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COMPACT COPPER CABLE ANTI-THEFT SYSTEM SOLUTION

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ABSTRACT

As the price of the copper increased due to high demand globally which used in various sectors, it become a major factor in boasting cable stealing activities particularly telecommunication cables since it is low risk, less hazard and easy to cut. The present invention relates to anti-theft monitoring apparatus for cables, especially for telephone lines, electrical cables and other communication lines, and more particularly, relates to the apparatus for detecting the cable theft by sensing the cables vibration. This system applies combination of vibration sensor, GSM and GPS module in order to form a complete solution for cable theft. The system able to detect the theft incident by recognising the vibration pattern made by cutting tools such as hacksaw, cutter and dagger. It also able to give information such as movement and location of the stolen cable.

Keywords: copper cable theft, GSM, GPS.

INTRODUCTION

Telephony cable theft is a widespread problem that results in revenue losses to the data service industry totaling several billions of dollars per year. This action will increase the data service interruption and further decrease the possible arrest of convict due to cable theft if proper security is not established. This action will further increase the financial impact in service restoration and cable replacement by service providers.

Current situation shows one of the problems facing by the telecommunication company such as disrupt transmission line of telephony and data services due to cable theft and the number of cases increasing year by years. For instance TM Malaysia reported 11.539 cases of cable theft and 6,759 cases in the first eight month of 2012 [1] and TM suffered about RM 8.8 million for the whole 2012 due to cable theft [2] . It cost to South African economy about R5-billion a year and copper cable theft was declared a high priority crime [3]. Hence there is a need for low cost apparatus in detecting the overhead cable theft by sensing the physical.

The present invention relates to anti-theft monitoring and tracking system for overhead telecommunication copper cable and more particularly, relates to the device for detecting the cable theft by sensing the cable vibration as shown in Figure-1. CAT is an abbreviation for Cable Anti-Theft (CAT) system which is first entry level deterrent system to protect telecommunication overhead (OH) copper cable from theft. It comprise of devices attached to the OH copper cable and connected to the remote terminal unit (RTU) inside the telecommunication cabinet.

The CAT device consists of low cost microcontroller and unique vibration sensor which has been calibrated to detect the vibration pattern of theft attempts with various techniques such as theft attempt using tools such as cutter, jigsaw and dagger. The CAT device also consists of lithium ion battery to power the device when the cable is cut and removed from its initial location. For tracking functionality the device is equipped with GPS (Global Position System) and GSM (Global System for Mobile) to determine the movement and locations of the stolen cable sent to the system via SMS.

When there is a theft attempt, the system will sense the cable vibration and sent alarms to CAT server. The CAT device will repetitively send SMSs in defined period which contain movement location of the cable to the server and recorded accordingly through Google Map application. Norizan et al. [4] has proposed the remote sensing cable theft device which only able to detect the occurrence of the cable theft without tracking capability using complex and expensive FPGA solution.

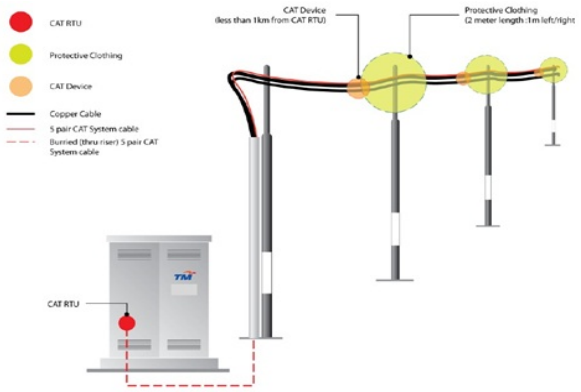

Figure-1. Deployment plan of CAT system at TM networks.

CAT SYSTEM COMPONENTS

The main components of the CAT system are divided into the following categories as in Figure-2 which consisted of hardware and software components, as below:

- Cable Protective Clothing
- CAT Device
- CAT RTU
- CAT Application

A mechanical barrier which assembled together encapsulates copper cable to protect the copper cable from

theft. It consisted of an enclosure made of reinforce plastics that is wrapped around the copper cable. The clothing is also reinforced with galvanised steel rope wire at left and right side of the protective clothing. The design intent is to create difficulty to cut the copper cable using available cutting tools in the market.

