THE UTILIZATION OF TCP/IP IN FAULT AND DISTURBANCE RECORDERS - OPERATING COST OPTIMIZATION

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Summary: *Power systems are subjected to minor or major disturbances. Disturbances in power system may leads to longer outage and caused interruption of power supply to the consumers. It is important to analyze each disturbance in order to optimize the network operating cost. Prior to the application of digital fault recorders, System Operators relied mainly on the relay operations, which sometimes led to inaccuracy in the decision making process and caused longer outage period. Hence, increased the operating cost unnecessarily.*

This paper describes the practical analysis on Malaysian transmission grid network operating cost. It is also made an economic comparison before and after adopting this new approach, which the information from the digital fault recorders has demonstrated to be more accurate, thus enabling quicker judgment and normalizing the supply. This approach helps Tenaga Nasional Berhad (TNB) Malaysia in saving operating cost for every disturbance in the power system.

Keywords: ***Network Operating Cost, TCP/IP, Fault Recorder, Disturbance Recorder***

1. INTRODUCTION

The importance of monitoring the performance of power system has steadily increased over the years [1]. The evaluation of system disturbances has become more complex and the monitoring of equipment's performance has become essential for power system reliability to ensure competitive power supply in the deregulation industry.

In the electrical power system business industry, economic factor plays an importance role in order to sustain continuous and reliable power supply.

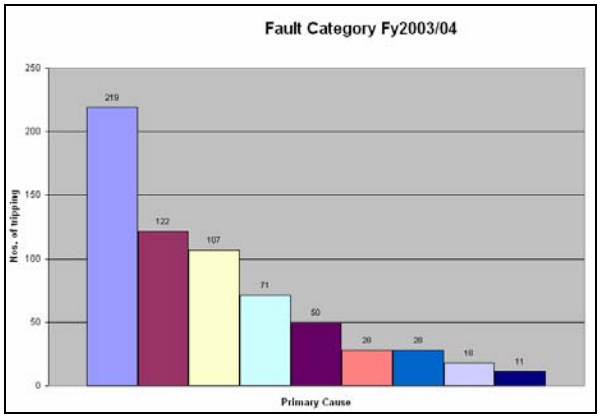
2. ECONOMIC IMPACT ON OPERATIONAL COST

In large power networks such as TNB, there are hundreds of disturbances each year. Hence the analysis is a significant problem. The operational costs for each disturbance may add up to thousands of dollars each year. To overcome these problems, fault analysis is implemented as a tool to help the System Operator to identify the power system failure.

Fault analysis is a method for power system evaluation to achieve an economical, reliable and secure power supply in the grid system. This analysis will be the greatest challenge faces by Power System Operators during system disturbance. The situation becomes more critical if the communication medium to download the data takes a few hours to complete. There are a few methods to download the tripping data from a recorder remotely such as dial-up via Telecommunication PSTN and Power Line Carrier. The latest and economical approach was using Ethernet Communications Protocol (TCP/IP). By using the latest approach, the fault analysis in transmission grid system becomes faster in identifying the location and types of the fault which occurs in the electrical network [2]. A part from the evaluation functions, the fault analysis is used for various purposes, such as minimizing outage period from accurate fault type identification, fault location, and detection of weak points and faulty equipment in the power system [3]. As a result from the above application, by using the right tools the utilities are able to improve the Transmission Grid System reliability, at the same time minimizing the operational cost.

2.1 Fault Statistics

Faults that occur in transmission grid system can be grouped into few categories. These categories correspond to the cause of tripping that was found during analysis of the fault.



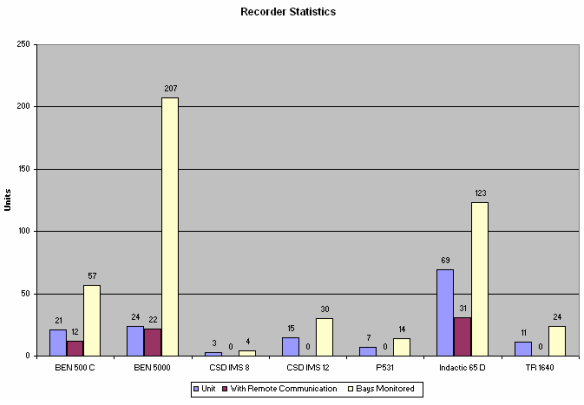
Primary Cause	Total
Defective Equipment	219
Adverse Weather	122
Other	107
Subsidiary System	71
Foreign Interference	50
Abnormal System Condition	28
Human Factor (TNB Staff)	28
Adverse Environment	18
Utility/Customer	11

The data shown above are current tripping data from year 2003/2004. The data shows that primary causes of tripping are defective equipment followed by weather and other causes. It is not a surprise since Malaysia is a tropical country where lighting strikes, heavy storms occurs in common. The total fault recorded in these year alone amounts to 654 cases.

To enable these faults to be analyzed quickly, a faster and cheaper way to download all the tripping information need to be adopted and the most viable way is by using TCP/IP.

