MODELING OF THE COMMUNICATION LINK FOR DATA CORRECTION IN NETWORK-RTK

Arief. M[1], Tajul A. Musa[2], Halim S[3], Shahrum S[4], Khairul A[5]
Dept. of Geomatics Eng., FKSG, Universiti Teknologi Malaysia,
81310 Skudai, Johor, Malaysia.
Phone: +6075530830; Fax: +6075566163
Email: a_marwanto@yahoo.com[1]; tajulariffin@utm.my[2];

Sevia M.Idrus[6]
Photonic Technology Centre,
Faculty of Electrical Engineering,
University Technology of Malaysia,
81310, Skudai, Johor Darul Takzim.
Tel : +607-5535302

Abstract

The current communication in several network-RTK systems is frame relay technology that applied packet switching network (leased line) based on IPVPN which services data transmission between reference stations to control station. The most significant shortcoming of frame relay technology is depend on cabling networks and bandwidth limitation that is not effective for the rural or suburban area. In other hand the channel speed of frame relay is relative small for data transmission. This limitation has an effect on bandwidth, cost and time delay of the data transmission. In this paper we propose the system model of the 3G technology that is capable to overcome cabling dependency due to complicated installation, cost and time delay due to low data rate that will be applied for Network-RTK system in Metro-Area of Iskandar Malaysia. 3G technologies offer users a wider range of more advanced services while achieving greater network capacity through improved spectral efficiency. Services include wide-area wireless voice telephony, video calls, and broadband wireless data, all in a mobile environment. It can be expected by applying of 3G technology in network-RTK, the performance system of real time data transmission are improved in bandwidth capacity, channel speed and diminish the expenditure of cabling installation.

Keywords: GPS, Continuous Operating Reference Station, Wireless Communication, 3G, Communication Systems

1.0 INTRODUCTION

Permanent GPS networks of regional scale have been established in many places around the world to support carrier phase positioning applications. Carrier phase-based positioning by combining and interpolating measurements from a network reference stations is often referred to as "network-based positioning" in this technique, network corrections' must be created in order to model the GPS systematic errors due to the effect of atmospheric delay and orbital error. The effect of correction term is to reduce the distance-dependent errors for the user and to therefore improve the carrier phase ambiguity resolution (AR) – a key step for centimetre-level positioning (Musa, 2007).

The conventional real time data correction services have been provided data messages via a radio transmission and limitation distance constrained coverage less than 10-20 km. A specification recommended by Radio Technical Commission for Maritime Service (RTCM) special committee 104

(SC-104) is a standard data format for differential GNSS services. Most GNSS receivers for RTK positioning are able to decode RTCM SC-104 data types. Networked Transport of RTCM via Internet Protocol (NTRIP) is a de facto standard protocol for real time GNSS data transfer. NTRIP comprises three components: an NTRIP server, an NTRIP Caster and an NTRIP client.[9]

The deployment of wireless internet capability has opened up the potential of disseminating these messages over the internet. It enables simultaneous PC, Laptop, Personal Digital Assistance (PDA), or receiver connection to a broadcasting host via mobile IP networks such as Global System for Mobile (GSM), General Packet Radio Services (GPRS), Enhanced Data Rates for GSM Evolution (EDGE) or Universal Mobile Telecommunications System (UMTS). Because the primary application is dissemination of RTCM SC-104 messages, the system as a whole present a transport protocol that will referred to herein as the NTRIP Protocol. NTRIP is designed to enable the simultaneous data dissemination from hundred of GNSS receivers to a few thousands of clients, in real-time.

2.0 SYSTEM DESIGN CONSIDERATION
2.1 Communication and System Architecture

In order to deliver real-time data to the application server, Figure 1 illustrate the fundamental connectivity of the 3G protocol and network interfacing. On the wireless mobile networks, the Internet Protocol (IP) is assigned by UMTS Terrestrial Radio Network (UTRAN). The UTRAN has diminished network latency; The Radio Network Layer is concerned with user data and control information. The Transport Network Layer is concerned with the transport technologies used for the UTRAN interfaces. The two layers are logically independent of each other. This makes it possible to change the Transport Network Layer without affecting Radio Network Layer, if required. In Release 99, the Transport Network Layer is based on Asynchronous Transfer Mode (ATM). In Release 5, IP is used. These communications network supplying many traffic types from the real-time Circuit Switched to IP based Packet Switched.