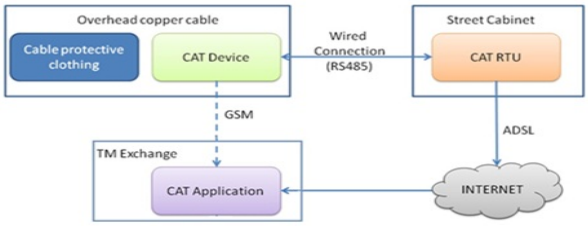

Figure-2. CAT system overview.

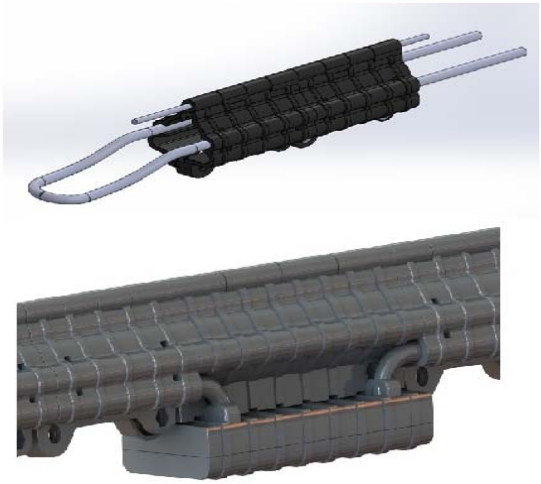

Figure-3. Cable protective clothing.

CAT device is a low cost microcontroller hardware device that is assembled on the overhead copper cable to detect vibration generated during attempt to cut the cable as in Figure-4. The CAT device in connected to the CAT RTU via a five pair power cable for charging and communication (full duplex RS485) purposes. The CAT device is also equipped with a GSM module so that it can alert user when there is an attempt via SMS. In addition, the CAT device is equipped with a GPS module to track the movement of the copper cable if the copper cable is being cut and taken away from its original location. The GPS tracking information is pre-configured at one minute interval (tracking interval can be re-configure according to user requirement). When there is a theft attempt, the CAT device will send signal to CAT RTU thru RS485 wire and alert CAT Application server by SMS. CAT device vibration detection technique is done by if the vibration level detected is above the pre set vibration threshold value for the CAT device, an alarm signal will be triggered. Alarm signal also will be sent if the CAT device is disconnected from CAT RTU. Alarm SMS signal contains information about Cat device status such as alarm type (vibration/cable cut), coordinate and battery level status and time stamp.

CAT RTU is a hardware device that is placed inside the street telecommunication cabinet. Its main functions are to monitor the status of the CAT device connectivity with RTU, relay the alarms to CAT Application server and charging the CAT device battery. The CAT RTU is connected to the CAT Application server via ADSL connection to alert the server system in case of attempt to cut the copper cable. CAT RTU is powered up using 240 volts supply at cabinet. Outdoor modem is being used to make CAT RTU communicate with CAT application through ADSL line.

CAT application is a monitoring and tracking application which consists of a backend engine and a web portal. Ideally, the CAT application's main functionality is to send out alerts to the security team in the event of a cable theft attempt as well as tracking the location of the stolen cable via GPS. Alarm data sent by RTUs as well as CAT devices will be processed by the engine and interpreted to a readable format before being forwarded to the relevant personnel. The engine will process all relevant information from the received data such as alarm type, battery level, device location, cabinet inventory information and cable location, among others. This will enable the security team to act promptly in the event of a cable theft attempt. Additionally, if cable theft does occur, the position of the device attached to the cable can be viewed and tracked via the web portal. This will ensure the swift retrieval process of the stolen cable. The inventory of RTUs and CAT devices are also being managed by the CAT application.

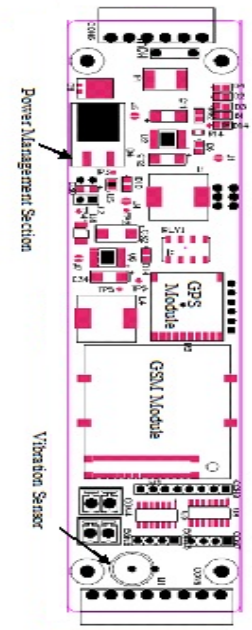

Figure-4. CAT device PCB top layer.

