An Investigation into Dynamic TLPs for Smartphone Communication
: To Facilitate Timed Response in Way Finding for Vision Impaired People

Dhammika H. De Silva[1], Dr. Iain Murray[2]

Department of Electrical &Computer Engineering, Curtin University
Western Australia [1, 2], Sri Lanka Institute of Information Technology[1]

[1]dhammika.koggalap@postgrad.curtin.edu.au, [1]dhammika.d@sliit.lk
[2]i.murray@curtin.edu.au

Abstract—**A reliable, high speed and efficient data transfer method is a very important factor in real time Way-finding systems since it requires information with very low latency to discover paths, avoid dangerous situations, identified changes in existing maps and alternative routes. This research will develop models and methods to facilitate bounded timing with minimal latency for way-finding application for vision impaired people. As a result of analyzing the requirements for way-finding applications, it was noted that some typical behaviours involve relatively small amount of data transfer through networks. Existing Transport Layer Protocols (TLP) are not ideal for providing such requirements. This research investigates existing TLPs and proposes modifications / extensions to facilitate demands in Way-finding applications and will implement the Dynamic TLP to incorporate both reliable data transfers with high efficiency as well as frequent data transfers which do not require reliability.**

Keywords— **Dynamic Transport Layer Protocol, Way-finding, indoor navigation**

I. INTRODUCTION

This paper discuses dynamic data transfer behaviour used in Way-finding application on infrastructure and ad-hoc networks and a specific Transport Layer protocol, Dynamic Transport Layer (DTL) protocol which will fulfil the data transfer requirements of Way-finding application. Figure 1 illustrates the overview of the system.

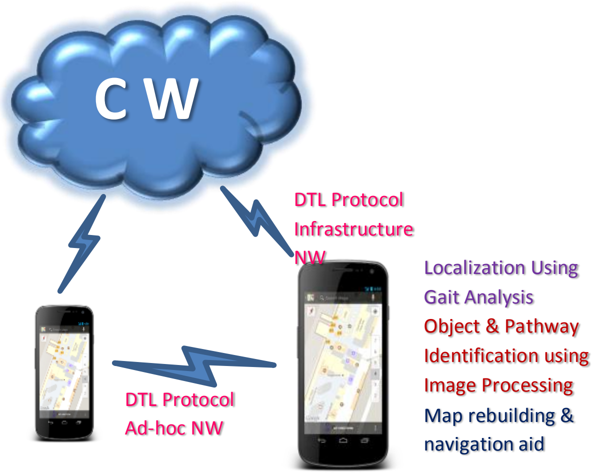

Figure: 1 Overall CWA system

The overall project includes *localization* using gate analysis, object & pathway identification using image processing, map rebuilding & navigation aid, and DTL protocol. All aspects will be designed and developed by several PhD candidates under sponsorship by Curtin University Offshore Partner Research Scholarships.

This research model, design & development of DTL protocol concentrates on the Transport Layer to improve the data transfer efficiency, specifically as applied to the requirements of Way-finding applications. Modifying the lower layer (Network layer, Data Link layer and Physical layer) are not considered in this research since alterations to these layers will leads to inconsistencies in routing and delivery on the Internet.

II. DATA TRANSFERS AND CHARACTERISTICS

The way finding application designed for Vision Impaired People requires efficient data transfer in between Building Information Model (BIM) and the person with disability - Infrastructure Network and among the peers (Ad-hoc network). This research identified the size of data, data transfer frequency, reliability, transfer direction and type of the network. Table I shows the summery of identified data transfers and behaviour of data in this system.

Table I: Behaviour of data transfers

Data	Size	Transmission Frequency	Delivery Reliability	Direction	Network
GPS - Processed	Very Small	High	No	C → S	I
Wi-Fi - Processed	Very Small	High	No	C → S	I
Obstacle - Fixed	Medium	Triggered	Yes	C → S	I
Obstacle – non stationary	Small	Urgent	Yes	C → S C → C	A, I
Map Data	Large	Triggered	Yes	S → C, C → S	I
User Location	Very Small	High	No	C → S C → C	A, I
Sensor data - Processed	Very Small	High	No	C → S	A, I
Instruction	Small	Urgent	Yes	S → C C → C	A, I

C- Client, S-Server, A – Ad-hoc, I-Infrastructure

The mobile device of the vision impaired person will capture the GPS, Wi-Fi and sensor data depending on availability and processed data will be send client to server. This data has very small payload. Due to the very high data transfer frequency the end-to-end reliability is not required. If one segment lost, there is another within very short bounded time.

