually done with the help of the throughput metric, which is defined in [Mohan et al] as the ratio between the numbers of correctly received frames to the total number of frames received.

$$\eta = \frac{Number\_of\_sucessfully\_transmitted\_frames}{total\_number\_of\_frames\_transmitted}$$

From this definition, it is seen that the throughput is a ratio with a maximum of one if all transmitted frames are received correctly and zero if none of the transmitted frames are received correctly.

Another expression of the throughput as a statistical measure of probabilities uses expectation of the previously expressed parameters in eq. ().

$$\eta = \frac{E[Number\_of\_correctly\_received\_frames]}{E[Total\_number\_of\_frames\_transmitted]}$$

Where the throughput, η can be expressed as a percentage of the probability.

4   CONCLUSION

From the review done so far, it is seen that SR-ARQ is well established technique utilized in point to multipoint broadcast networks. It is also better suited for timely retransmissions since it only retransmits those data frames which were incorrectly received. The main drawback to utilizing SR-ARQ remains the size of the buffer. Also several optimizing techniques have been mentioned and recommended for use in improving the throughput of the SR-ARQ scheme. This has been proposed to investigators and researchers as future work.

REFERENCES

FL K. Sastry, "Improving Automatic Repeat-Request (ARQ) performance on satellite channels under high error-rate conditions," IEEE Trans. on Commun. Vol COM-23, pp. 436-439, Apr. 1975.

2] D. Towsley, "The Stutter Go Bach N ARQ Protocol," IEEE Trans. on Commun. Vol COM-27, pp. 869-875, June 1979.

S. Lin and P. S. Yu, "An effective Error-Control Scheme for Satellite Communications," IEEE Trans. on Commum,
Vol. COM-28 No. 3 pp. 395-401 Mar. 1980.

P. S. Yu and S. Lin, "An Efficient Selective-Repeat ARQ Scheme for Satellite Channels and its Throughput Analysis," IEEE Trans. on Commun. vol. COM-29, pp. 353-363 Mar 1981.

E. J. Weldon, Jr., "An improved selective-repeat ARQ strategy with finite receiver buffer," IEEE Trans. On Commun. Vol. COM-30, pp. 480-486, Mar 1982.

M. J. Miller and S. Lin, "The Analysis of some Selective Repeat Schemes with finite receiver Buffer," IEEE Trans.
On Commun. Vol. COM-29, pp. 1307-1315, Sept. 1981.

S. Ramachandran and S. Lin, "A selective repeat ARQ scheme for point-to-multipoint communications and its throughput analysis," Computer Communications Review, Vol. 16, No. 3, pp. 292-301, Aug. 1986.

J. J. Metzner, "A study of an efficient retransmission strategy for data links," in NTC'77 Proc., pp. 03B: l-1 - 03B: 1-5, 1977.

K. K. Sabnani, "Multidestination protocols for satellite broadcast channels," Ph. D. dissertation, Columbia University,
New York, NY, 1982.

[lo] K. Mase, T. Taker&a, H. Yamamoto and M. Shinohara, "Go-Bach- N ARQ scheme for point-to-multipoint
Satellite communications," IEEE Bans. Commun. Vol. COM-31, No. 4, pp. 583-589, Apr. 1983.

[ll] I. S. Gopal and J. M. JafTe, "Point-to-multipoint communication over broadcast links," IEEE Trans. Commm.,
Vol. COM-32, No. 9, Sept. 1984.

[12] D. Towsley, "An analysis of point-to-multipoint channel using a Go-Bach-N error control protocol," IEEE Tnzw.
Commun. Vol. COM-33, No. 3, pp. 282-285, Mar. 1985.

Y.M. Wang and S. Lin, "A modified selective-repeat type-I1 hybrid ARQ system and its performance analysis," *IEEE Trans. Commun.,* vol. COM-31, pp. 593-608, May 1983.

[lo] M.J. Miller and S. Lin, "The analysis of some selective-repeat ARQ schemes with finite receiver buffer," *IEEE Trans. Commun.,* vol. COM-29, pp. 1307-1315, Sept. 1981.

1111 E. J. Weldon, Jr., "An improved selective-repeat ARQ strategy," *IEEE Trans. Commun.,* vol. COM-30, pp. 480-486, Mar. 1982.

[12] G. Benelli, "A go-back-N ARQ scheme with buffer at the receiver," *Proc. IEE,* part F, vol. 133, pp. 271-276, June 1986.

[13] -, "An ARQ scheme with memory and soft error detectors," *IEEE Trans. Commun.,* vol. COM-33, pp. 285-288, Mar. 1985.

[14] ~, "An ARQ scheme with memory and integrated modulation," *IEEE Trans. Commun.,* vol. COM-35, pp. 689-697, July 1987.

1151 -, "An efficient ARQ technique using soft demodulation," *Electron. Lett.* vol. 22, pp. 205-206, Feb. 1986.

A. R. K. Sastry, "Improving automatic-repeat-request (ARQ) performance on satellite channels under high error rate conditions," *IEEE Trans. Commun.,* vol. COM-23, pp. 436-439, Apr. 1975.

J. Metzner, "Improvement in block retransmission schemes," *IEEE Trans. Commun.,* vol. COM-27, pp. 525-532, Feb. 1979.

S. Lin and P. S. Yu, "An effective error control scheme for satellite communications," *IEEE Trans. Commun.,* vol. COM-28, pp. 395-401, Mar. 1980.

P. S. Yu and S. Lin, "An efficient selective-repeat ARQ scheme for satellite channels and its throughput analysis," *IEEE Trans. Commun.* Vol. COM-29, pp. 353-363, Mar. 1981.

S. Lin and P.S. Yu, "A hybrid ARQ scheme with parity retransmission for error control of satellite channels," *IEEE Trans. Commun.,* vol. COM-30, pp. 353-363, Mar. 1982.

S. Lin and D. Costello, **Jr., *Error Control Coding: Fundamentals and Applications.*** Englewood Cliffs, **NJ:** Prentice-Hall, 1983. pp. 827-832,

S. Lin, D. Costello, **Jr.,** and M. **J.** Miller, "Automatic-repeat-request error-control schemes," *IEEE Commun. Mag.,* vol. 22, pp. 5-17, Dec. 1984.

R. J. Bernice and A. **H.** Frey, **Jr.,** "An analysis of retransmission schemes," *IEEE Trans. Commun. Technol.,* vol. COM-12, **up.** 135-145, Dec. 1964.

S. Mohan, J. Qian and N. L. Rao, "Efficient Point-To-Point and Point-To-Multipoint Selective- Repeat ARQ Schemes with Multiple Retransmissions: A Throughput Analysis"