Context-ID detection method for Robust Header Compression in wireless packet communication

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Abstract: Communication schemes are currently changing from circuit switched towards packet switched. These changes enable access to Internet and multimedia services in wireless network. Provision of real-time IP services in air interface introduces relatively large overhead in RTP/UDP/IP headers. To reduce the overhead, the header compression schemes are required. There exist two header compression schemes (CRTP, ROHC) which are IETF standards. We propose Context-ID detection method which reduces more efficiently the packet loss rate than two existing schemes. Its performance in WCDMA system environment is evaluated for CRTP and ROHC schemes.

1. Introduction

Currently cellular access networks are based on circuit-switched technology and have been optimized for quality and spectrum efficiency, resulting in high efficiency voice services but very low service flexibility. 3G-wireless telephony systems are expected to deliver real-time multimedia data, such as high quality audio and video, web browsers, e-mail clients, computer-generated graphics and animations, networked-games, interactive video conferencing and so on. This can be best achieved by using end-to-end packet based IP over wireless link. The Internet Protocol is increasingly used as the common service interface for applications and services provided over different networks. 3G networks will therefore allow for a wide range of real-time IP-based multimedia applications to operate over the mobile networks.

In the internet, the *Real-time Transport Protocol (RTP)* delivers real-time data streams over UDP/IP. But the protocol overhead using the IP, UDP, RTP internet protocols can be a serious problem when transmitting real time packets in bandwidth-limited environments, and the radio channels used in cellular systems have very high bit error rates(BER) due to shadow fading , multipath fading, and continuous mobility. The header compression scheme is required to solve these problems. The header compression scheme should not only be robust against channel errors, but also have efficient compression algorithms.

Existing header compressing algorithms such as CRTP and ROHC can compress 40 octets of RTP/UDP/IPv4 headers to a minimum of 2 octets which consist of Context-ID and header field. In this paper, we propose a new header compression scheme, Context-ID detection method which has superior performance in robustness over CRTP and ROHC.

In chapter 2, the general header compression schemes are presented. Chapter 3 gives the principles and functionality of the Context-ID detection method. Chapter 4 shows the simulation results CRTP and ROHC schemes with context-ID detection method, applied to the WCDMA system. Chapter 5 concludes the paper.

2. Header Compression

Media data will most likely be carried by Real-Time Transfer Protocol (RTP) [1]. The combined headers required for the transmission of real-time multimedia information over IP-based networks typically totals 40 bytes. One packet has an IP [2] header (20 octets), a UDP [3] header (8 octets), and an RTP header (12 octets), for a total of 40 octets. The IP header with IPv6 [4] is 40 octets, for total of 60 octets. When transmitting speech or audio streams, which have been compressed to low data rates, packet header occupies a considerable proportion of the total packet. For example, when using AMR speech codec, it requires up to 56% bandwidth consumption. When transmitting video streams, which have compressed to relatively high data rates, long packet header is more sensitive over the air interface. Besides, one packet loss may cause frame error in high layer. The header compression schemes can reduce these header overhead and packet loss rate caused by long packet header.

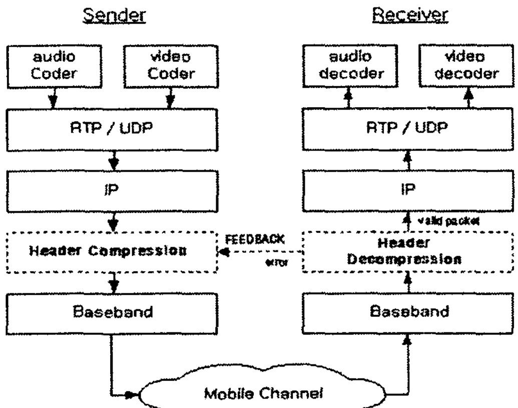

Figure 1. Header compression scheme

2.1 CRTP

A standard for compressing RTP/UDP/IP headers over low-speed serial links, Compressed RTP (CRTP) has been approved as RFC 2508 by the Internet Engineering Task Force (IETF) [5]. This compresses 40 octets of RTP/UDP/IP headers to a minimum of 2 octets when the UDP Checksum is not enabled. If the UDP Checksum is enabled, the minimum CRTP header is 4 octets.