In the case of a change in the existing map (Obstacle-Fixed), mobile device will be triggered to transfer data to the server. Urgent data transfer is required when a moving obstacle is found and data will be sending from client to server and client to client in addition to the instructions given by mobile device itself. The received information will be sent to the other vision impaired people who surrounding the same locations to avoid

the dangerous circumstances. All these data require low latency transfers with reliability.
When vision impaired person comes to the building, the server can transfer initial section of map. (Transfer, triggers by GPS data, Wi-Fi data or any specified mechanism). When the person is moving inside the building, the adjacent section of map can be send from server to the client based on moving direction. Fairly a large amount of data is transferring and data should be reliable. This data transfer direction is from server to user and it is not urgent.

III. LITERATURE REVIEW

In the Transport Layer, TCP provides reliability by process to process connection establishment, flow control, error control, congestion control and finally connection termination. TCP adds 20 bytes of standard header and up to 60 bytes with options by describing Transport Layer services required [1]. TCP is well suited to transferring large amount of data. However for smaller amount of application layer data, TCP can impose considerable overhead leading to significant additional delay effecting data transfer efficiency [2].

UDP does not provide processes for reliability due to absence of flow control, error control and congestion control mechanisms [3]. UDP is also not well suited for the Way-finding application since it not provides reliability. However UDP may provide lower overhead and latency, when considering small data transfers, than TCP since it has 8 bytes of header in Transport Layer. Table II provide the comparison of UDP and TCP.

Table II: Comparison of UDP and TCP [4].

Characteristic / Description	UDP	TCP
General Description	Simple, high-speed, low-functionality Protocol	Full-featured protocol with data transfer reliably
Protocol Connection Setup	Connectionless; data is sent without setup.	Connection-oriented; connection must set prior to transmission.
Data Interface To Application	Message-based; data is sent in discrete packages by the application.	Stream-based; data is sent by the application layer
Reliability and Acknowledgments	Unreliable, best-effort delivery without acknowledgments.	Reliable delivery of messages; all data is acknowledged.
Retransmissions	Not performed. Application must detect lost data and retransmit if needed.	Delivery of all data is managed, and lost data is retransmitted
Features Provided to Manage Flow of Data	None	Flow control -sliding windows; congestion control.
Overhead	Very low	Low, but higher than UDP
Data Quantity Suitability	Small to moderate amounts of data (up to a few hundred bytes)	Small to very large amounts of data (up to gigabytes)

A. *Drawbacks of TCP, UDP for requirements of CWA*

H. Falaki, *et al.* [5] found that most smartphone data transfers are small; with the median size being only 3KB. They showed that many data transfers, header bytes represent over 12% of the total. In the presence of transport security, this overhead grows up to 40%.

C. Wang *et al.* [6] details the following disadvantages of TCP in small data transfers:

- The overhead associated with TCP connection establishment might not justify its usage for short data collections in most event driven applications;
- TCP has degraded throughput under wireless systems especially with the high rate of packet loss because TCP assumes all packet losses are due to congestion and it triggers rate reduction whenever packet losses are detected.
- In contrast to hop by hop control, end-to-end congestion control in TCP has a delayed response, which needs longer time to mitigate and in turn leads to more packet loss when congestion occurs.
- TCP still relies on end-to-end retransmission to provide reliable data transport, which basically consumes more energy and bandwidth than hop-by-hop retransmission.
- TCP guarantees successful end-to-end retransmit of each segment which is not suitable for event-driven application. [6], [7].

Due to above factors TCP is not well suited transport layer protocol for the all aspects of the Way-finding application.
P. Benco, *et al.* [8] have discussed the connection setup delay has peak around 1 sec and has long tails 5 to 10 Sec in GPRS as shown in the first histogram in the figure 2.