FALSE ALARM REDUCTION TECHNIQUE

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In order to reduce the number of false alarm made by the CAT device, unique technique is implemented in order to reduce the false alarm trigger by the nature factors such as wind, rain and small animals. The actual data of cutting the cable were collected during CAT system which covers techniques such using various cutting tools such as hacksaw, cutter and dagger. More than 10 samples of each technique are recorded and the average pattern is calculated via moving average algorithm in order to come out with default profile reference for cable theft attempt. Moving average algorithm is simple software technique used in order to smooth the vibration sensor data which consists of equidistant points is moving average. An array of raw vibration sensor data [Z_1, Z_2, Z_3, …, Z_n] can be converted to a new array of smoothed data. The smoothed point $(Z_k)_s$ is the average of an odd number consecutive 2n+1 (N = 1,2,3,..) points of the raw vibration sensor's data:

$$(Z_k)_s = \sum_{i=-n}^{i=n} \frac{Z_{k+i}}{(2n+1)} \quad (1)$$

The reference pattern is used by the CAT devices in determining the sensitivity of the vibration can be defined below:

CAT Devices Sensitivity = (Current sample attempt $(G_k)_s$ – Default Profile$(Z_k)_s$) > 0

$$= \sum_{i=-n}^{i=n} \left(G_{k+i} - \frac{Z_{k+i}}{(2n+1)}\right) \quad (2)$$

From Figure-5, the CAT devices system will calculates the sensitivity using Equation (2), between the sample vibration sensor data, the default profile data and count the number of the data which equal or exceed from the default profile curve within the same normalized period. If the sensitivity number exceeds the defined setting (which based on experimental result) the alarm will be triggers. Optimum sensitivity setting is 50 for CAT device after series of experimental analysis. The value can be set from range of 1 to 255 which indicates the higher to lower sensitivity. Vibration pattern value detected above 50 will generate alarm. Time out: 100 steps or 20 sec for each pattern reading before sensitivity value calculated. Figure-6 shows the typical experimental data collection graph between the running sample collections with the default profile which trigger the alarm due exceed the sensitivity level of the CAT devices.

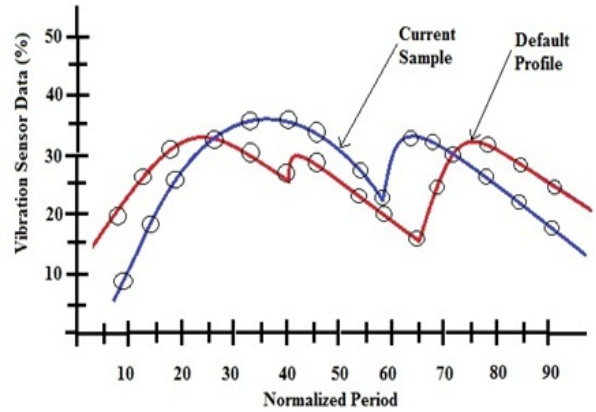

Figure-5. Comparison graph between running current sampel of CAT devices and the theft default profile.

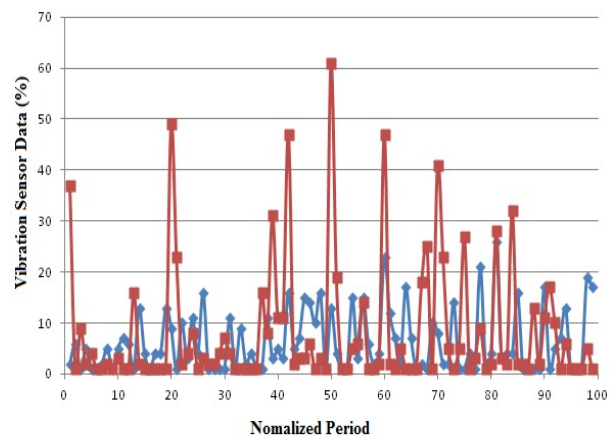

Figure-6. Experimental graph between running current sampel of CAT devices and the theft default profile.