CRTP is based on two basic ideas. First, many of the bytes in the RTP/UDP/IP headers remain constant over the life of the connection. After sending the uncompressed header once, these fields may be omitted from the compressed headers that follow. Second, the changing fields can be coded, resulting in reduced packet size. The difference from packet to packet is often constant and therefore the second-order difference is zero. By maintaining both the uncompressed header and the first-order differences in the session state shared between the compressor and decompressor, the decompressor can reconstruct the original header.

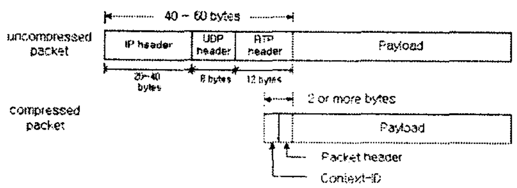

Figure 2. Compressed packet format

But if one of CRTP packets is lost over the air interface, decompressor discards a packet received from compressor until a complete packet is received successfully. With a long round-trip delay over the link, the packet loss is more increased [6].

2.2 ROHC

The other Compression Scheme, Robust Header Compression (ROHC) [7], utilizes the traditional concepts, but adds several encoding methods in order to overcome the issues encountered as a result of operation in wireless environments. ROHC has mainly four encoding methods which have one packet loss of packet streams not to trigger the next additional packet loss. Then ROHC reduces more the packet loss rate than CRTP. In addition, A CRC over the original header is used by ROHC to verify correct decompression and to prevent damage propagation and wrong context updates. However, ROHC still discards the current packet with damaged header over cellular links.

3. Context-ID detection method

When receiving the packet with compressed header, the decompressor should make the original header from the compressed header. The context has the information about original header in order to correctly compress or decompress the header of the packet stream. Contexts are identified by a context identifier (CID) which is sent along with compressed headers and feedback information. Compressor and decompressor keep contexts in a table, and the context table is indexed using the CID. Decompressor can reconstruct complete set of original RTP/UDP/IP header using stored context and update header information. Traditional schemes try to improve header efficiency and reduce error propagation into variable encoding methods. But there is no scheme to cope bit error from CID which occupies one or two bytes length. CID occupies about a half of compressed packet, which is 1~2 octets in CRTP and 4 bits~2 octets in ROHC, and a lot of parts of packet loss, on average 58% in CRTP and 52% in ROHC, are caused by invalid CID. Most of loss packets have only 1~2 bit errors. We evaluated bit errors distributed in one octet over the WCDMA links. 84.4% for the BER of 3e-3 and 99% for the BER of 5e-5 had one bit error. Proposed Context-ID (CID) detection method can reduce packet loss due to CID with a few bit errors. The decompressor contains the lists of the successfully received CID in a table. When receiving the compressed packet, the decompressor compares its CID with the last received CID. If it is not equal to the last CID, it calculates correlation between the CID of incoming packet and each CID in the table. The output of the correlator is compared with Correlation Threshold (CT), and when the maximum value of the output of the correlator is greater than the threshold, the corresponding CID is detected.

When transmitting only one media data, the decompressor accomplishes fast reconstruction since the context is detected by comparing with last received packet. When more than two media data are transmitted, the decompressor first compares the received CID with that of the last received packet. If two CIDs are not equal, the decompressor computes correlation with CIDs in context table and finds the best matching CID with received CID. By doing so, the decompressor can reduce packet loss rate by erroneous CIDs.

When allocating the CID, the compressor should select a CID in order of a long distance for the damaged CID to be repaired in the decompressor using correlation. The decompressor should limit the context table length and discard the context not used for a long time. The decompressor negotiates this method with the compressor before a channel is established together with CID length.