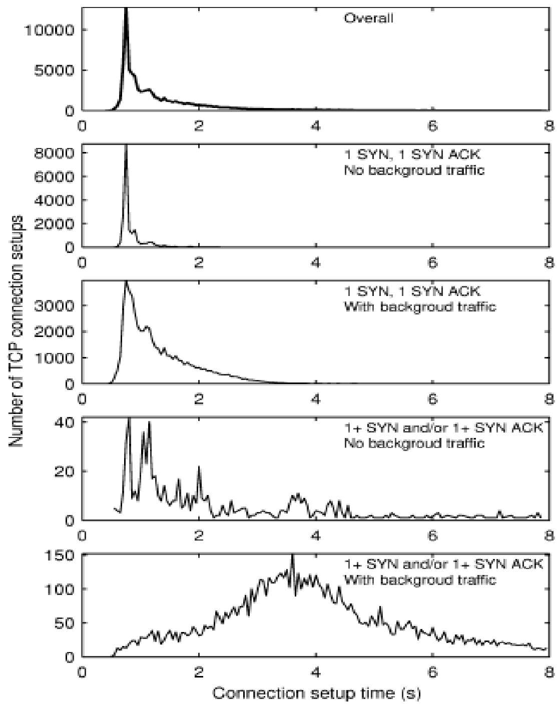

Figure: 2. Connection setup time components in a GPRS network [8]

From second histogram onwards shows the same without background data, with background data, without retransmission and with retransmission of *1+SYN* and / or *1+SYN/ACK*.
Way-finding application will have tight time constrains with the average walking speed of 2 steps per second (1.8 m/sec) [9], the mean connection time of TCP under the above condition is five seconds with background data and retransmission of *1+SYN* and / or *1+SYN/ACK*. Hence the vision impaired person has traversed 9 meters prior to being

given any updates. This delay is cause for great concern in way finding applications.

B. *Drawbacks of other TL protocols*

This research investigated Streaming Control Transport Protocol (SCTP) since it is useful for the map data transfers. SCTP is a reliable transport layer protocol which designed to transport data through Public Switched Telephone Network (PSTN) signalling messages over IP networks. It is capable to transfer data of various applications. SCTP offers the following features.

- *acknowledged error-free non-duplicated transfer of user data,*
- *data fragmentation to conform to discovered path MTU size,*
- *sequenced delivery of user messages within multiple streams, with an option for order-of-arrival delivery of individual user messages,*
- *bundling of multiple user messages into a single SCTP packet, and*
- *Network-level fault tolerance through supporting of multi-homing at either or both ends of an association.* [10]

SCTP includes appropriate congestion avoidance behaviour and resistance to the flooding. However SCTP has four-way handshake while TCP has three-way-handshake as illustrated in figure 3, which may be time consuming.

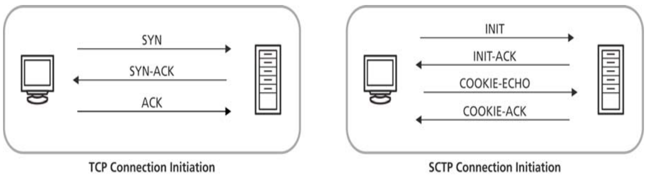

Figure 3: TCP and SCTP Connection Establishment Process [11].

UDP-Lite is similar to UDP, in that it can serve applications in network environments with high bit error rates that prefer to have partially damaged payloads delivered rather than discarded as in UDP [12].

Due to low payload overhead and some features of connection oriented behaviour, this research investigated Datagram Congestion Control Protocol (DCCP). DCCP provides bidirectional unicast connections by controlling the congestion via Congestion Control Identifier (CCID). However DCCP is mostly suitable for applications that transfer fairly large amounts of data [13].

Reliable Data Protocol (RDP) is designed to support bulk data transfers with reliability by providing connection establishment using three-way handshake similar to TCP [13]. Therefore RDP also have similar drawbacks as TCP has in connection establishment process.

A. Sharif *et al.* have discussed a sophisticated performance analysis based on transport layer protocols. They compare UDP, FACK, NRENO, RENO, SAK, TAHOE, and VEGAS. They clearly showed the average data loss, throughput, average delay and average power consumed. Most of the above mentioned transport layer protocols shows better performance than UDP [15]. However none of the above mentioned protocols are suited well to achieve the main objective i.e. dynamic behaviour of data transfer.

The table III shows the brief comparison of transport layer protocols and none of the above mentioned protocols fully facilitate all the requirements of CWA.

Table III: In of Transport Layer protocol in brief.