The UTRAN allows connectivity between the UE (user equipment) and the core network. The UTRAN comprises of the base stations, which are called Node Bs, and Radio Network Controllers (RNC). The RNC provides control functionalities for one or more Node Bs. A Node B and an RNC can be the same device, although typical implementations have a separate RNC located in a central office serving multiple Node B's. The transport network control plane includes the access link control application protocol (ALCAP). ALCAP is used to set up transport bearers to carry user and control plane information. It is not visible to the Radio Network Layer.
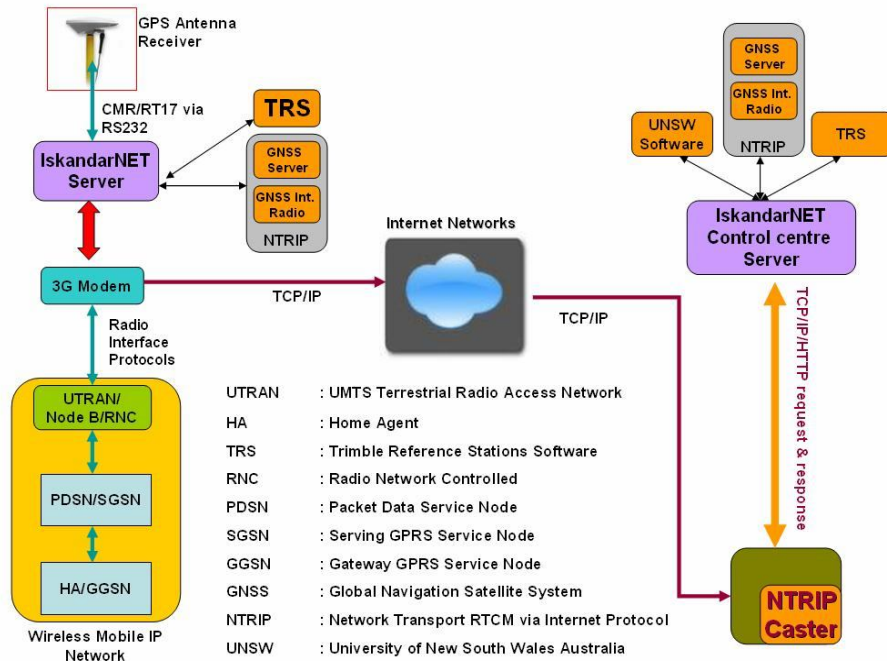
Figure 1: The 3G connection model on Network RTK

The Internet networks provides high reliable protocol that matches with 3G protocol towards assemble the connection setup of TCP/IP protocol. The standard TCP communication of NTRIP is based on the Hyper Text Transfer Protocol (HTTP) [RFC2616]. The HTTP is designed as an application-level protocol for distributed collaborative hypermedia information system, but it can also be used for linear streaming media. The basic unit of HTTP communication, consisting of a structured sequence of octets matching the syntax, is defined in the protocol and transmitted via a TCP/IP connection. Client and server must understand HTTP request messages and must answer with adequate HTTP respond messages. [9]

TCP operates at a higher level, concerned only with the two end systems; in particular, TCP provides reliable, in-order delivery of a stream of bytes from one program on one computer to another program on another computer. Whereas IP handles lower-level transmissions from computer to computer as a message makes its way across the Internet. The communications of the NTRIP caster and with clients are located in the middle of the networks.