PROOF OF CONCEPT

Proof of concept (POC) objective is to confirm effectiveness, reliabilities and practicalities of the system on the real situation at field. The location was selected by TM Selangor due to higher number of cable theft cases occurred at that area. The test site location is at 3.487808N 101.631188E as shown in Figure-7.

Installation CAT system for POC is completed at Rasa (F017) Taman Cemperai, Rawang. The theft simulation were performed at this site and the details of the location of the simulation on Google map™ showed in Figure- 7. Theft alarm is generated through the CAT portal which showed the status of the cable, which has been cut when RTU can communicate to the device in pre-defined period. The CAT device will sent a location coordinate to the CAT SMS server and by the data, the location of the moving cable is plotted on the map as in Figure-8.

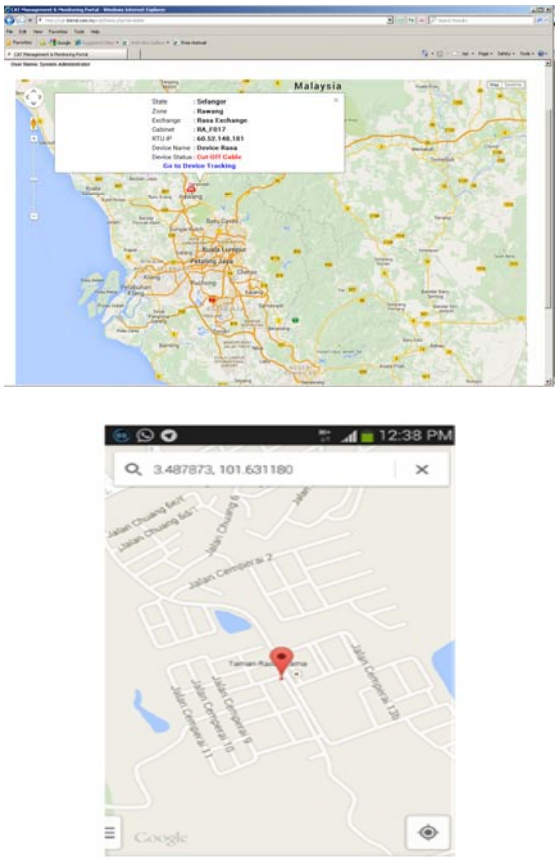

Figure-7. Alarm generated during cable theft at Rasa, Rawang exchange (viewed inside CAT portal).

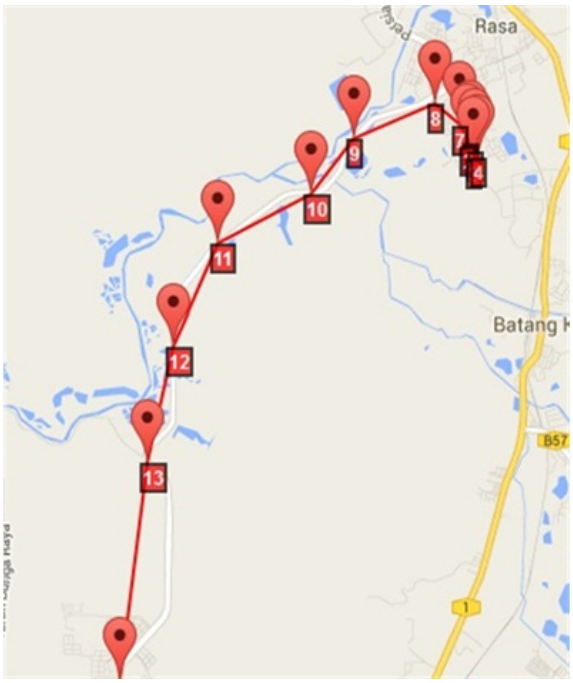

Figure-8. Cable movement tracking inside CAT portal.

CONCLUSIONS

The CAT system is designed to combat the cable theft crime facing by telecommunication companies nowadays. The CAT device is attached to the telecommunication cable with mechanical clothing. The system is comprise of mechanical vibration sensor, GPS and GSM module in order to senses the theft characteristic cable vibration pattern and send SMS alarms to the users which contained location of the movement of the cable. The system has been tested in real environment in POC stages at Taman Cemperai, Telekom Malaysia (TM) Rawang and successfully detected the simulation theft activities as well as tracked down the location of the movement cable.

ACKNOWLEDGEMENTS

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