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Effect of Using Header Compression Method in TCP/IP Protocol Over HDLC in SCADA System

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Abstract

Most of the header information remains constant over the life-time of the connection. For TCP connection many fields are constant and others change with small values. To initiate compression of the headers of a packet stream, a full header is transmitted over the link. The compressor and decompressor store most fields of this full header as reference. The reference consists of the fields of the headers whose values are constant and thus need not be sent over the link at all, or change little between consecutive headers so that it uses fewer bits to send the difference from the previous value compared to sending the absolute value.

To improve interactive response time and to decrease the header overhead on the system we used the method of Compressing Protocol Headers (TCP/IP). Also it is used to compress the HDLC header. The simulated communication protocols have been tested between two PCs and the time delay, throughput and utilization have been measured.

Keywords: (TCP/IP) Transmission Control Protocol Internet Protocol, (SCADA) Supervisory Control And Data Acquisition, (UDP) user datagram protocol,(HDLC) High Level Data Link Control,(AES) Advanced Encryption Standard.

تأثير أستخدام طريقة ضغط العنوان الرأسي في بروتوكولTCP/IP فوق طبقة HDLCفي نظام SCADA

الخلاصة

أغلب العناوين الرأسية للمعلومات تبقى ثابتة أثناء فترة الاتصال.مثلا البروتوكول TCP تبقى الكثير من الحقول ثابتة وهناك بعضها يتغير بقيم صغيرة . للبدء بضغط العناوين الرأسية لحزمة البيانات المرسلة سوف ترسل الحزمة مع كامل العنوان الرأسي. سوف يعمل الضاغط ومفك الضغط بخزن نسخة من العنوان الرأسي الكامل وتعتبر هذه النسخة كمصدر للاعتماد عليها. نسخة المصدر تحتوي على الحقول التي تكون قيمها ثابتة ولاتحتاج الى إرسال مرة أخرى أو تتغير بقيم قليلة بين العناوين الرأسية المتتالية والتي يستعمل قيم قليلة لإرسال الفرق بين القيم السابقة اذا ما قارنت مع إرسال القيم المطلقة. لتَحسين وقتِ الردِّ التفاعلي ولتقليل الحمل على النظام تم استعمال طريقة لضغط العناوين الرأسية للبروتوكول TCP/IP بالإضافة الى ضغط العنوان الرأسي لطبقة HDLC . تمت عملية النمذجة للأتصال بأختبارحاسوبين شخصيين وقياس زمن التأخيرَ والطاقة الإنتاجية والاستخدام.

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1. Introduction

The Region to region communication in SCADA system for TCP/IP protocol is achieved by a RS-232-c link between these control centers. Communication protocols based on a layered architecture are responsible for managing the like [1, 2]. Most of the header information remains constant over the life-time of the connection. For TCP connection many fields are constant and others change with small values [3, 4].

1.Van Jacobson [5] has been used a method to improve TCP/IP performance over low speed (300 to 19,200 bps) serial links and compression TCP header, IP header over serial communication between many computers.

2. Stephen Pink and Mikael Engan [6] used new header compression schemes for UDP/IP and TCP/IP protocols. They show how to reduce the size of UDP/IP headers by an order of magnitude, down to five bytes.

3. Jason Jeffords and Lou Berger [7] used MPLS/IP header compression over PPP, each end of the link must agree on the use of compression and on the associated set of configuration options. PPP supports the negotiation of link parameters for network layer protocols via a family of network control protocols.

The purpose of the present work is to design and simulate the region to region communication system which uses a header compression of TCP/IP layers architecture. The developed TCP/IP protocol over developed HDLC protocol will be used with the Advanced Encryption Standard (AES).Also to applying the application layers to SCADA system and testing the performance of the implemented system in terms of delay, throughput, and efficiency.

2. Simulation of Region to Region Model with Header Compression

The simulation of the software system of region to region depending on using header compression in TCP/IP protocols.

The Region-To-Region system consists of five layers (Physical, Data Link, Network, Transport, and Application). The Physical layer uses the RS-232-c or USB to connect the control centers. In the Data Link layer uses HDLC frame to carry data from upper or down layer with depending authentication protocol (for security) in this layer. Network layered uses the IP (Internet Protocol) which have unique address of the host to deliver the data to specific host. Transport layer uses the Transmission Control Protocol (TCP) which is responsible for making and maintain the connection and sending/receiving data. Finally, the application layer which is used SCADA system for supervise the control center and this layer used AES as a method of data encryption. The three layers (Data Link, Network and Transport) will be used the headers compression methods to reduce the overhead on the system. Figure (1) shows the algorithm that used in region to region communication.