3.0 THE 3G COMMUNICATION MODEL FOR ISKANDARNET

The ongoing development of Iskandar Network (IskandarNET) in Johor is to provide real-time network RTK services and data correction within Iskandar Development Region. The network comprises three reference stations, i.e., IskandarNET1 as a control station, is located in Faculty of Geoinformation Science and Engineering UTM; IskandarNET2 in Gelang Patah; and IskandarNET3 in Pasir Gudang.
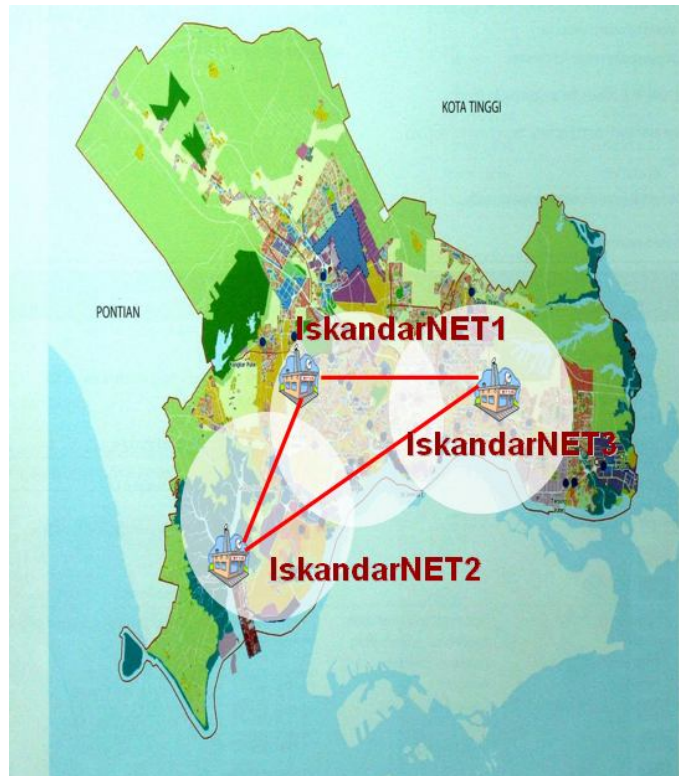
Figure 2: The IskandarNET

In order to streaming data real time on IskandarNET, Figure 3 illustrated the communication models using the 3G modem. The 3G is capable in providing fairly-high-speed wireless communication to support multimedia, data and video, with high bandwidth wireless communication. An important design goal for the 3G is to limit channel usage to 5 MHz, whereas 5 MHz is adequate for supporting data rates of 144 and 384 kHz.
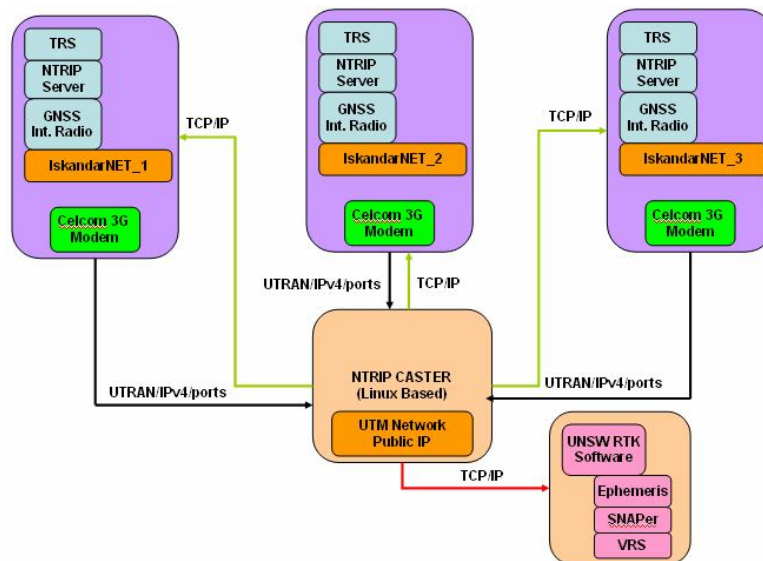