	TCP	**UDP**	**UDP-Lite**	**DCCP**	**SCTP**	**RDP**
Connection Oriented	Yes	No	No	Yes	Yes	Yes
Reliable	Yes	No	No	No	Yes	Yes
Header size (in Bytes)	20-60	8	8	12, 16	12	16+ V. Header
Data checksum	Yes	Yes	No	Yes	Yes	Yes
Path MTU	Yes	No	No	Yes	Yes	Yes
Flow control	Yes	No	No	No	Yes	Yes
Congestion control	Yes	No	No	No	Yes	Yes
Multi home	No	No	No	No	Yes	No
RFC's	793	768	3828	4340	4960	908, 1151
All CWA Requirements	No	No	No	No	No	No

Furthermore this research investigates the possibility to use header compression technique in order to improve the data throughput by reducing processing time and/or header overhead. V. Jacobson has described compression technique, AROHC that shows better performance in data transmission than TCP without header compression [16].

IV. Significance of this Research

Providing timely data transfer with reliability will be very useful especially for the vision impaired people to avoid dangerous situation such as drop off and change in shoreline. This will be useful when existing maps are change or new routes are found. Such changes also should transfer at an appropriate time or event to the main system so it will help to next person come in to the same area.

Location data does not required reliability since that data transfers frequently and if dropped, damaged or lost, will be retransmitted within a short bounded time. The outcome of dynamic behaviour in this research is very important to facilitate above requirements.

V. Modelling Methodology

As mentioned in objectives, this research is to design and develop a Dynamic Transport Layer (DTL) protocol, which is well suited to the low latency, small payload data transfers or large data without latency requirement or combination of both. In order to design DTL protocol, following stages are required as shown in figure 4.

Network Simulator 2 (NS2) is used to this research in order to simulate above mentioned stages. NS-2 simulator provides significant support for simulation of TCP over wireless networks and provides very good approximations of the overall process and come closer to the reality regarding the final values [17], [18], [19]. Firstly it is necessary to simulate with existing Transport Layer protocol such as TCP, UDP and SCTP. This information will be used to established benchmark and baselines for comparison to the proposed DTL protocol. This simulation requires several iterations with each change of the DTL protocol.

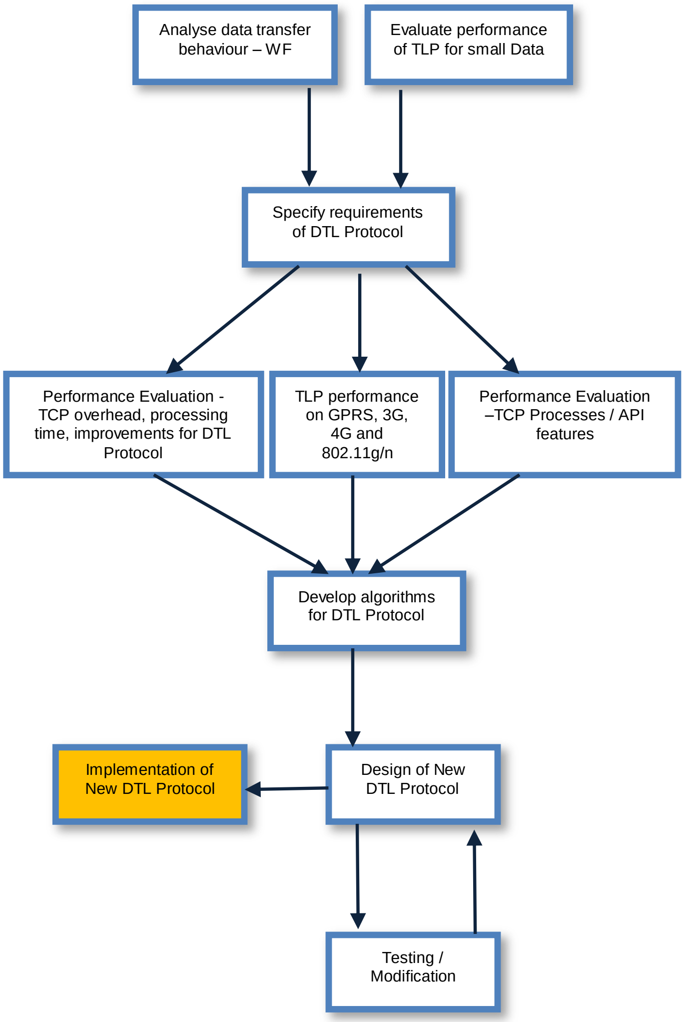

Figure: 4. Steps of Research Method

The final stage of testing would include "real world" testing with simulated data as availability of the completing of Way-finding application cannot be guaranteed. This will require the creation of simulated data set that include relevant sensor and map data to be communicated in standard mobile devices.