2.2 Recorder Statistics

TNB has implemented Digital Fault Recorder (DFR) on system wide basis. There are 7 type of DFR being installed and use with the total of 150 units of DFR.



Type	Unit	With Remote Communication	Bays Monitored
BEN 500 C	21	12	57
BEN 5000	24	22	207
CSD IMS 8	3	0	4
CSD IMS 12	15	0	30
P531	7	0	14
Indactic 65 D	69	31	123
TR 1640	11	0	24
Total	**150**	**65**	**459**

Each DFR will monitor certain number of bays and some of the critical area recorders are provided with remote communication for faster data retrieval. The performance of the remote communication between TCP/IP and PSTN are being examined in this paper.

2.3 Fault Location

It is important to monitor and provide accurate fault location in order minimize the outage period. Prior to the application of recording devices, fault location was done by patrolling resources using helicopter and walking under the transmission lines rentice. By using the conventional approach, which is dangerous, it is also very costly and takes longer time to determine the location of the fault.

After six years adopting this new fault location approach, information from the fault recorders in fault location has demonstrated to be more accurate, thus enabling quicker fault locating and normalizing the supply. The new approach has helps TNB in reducing the operating cost for each disturbance.

Below is the comparison on operation cost between two methods; conventional and using Recorder's fault location.

Items	Operation Cost (USD)	
	(Before)	(After)
Helicopter services	3,200.00 for 6 hours	Nil
Line's Team Salary	162.00 for 8 person -16 hours patrolling	8.00 for 2 person –3 hours patrolling
Outage Cost	730,000.00 for 2 days outage	45,400.00 for 3 hours outage
Total Operation Cost	733,362.00	45,408.00

Table 1: Operation Cost Before and After Fault Location Application for 275kV Overhead lines [4]

From the table 1 above, the total operational cost saving is USD 687,954.00 for each disturbance for a critical lines.

3. GENERAL CONSIDERATIONS

Cost, fast data retrieval and availability of network are the factors taken into account before adoption of TCP/IP into the system. With high number of tripping cause by weather and equipment, fast on-demand data is the utmost important part being evaluated.

3.1 Drawback of PSTN

PSTN are prone to noise disturbance which leads to errors of data being transferred and received. PSTN does not have error detection inside its system except at the modem. If errors occur modem will have to request data to be transmitted again and this takes up a lot of time.

Long connection time with the recorder means higher are the calling cost. Total costs of USD 90,000.00 per year were spent by TNB just on calling cost to the data recorder.

PSTN is just not suit to be a dedicated data communication channel as it is not efficient in terms of bandwidth handling and it is superior for voice application not data.

3.2 Adoption of TCP/IP in fault recorders

TNB have an optical fiber backbone connected between substation as communication channel for teleprotection and telecontrol application. Since network is already available, it is more economy to use Ethernet protocol to retrieving data from fault recorders.

TCP/IP communication does not require modem in order to communicate. This 'always on' communication helps in term of fast data retrieval from many data recorder at once. No additional cost need to be invested except maintaining the network for a lot of other applications.

4. ETHERNET COMMUNICATION PROTOCOL – TCP/IP

4.1 Dial-up Communication (PSTN)

In 1994, TNB's Kuala Kangsar's substation installed their first PSTN in their existing recorders. However, there are certain disadvantages when using PSTN. Dial-up (PSTN) uses analog transmission to transmit data. In order to retrieve data, fault analyzer will have to contact the recorder via modem. Although this seem easy enough, establishing connection using dial-up takes some time. Moreover, the PSTN architecture built for voice is not flexible enough to carry data. Therefore, TNB is now gradually shifting to using TCP/IP instead of PSTN.

4.2 TCP/IP

TCP/IP protocol suite has become the common standard for computer communications in today's networked world. TCP/IP, a packet based data communications protocol functioning at layer 3 (IP) and layer 4 (TCP), can use multiple paths to reach its destination. The main design goal of TCP/IP was to build an interconnection of networks that provided universal communication services over varied physical networks.

The obvious advantage of such an internetwork is the enabling of communication between hosts on different networks, perhaps separated by a large geographical area. Therefore, TCP/IP enables a faster and precise fault locating over a long distance and thus leads to the reduction of time for locating the fault as well as the operating cost.

Fault recording using TCP/IP was first used by TNB in 2001 in the Yong Peng North Substation. The use of TCP/IP has clearly shown the increase of speed of the data transmitted. From the screen capture comparison, the data retrieved by using PSTN is only 85 bytes/s where as the data retrieved by using TCP/IP reads 29579 bytes/s. With the quicker transmitting of data from the fault recorder, more accurate analysis on the fault can be obtained. This is important as the fault analysis data could be used to minimizing outage period, fault location, and detection of weak points and faulty equipment in the power system. Thus, as a result from using TCP/IP, Transmission Grid System reliability can be improved and at the same time minimizing the operational cost.