Figure 3: The 3G communication model for data Correction in Network RTK

The 3G act as communication link from reference stations to the control centre over the radio interface protocol in mobile IP network. In the 3G, the Radio Network Controlled is used to setup the Radio Interface Protocol which assigns a mobile IP address in the device or modem. The 3G IP connectivity are complement with the TCP/IP protocol to construct the connection session between reference stations in IskandarNET.
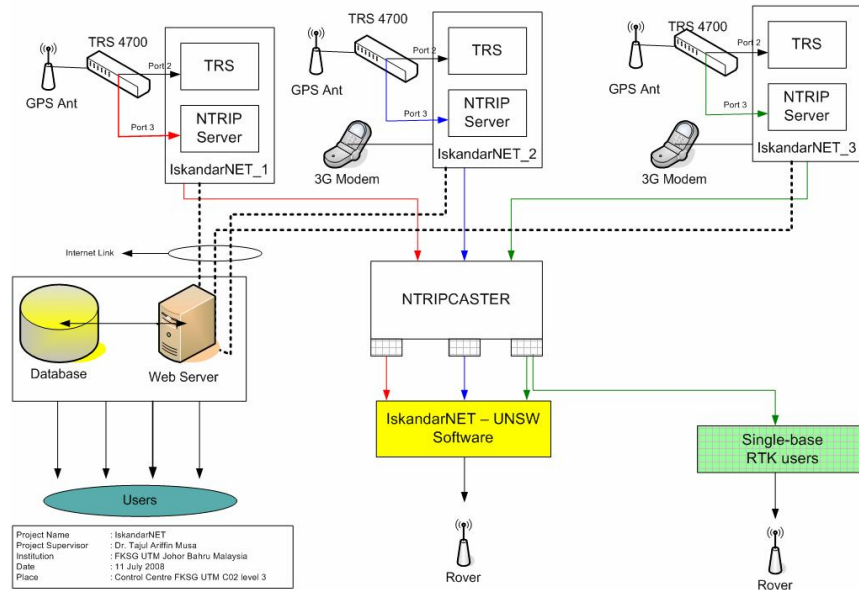

Figure 4: The architecture of IskandarNET with 3G technology

The algorithm of the connection setup is demonstrated in Figure 4. Trimble data in RT-17 format is submitted to the NTRIP caster via Ntrip Server 1.3.1 tools over TCP/IP connection setup. The function of NTRIP caster is to manage the packets flow within the IskandarNET. The clients will receive data corrections from NTRIP caster through GNSS Internet Radio 1.4.11. The real-time data corrections are performed by IskandarNET-UNSW software. The connection establishment of the IskandarNET - UNSW software and GNSS Internet Radio 1.4.11 are conducted via TCP port.

4.0 RESULTS AND ANALYSIS

The objective of the 3G model investigation is on reliability to run stable IskandarNET data communication. The investigation focuses on transport and network layer based on TCP/IP and OSI layer. The method involved the throughput or bandwidth measurement, reliability of connectivity and Round Trip Time (RTT). The traffic is consignment by real-time data streaming from IskandarNET. The 3G modem with a maximum transmission rate of 3.6 Mbps UMTS packet data service is used. The network analysis software such as Ethereal, Wireshark, OPNET IT Guru Edition, NS2 and OMNET++ were implemented in order to maintain data and analysis.
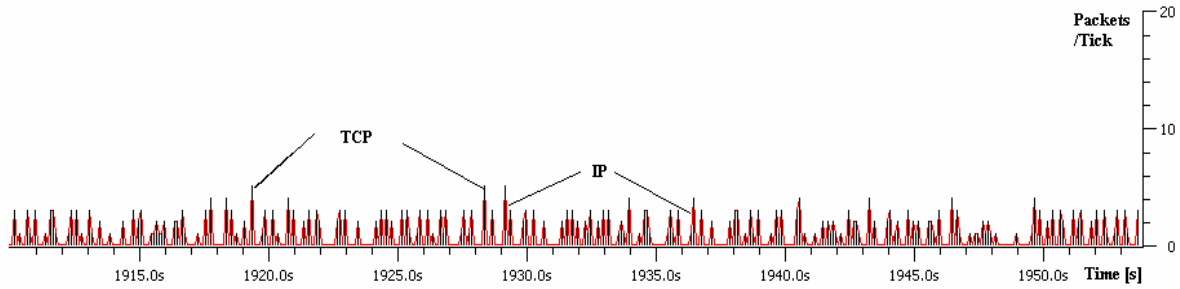.