3. Results and Discussion

The system that work in real time it need high speed for communication and the time delay is very small, and need to calculate the utilization and throughput to ensure that the system is efficient for real time communication.

3.1 Time Delay Calculations

Time delay is calculated as the interval of the time required for a message ready for transmission to be sent from sender station until its successful reception at the receiver station.[8]

- For an uncompressed header frame

The overhead added by the transport layer is 20 byte. The overhead added by the network layer is 20 byte. Also the overhead added by the data link layer approaches to 8 byte. Hence, the total overhead added by these layers will reach 48 byte.

$$\text{Delay} = (\text{information length}+48) \times 11/\text{bit rate} \quad ....(1)$$

- For compressed header frame:

The compression headers added by the transport layer is 6 bytes, and by the network layer is 11 bytes, and by the data link layer approaches to 4 bytes. Hence, the total overhead added by these layers reaches 21 bytes.

$$\text{Delay} = (\text{information length}+21) \times 11/\text{bitrate} \quad ....(2)$$

The values of the time delay were reduced by using the compression header than that by using uncompression header and this is due to reduce in size of header with information transmission Moreover the calculated values of the time delay as shown in figures (2,3) by using USB 2.0 was less than that by using RS-232. The time delay values were decreased by using the USB 2.0 since the transmission speed was very high than that in the case of using the RS-232-c.

3.2 Throughput Calculations

The throughput rate is the average rate of transfer of the actual error-free bits of user data not counting overhead bits. [8] Information throughput rate can be defined as:

$$\text{Throughput Rate (TR)} = \text{Number of information bits/Total time} \quad .....(3)$$

Figures (4,5) show that the calculated throughput values were higher by using the header compression than that by using the header uncompression with all the speed of transmission used. The increase in the throughput was mainly due to decrease in the header overhead. In addition to that using the USB 2.0 as a physical media increase the throughput values compared to that using the RS-232-c due to the high speed transmission data.

3.3 Utilization Calculations

- For the uncompressed headers:[2]

$$\text{Utilization} = \text{Message Length (byte)} \times 8 \,/\, ((\text{Message length (byte)} + 48) \times 11) \quad .....(4)$$

In these frames the physical layer adds three bites (start bit, stop bit, and parity bit).

11= 8 (for one byte) + 3 *(start bit, stop bit, and parity bit).

- For the compressed headers:[2]

$$\text{Utilization} = \text{Message Length (byte)} \times 8 \,/\, ((\text{Message length (byte)} + 21) \times 11) \quad .....(5)$$

From figure (6) the calculated utilization valued were increased with increasing the information length. Also the utilization values were higher by using the compression header than that by using the uncompression header because the header overhead was reduced.

4. Conclusions

- Using the compression header method in the developed protocol improve the throughput, reliability, robustness and the speed of the protocol. The use of the USB 2.0 cable gives the system high speed (in compression to the RS-232-c cable) for sending-receiving data.
- Using the HDLC layer in the developed protocol protected all the transferred messages by applying the error detection mechanism (CRC).

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Send( )

Input: data.
Start :
Read data in application layer.
Encrypted data using AES.
IF (first frame send) **THEN**
Added TCP header.
Added IP header.
Added HDLC header.
ELSE
Add compressed TCP header.
Add compressed IP header.
Add compressed HDLC header.
ENDIF
Send compressed frame.
End.

Receive ( )

Input: frame.
Start:
IF (compressed frame) **THEN**
Decompressed TCP header.
Decompressed IP header.
Decompressed HDLC header.
ELSE
Removed the headers of all protocols.
Decrypted data using AES.
ENDIF
Get real data.
Closed the connections.
End.

Figure (1) The region to region communication with TCP/IP header compression algorithm.