4. Simulation results

Link level simulations have been made for CRTP and ROHC over WCDMA channels. The simulated scenario is shown in Figure 4. A source generates speech and video RTP packets, which are sent over a network and wireless link. The link level simulation on the path to the end system is performed in a cellular link. Compressed RTP/UDP/IP headers are sent from the compressor (HC) to the decompressor (HD).

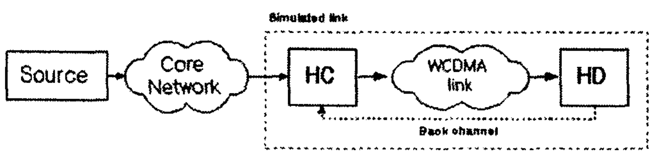

Figure 4. Scenario for link level simulations

In simulation, the speech source goes through AMR speech codec characterized by 12.2 kbit/s data mode with silence suppression. It generates payloads of 1~31 octets at a rate of one packet every 20ms. The video source is applied to H.263 video codec, and one packet is sent every 10ms with output of 45kbit/s and 15 frames/sec. All of 3000 packets are transmitted by the compressor. Table 1 shows properties of the link.

Interleaving	Block Interleaving
Channel coding	Turbo code 1/3
Gaussian white noise interference	10 ~ -10 dB
Fading	Multi-path fading 4km/h Doppler fading
spreading factor	8

Table 1. Properties of the simulated link

The reported bit error rate, BER, is the BER seen by the link layer. It is assumed that the back channel never damages the context request messages and the round trip time for the cellular link and the back channel is set to 120ms.

Figure 5 shows the packet loss rate versus channel BER (Bit Error Rate) in CRTP. Whenever the decompressor detected an error in a particular packet stream, it would simply discard all packets in that stream until an uncompressed header was received for that stream. Therefore, a packet loss between a CRTP compressor and decompressor triggers a burst of additional packet losses due to CRTP's context repair mechanism. The link round trip time in these simulations is 120ms, meaning that a single discarded packet would cause at least six additional frames to be lost due to context damage. This simulation result shows that the performance for CRTP can be improved by using CID detection. CID detection can find the most probable CID from damaged CID with a few error bits using threshold-based correlation technique. The packet loss rate of CRTP with CID detection method shows about 30~50% of reduction, compare to that of ideal CRTP scheme

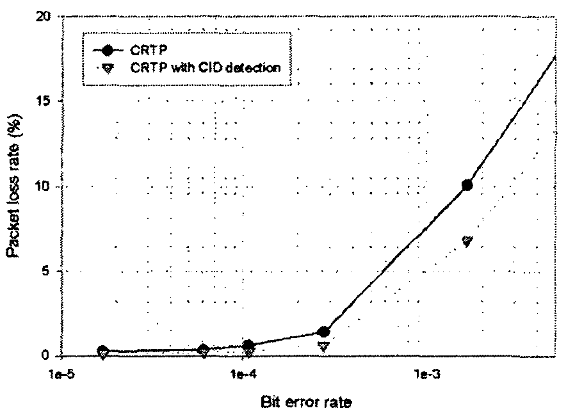

Figure 5. Packet loss rate for CRTP

CID detection method reduces the increase of the average header size through infrequent transmission of update packets due to packet loss. This also reduces transmission bandwidth. For a BER of 10-3, CRTP with CID detection method gives an average header size of 2.8 octets, while CRTP gives 3 octets. For the BER of less than 2e-3, CRTP with CID detection method reconstructs almost all of the loss packet due to damaged CID.

In ROHC, one packet loss does not trigger the additional packet loss due to long round trip time. The robustness of ROHC ensures that the context is not damaged by a few consecutive loss packets because previous loss packet does not affect the next packet. But more consecutive packet loss triggers unrecoverable context damage, which follows context update and additional packet loss. Figure 6 shows the packet loss rate versus channel BER in ROHC.