Figure 5: The 3G packets traffic based on TCP and IP protocol

Figure 5 illustrate the 3G packet stream up over IskandarNET to the NTRIP Caster. The traffic in Figure 5 shows TCP protocol dominates the data stream. According to the Figure 5, both the TCP and IP are feasible for delivery of data streams in real-time; however, TCP is preferable because of its better reliability.
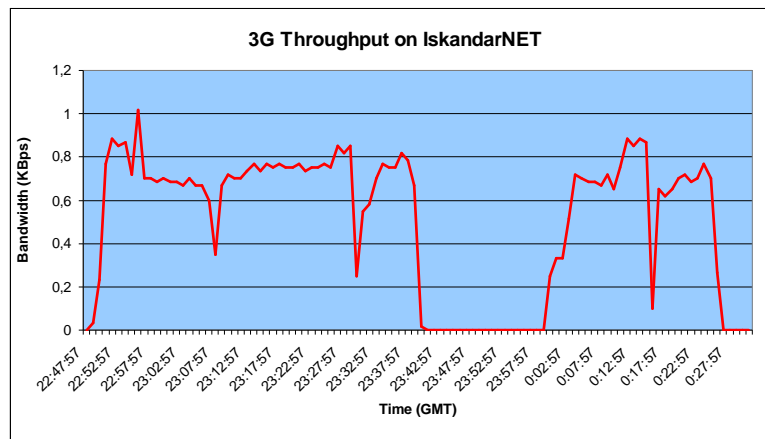

Figure 6: The 3G Throughput on Network RTK

Figure 6 shows the 3G throughput on IskandarNET according to Round Time Trip (RTT) and delay time. The line represent instantaneous throughput, which is defined as the size of the segment (in Kbytes) vs. the time since the last segment was seen. According to Figure 6, the capability of session connection in 3G is unstable probably due to some factors e.g. indoor environment of 3G access; multipath fading and session priority demands. On average the 3G data remain between 0.8 to 1 KB/s better than LAN connections. The throughput has demonstrated that connectivity of the 3G is unfairly in the indoor environment.
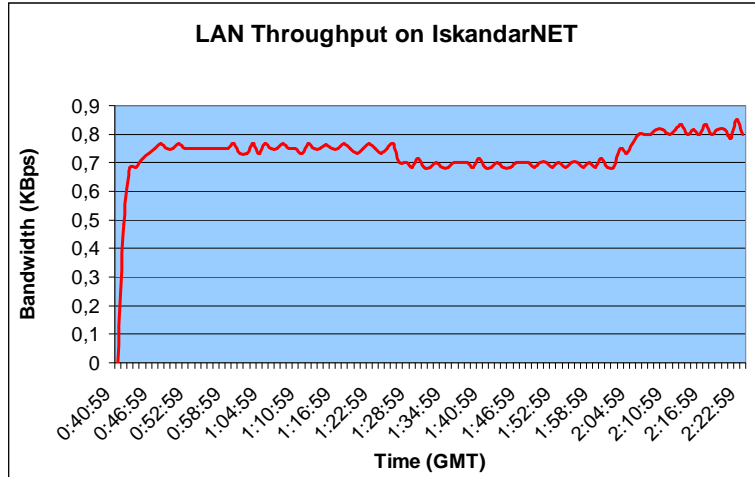
Figure 7: LAN Throughput on Network RTK

In order to compare 3G performance, we also performs LAN throughput on IskandarNET. Figure 7 shows the average of LAN throughput is below 1 KB/s if compare to the 3G throughput. The graph also shows LAN throughput is settled on the stable position. As being expected, LAN has a constant connectivity due to the leased line connection that is installed with Wide Area Network (WAN).
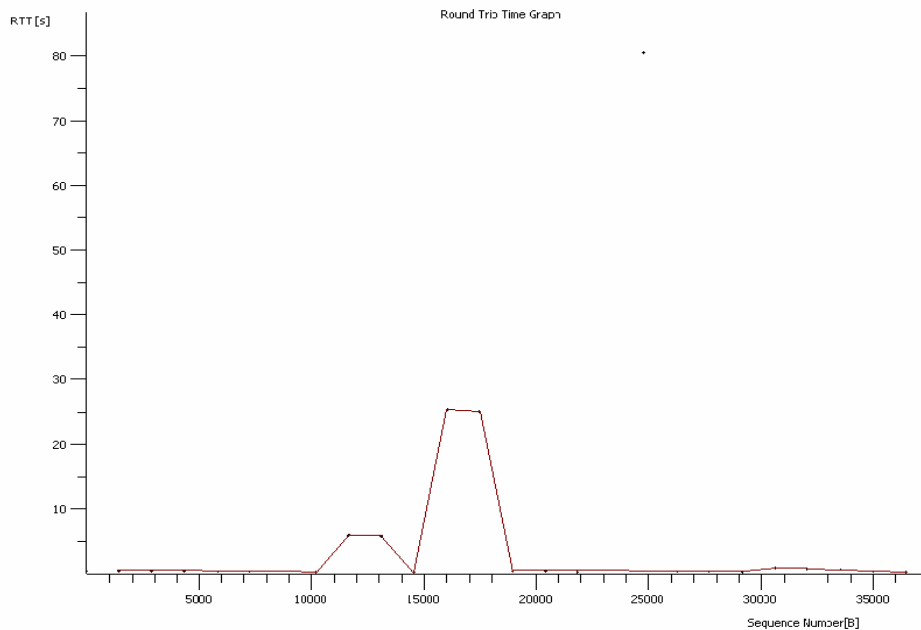