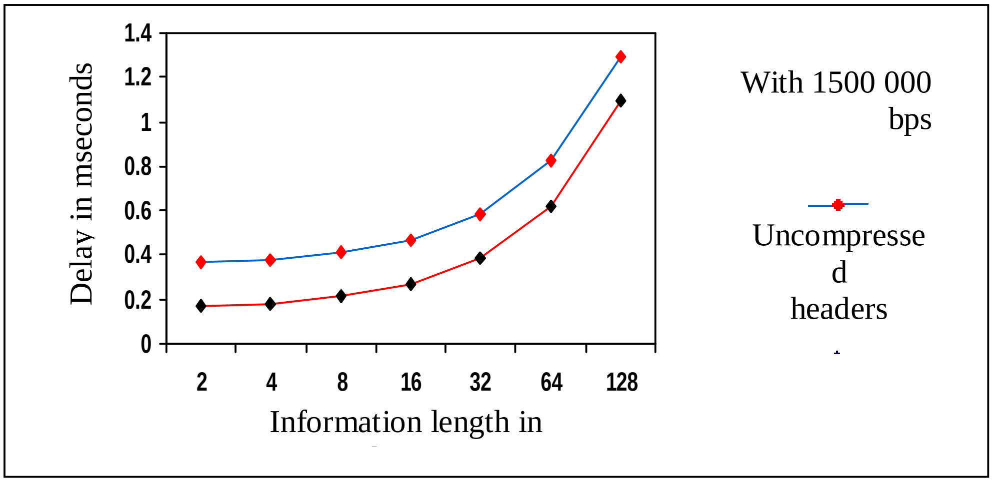

Figure (2) The relation between data information and round trip delay for both uncompressed and compressed headers using USB 2.0 cable.

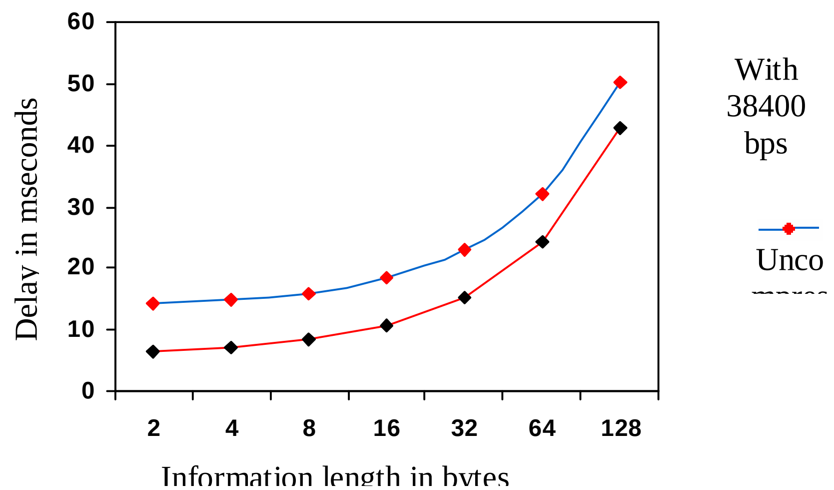

Figure (3) The relation between data information and round trip delay for both uncompressed and compressed headers using RS-232-C cable.

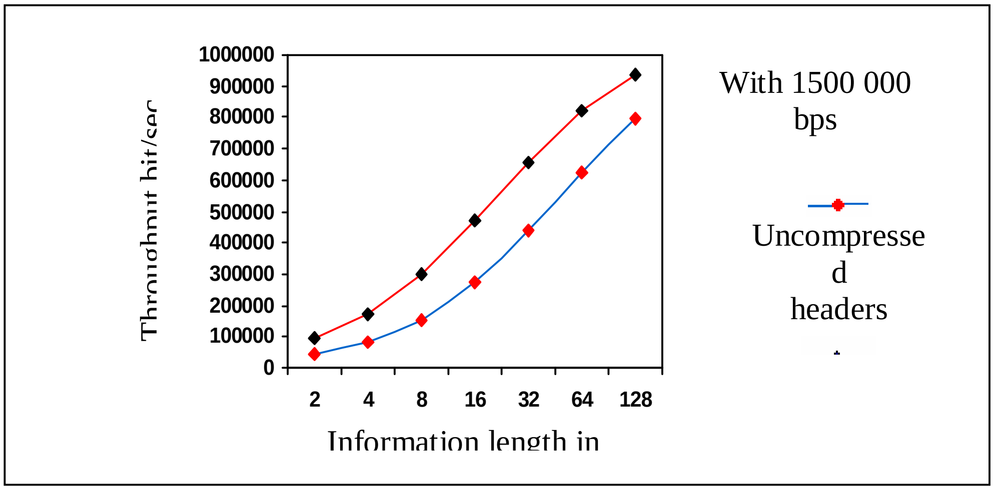

Figure (4) The relation between information length and throughput for both uncompressed and compressed headers using USB 2.0 cable.