VI. Conclusion / Investigation

This research identifies specific data transfer behaviour in CUCAT Way-finding Application which requires dynamic and efficient data transfers in bounded time for small payloads. Due to lack of support of existing Transport Layer protocols to facilitate all requirements of the CWA, this research will be continue modification of low latency Transport Layer connection establishment process, variable bit sequence numbers and acknowledgment numbers, improved checksum mechanism, improved congestion control mechanism in order to meet the requirements of CWA.

This research may also be significant for other application areas, for example medical systems. These have similar requirements such as transferring of patient's vital signs (heart pulse rate, blood pressure, and blood glucose level) in real time, the delivery of large images (CAT scan, X-ray etc.) and patient notes at low priority

Acknowledgment

This research is one of sections of an ongoing Way-finding research project which is supported by Curtin Offshore Partner Research Scholarship and would like thank Curtin University and Sri Lanka Institute of Information Technology for providing this opportunity.

References

[1] B.A. forouzan, "Transmission Control Protocol" in *TCP/IP Protocol Suite*, 3rd Ed, Mc Graw Hill 2004.
[2] DARPA Internet Program Protocol Specification, "Transmission Control Protocol", RFC 793, September 1981.
[3] J. Postal, "User Datagram Protocol" RFC 768, August 1980.
[4] (2013-05-10). Summary Comparison of TCP/IP Transport Layer Protocols (UDP and TCP) [Online] Available: http://tcpipguide.com
[5] H. falaki, D. Lymberopoulos, R. Mahajan, S. Kandula, D. Estrin, "A first look at traffic on smartphones" IMC'10, November 2010, Melbourne, Australia
[6] C. Wang, K. Sohraby, B. Li, M. Daneshmand, Y. Hu, "A survey of transport protocols for wireless sensor networks" IEEE special issue on wireless sensor networks, May, 2006
[7] M. Park and S. Chung. "Distinguishing the cause of TCP retransmission timeouts in multi-hop in wireless networks", 12th IEEE international Conference of high performance computing and communications, 2010.
[8] P. Benco, G. Malicsko, A.Veres, "A Large-scale Passive analysis of end-to-end TCP performance over GPRS". IEEE Inforcom, 2004.
[9] T. Oberg, A. Karsznia, K, Oberg, "Basic gait parameters: reference data for normal subjects, 10-79 years of age", Journel of Rehabilitation and Development, Vol.30 No.2 1993, pp.210-223.
[10] R. Stewart, "Stream Control Transmission Protocol", RFC 4960, September 2007.
[11] P. Stalvig, "Introduction to the Stream Control Transmission Protocol (SCTP)", F5 networks, Inc. October 2007.
[12] M. Degermark, S. Pink, L-E. Jonsson, G. Fairhurst, "UDP-Lite", RFC 3828, July 2004.
[13] M. Handley, S. Floyd, "Datagram Congestion Control Protocol", RFC 4340, March 2006.
[14] D. Velten, R. Hinden, J. Sax, "Reliable Data Protocol", RFC 908, BBN Communications Corporation, July, 1984.
[15] A. Sharif, V. Potdar, A. Rathnayake, "Performance evaluation on different transport layer protocols on the IEEE 802.11 and IEEE 802.15.4 MAC/PHY layers for WSN". Proceedings of MoMM, 2009.
[16] V. Jacobson, "Compressing TCP/IP headers for low speed serial links", RFC 1144, February 1990.
[17] K.M. Reineck, "Evaluation and comparison of network simulation tools", M.S. Thesis, Dept. of Computer Science, University of Applied Science. August, 2008.
[18] (2013-06-05). Network Simulator 2 [online] Available: http://www.isi.edu/nsnam/ns
[19] T. Issariyakul, E. Hossain, "Introduction to Network Simulator NS2" Dept. of Electrical & Computer Engineering, University of Manitoba. Springer, 2009.