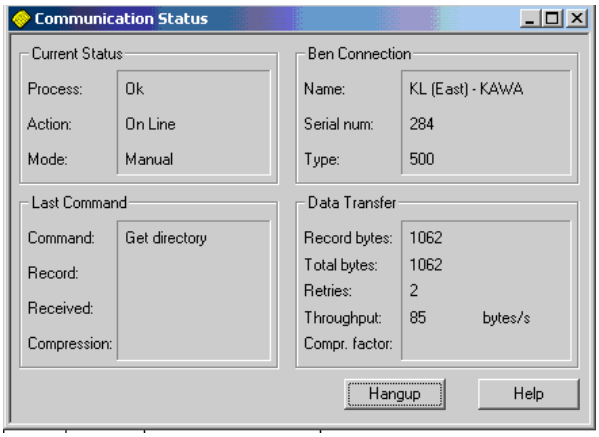


Figure 1: Screen Capture of Communication Using PSTN

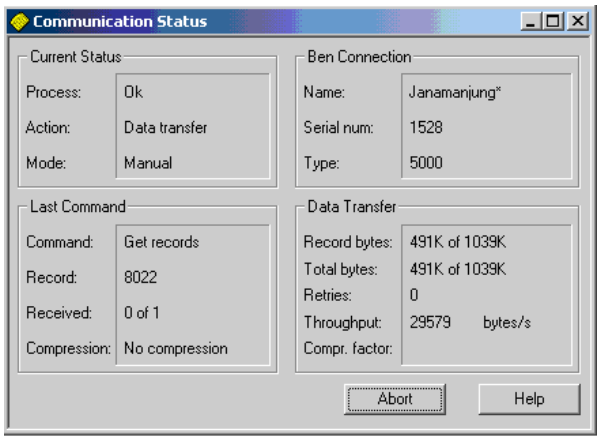


Figure 2: Screen Capture of Communication Using TCP/IP

5. CONCLUSIONS

The benefits of the fault and disturbance recorders installed in the TNB Transmission Grid System have made significant improvements in the operations of the power system. In conclusion, with the application of TCP/IP in the fault and disturbance recorders communication have proven to be extremely effective in providing the power system operators the tools they require in order to perform their work effectively and efficiently. After implemented the new communication medium (TCP/IP), the decision making process becomes much easier and faster. As a result TNB reduces the operational cost for each tripping that occurs in the Grid System.

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7. BIOGRAPHY

Ir. SAZALI P. ABDUL KARIM, P.Eng. has over 17 years of experience in Transmission Protection System specializing in fault investigation with Tenaga Nasional Berhad (TNB), a power utility company in Malaysia. Sazali has been intensely involved in the protection studies and application of Fault and Disturbance Recorders in the Transmission Network. With his experience in fault investigation, protection coordination and planning, Sazali has been entrusted to head a Fault and Disturbance Recorders specialist team. This team has successfully introduced new and very effective method and approach in conducting Fault and Disturbance Analysis. His work has contributed to significant reduction of system minutes.

Sazali has shared his ideas and experience by presenting several papers at various conferences and courses at the local and international level. At the national level, he has received an award as a recognition from the Malaysian Government which was presented by the H.M. the King in June 2000. Sazali's work also received an international recognition when his paper entitled "Tenaga Nasional Berhad Experience on the Application of Fault and Disturbance Recorders" won 1999 Best Paper Award at the Fault and Disturbance Analysis Conference in Atlanta, Georgia, USA.

Sazali received his Degree in Electrical Engineering with Honours from University of Technology Malaysia. He holds a Master Degree qualification in the same discipline with specialization in Fault Analysis for Transmission System. He is currently a member of Board of Engineers Malaysia (BEM), The Institution of Engineers Malaysia (IEM) and a registered Professional Engineer.

Other than being active in the research and development of Fault Recorders application, Sazali is currently responsible for developing and conducting Transmission Protection Courses for Tenaga Nasional Berhad. He is also currently active in conducting Fault Analysis Courses in University of Tenaga Nasional, Power Utilities in Asia Pacific and Middle East.

SUHYLEE SOYAT is currently attached as a Protection System trainer in TNB Training Institute. His experience in research ranging from power losses experience in Tenaga Nasional Berhad Distribution (TNBD) and voltage sag identification for power quality issues. His interested in the operation, application and research of protection scheme in TNB networks as well as fault analysis.

Suhylee received his degree in Electrical Power System with Honors from University Tenaga Nasional (UNITEN) and currently a member with Board of Engineer Malaysia (BEM).

NG THIEN LEE is currently attached as a Telecontrol trainer in TNB Training Institute. Her experience in research ranges from PSTN, PLC to the application of TCP/IP in TNB system. Her research also includes data transmitting using various methods. She is interested in the operation and application of networking systems in TNB. Currently, she takes interest in looking at the data transmitting for the purpose of fault analysis.

Thien Lee received her degree in Electrical Electronics with Honors from University Tenaga Nasional (UNITEN) and currently a member with Board of Engineer Malaysia (BEM).