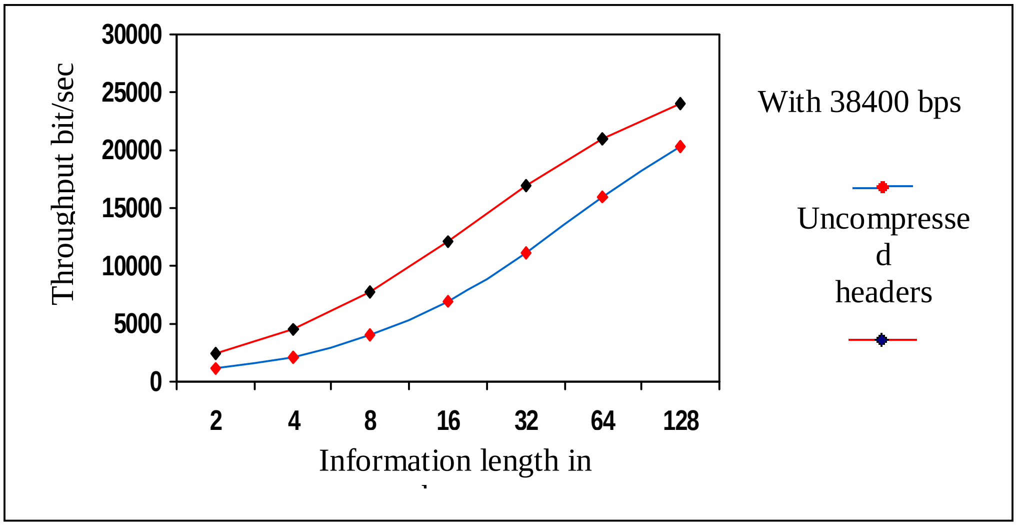

Figure (5) The relation between information length and throughput for both uncompressed and compressed headers using RS-232-C cable.

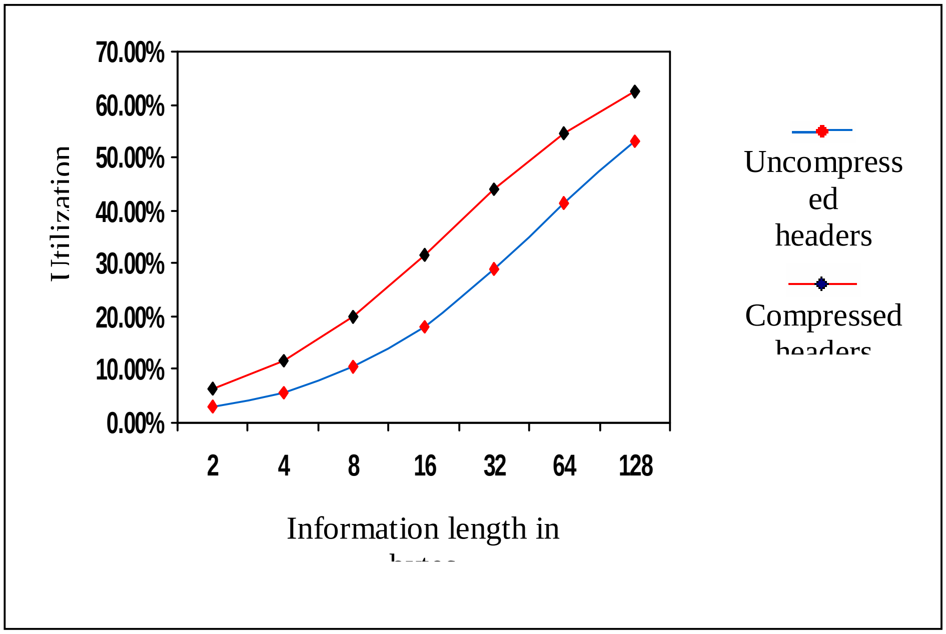

Figure (6) The relation between information length and utilization for both uncompressed and compressed headers.