Figure 8: The 3G Round Trip Time (RTT) on Network RTK

Round-trip delay time is significant in systems that require two-way interactive communication, such as voice telephony, or ACK/NAK data systems. The round-trip time directly affects the throughput rate, such as the Transmission Control Protocol (TCP). In Figure 8, the Y-axis represents RTT in milli-seconds and the X-axis represents time. The line represents RTT samples calculated from non-retransmitted

segments. Figure 8 demonstrated that RTT packet loss and errors during transmission and retransmission from UTRAN to the user (3G modem) influencing the 3G network latency due to high delayed time of bandwidth.
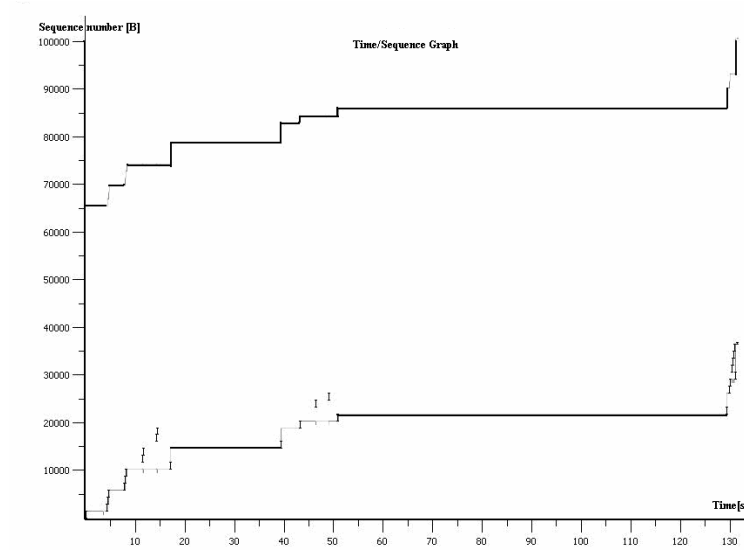

Figure 9: The 3G TCP Trace on Network RTK

Figure 9 illustrated the TCP trace linearly increases along to the number of TCP packet that is transmitted over IskandarNET. The top line refers to tracks of received window advertised from the other endpoint. It is drawn at the sequence number value corresponding to the sum of the acknowledgment number and the received window advertised from the last ACK packet. The little tick of black arrow is representing segments which were sent. The up and down arrows represent the sequence numbers of the last and first bytes of the segment respectively. The below line refers to track of the ACK values received from the other endpoint. The sequence number of bytes and segment of TCP increases linearly, hence affect the 3G performance.

5.0   CONCLUDING REMARKS

The 3G has successfully installed on IskandarNET. The throughput and RTT results show that the 3G is able to send data correction for IskandarNET. High level of Round Trip Time delay probably due to the signal to noise ratio is huge. The quality of RTT would be influenced of network latency and throughput in 3G networks. The effects of RTT and throughput impact to the connection session of 3G on network RTK. Effort should be made to reduce the TCP round trip time that is most heavily a requirement on the radio network. Indoors environment is one of the factors that reduce the 3G signals quality. However, the 3G communication model has performs in bandwidth provisioning that improved spectral efficiency and low network latency. By applying of the 3G technology, the performance system of real-time data transmission is improved in bandwidth capacity, channel speed and diminish the expenditure of cabling installation.

6.0   ACKNOWLEDGEMENT

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