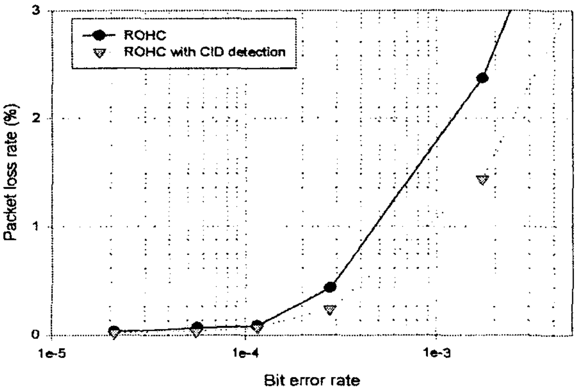

Figure 6. Packet loss rate for ROHC

If the packet which has damaged CID is received, the decompressor discards invalid packet only. The CID detection method helps these packets with a few bit errors reconstructed in decompressor, and helps the decompressor maintain valid context. The packet loss rate of ROHC with CID detection method shows about 30~50% of reduction compare to that of ideal ROHC scheme..

When there is no additional context repair mechanism, the average header size in ROHC gives 2.161. There is no great increase up to the BER of 10-3 because one packet loss does not trigger the additional packet loss.

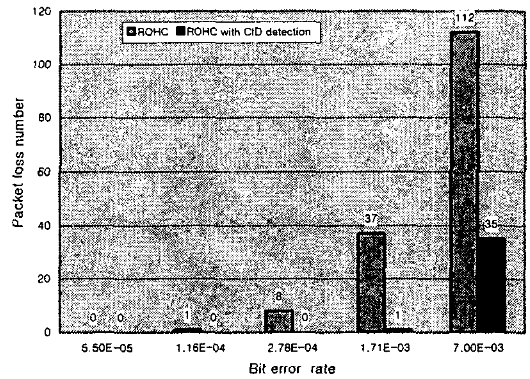

Figure 7. Packet loss due to damaged CID for ROHC

Figure 7 shows packet loss rate due to damaged CID for ROHC and ROHC with CID detection method in simulation environment. For the BER of less than 5e-3, ROHC with CID detection method reconstructs almost all of the loss packet with damaged CID, it means that most of damaged packets have only one or two bit errors. But for the BER of above 5e-3 it can not reconstruct many packets with damaged CID because it has high bit errors per one octet.

5. Conclusions

IP all the way, also over air-interface in cellular systems, enables IP service flexible. However, one of the main challenges for real-time IP over wireless is how to transparently compress the relatively large IP header over error prone cellular links. There exist two header compression algorithms such as CRTP and ROHC. These schemes can compress 40 octets of RTP/UDP/IPv4 headers to a minimum of 2 octets.

In this paper, we propose CID detection method to improve the performance of traditional CRTP and ROHC header compressing schemes. CID occupies about a half of compressed packet and lots of packet losses are caused by invalid CID, but most of bit errors in erroneous CID only have one or two bit error only. In the CID detection method, the decompressor calculates correlation between the CID of incoming packet and CID which the decompressor has in table. The CID detection method helps received packet with a few bit errors to be reconstructed in decompressor. It improves the performance of 30~50% for CRTP and ROHC in packet loss rate, 2~10% for CRTP in average header size. It is confirmed that packet loss due to damaged CID is almost removed by CID detection method in simulation results.

References

[1] Schulzrinne, H., Casner, S., Frederick, R. and V. Jacobson, "RTP: A Transport Protocol for Real-Time Applications", IETF RFC 1889, January 1996.

[2] Postel, J., "Internet Protocol", STD 5, IETF RFC 791, September 1981.

[3] Postel, J., "User Datagram Protocol", STD 6, IETF RFC 768, August 1980.

[4] Deering, S. and R. Hinden, "Internet Protocol, Version 6 (IPv6) Specification", IETF RFC 2460, December 1998.

[5] Casner, S. and V. Jacobson, "Compressing IP/UDP/RTP Headers for Low-Speed Serial Links", IETF RFC 2508, February 1999.

[6] M. Degermark and H. Hannu, "Evaluation of CRTP Performance over Cellular Radio Links," In IEEE Personal Communications, pp.20~25, August 2000.

[7] Carsten Borman et al, "Robust Header Compression (ROHC)", IETF RFC 3095, July 2001.