

A Survey of GSM Technology to Control Remote Devices

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Abstract

This work describes the different design and implementation of a GSM based remote systems. All existing systems either use GSM or GPRS technologies; however, GSM is the basic way of communication. Due to global GSM roaming facility and good network capability, there is virtually no requirement to build additional network. GSM based SMS services are very cheap and affordable; therefore transmission of data based on SMS in real-time applications has become very popular. GPRS data transmission speed is much faster than normal text message, approx 28 to 32 SMS per/min may be achieve over GPRS. This study explores different tools and technique being used to control communication network through SMS. We also critically review the merit and demerit of various existing solutions. The results of the study are reported in this paper.

Keywords: *Global System for Mobile Communication (GSM), GPRS*

1. Introduction

Voice and text message based communication services have been used broadly. GSM is the most fundamental way of communication. Due to global GSM roaming facility and good network capability, there is virtually no requirement to build additional network. GSM data transmission involves the following three types of communication.

- a. Short message service
- b. General Packet Radio Service

a. Short Message Service (SMS)

SMS is the most common and economically affordable service and it is used for both receiving and sending text message. SMS is based on transferring information via GSM network and a single text message can include up to 160 characters. When a message is sent by a mobile, it is called mobile originated (SMS-MO) and when a message is received by a mobile phone, it is called short message mobile terminated (SMS-MT). Since SMS is inexpensive and convenient to make use of, therefore, the transmission of data based on SMS in real-time applications has become popular. Bi-directional data transfer can achieve in SMS based application, and its stable performance gives a strong support platform for remote data communication and monitoring equipment. Extensive use of GSM services for industrial application is merely due to its low cost and good transmission quality, particularly for short text messages.

Existing network systems use alarm monitoring. For this purpose, alarm message is generated to the Network Operation Centre (NOC) team, which is a one way communication (paging) using SMS and Simple Mail Transfer Protocol (SMTP). Message is forwarded to NOC team members on their cellular phones using SMS-MT.

Several systems have been implemented for home automation such as communication network for smart home using existing power line as proposed by Lin *et al.*, [1]. In such systems, the existing electrical wiring is used for data communication inside the home. There are some systems which used conventional telephone lines for controlling and monitoring home appliances through telephone remote controller. Such a method for controlling home appliances still has its limitations, as it is not easy to control home appliances in any situation for example it is complicated to move wires and handling them physically.

Several industrial applications have been developed using wireless communication to boost security and safety standards. Wireless communication provides cost efficient solutions to an extensive range of remote monitoring and control applications [2]. A number of remote monitoring, tracking and control system application have also been developed using GSM technologies such as remote SOS system [3], remote monitoring system [4], theft control system [5] and intelligent door-control security [6] *etc.*

b. General Packet Radio Service

General Packet Radio Service is a packet oriented wireless data communication service available on the 2nd and 3rd generation cellular communication systems for mobile communications. GPRS operates at the speed up to 115 kbps and compared to 9.6 kbps speed of GSM. It supports a wide range of bandwidth. It is, therefore, it is not only suitable for sending and receiving small bursts of data such as web browsing and e-mail, but also is equally useful for large volumes of data transmission. The core network of GPRS allows WCDMA, 2G, and 3G mobile networks to transmit IP packets to outer networks such as the Internet. The GPRS system is an incorporated part of the GSM network switching subsystem. GPRS extends the GSM Packet circuit-switched data abilities to perform and makes the subsequent services possible like Multimedia Messaging Service (MMS), Wireless Application Protocol (WAP), SMS messaging and broadcasting, Push to talk over cell phone (PoC) *etc.* It supports Point-to-point protocol (PPP), Internet protocol (IP) and X.25 connections.

Transmission speed, approx 28 to 32 SMS per/min may be achieve over GPRS. It is faster than using the normal SMS over GSM, whose transmission speed of SMS is about 5 to 10 SMS per/min.

2. Literature Review

Vougioukas and Rouincliotis [7] propose a network management system based on GSM technology that supports multi-user, multi-session and a two-way network management. The system also provides remote network access to the administrator. The bi-directional communication functionality between cellular phone users and network services is developed by author. This proposed system receives short message, parses it, executes commands typed as a message and replies back to the sender the status of the executed commands accordingly. Nevertheless, the amount of information that mobile users can send and receive in one SMS is limited to 160 characters only. Since the response generated by the executed commands can consists of several hundred character; therefore, splitting a single message into multiple parts can be one possible

solution. Commands related to network services such as DNS, ping, finger, telnet, logout etc. have been implemented by the authors and authorized users can add new commands through a separate functionality provided in the tool.

Al-Ali [8] focuses on home appliances automation using GSM technologies. This system provides facility to user to control and monitor house electrical device via mobile phone by sending control commands in the form of text message and receiving the electrical devices status as well. There are two main parts of this proposed solution: software and hardware. Driver circuit is used to connect devices to 8-bits microcontroller to establish communication between homeowner and the system through SMS. The predefined SMS commands are limited to 160 characters only. The system received command via GSM modem, interprets it and operates the appliances accordingly followed by communicating current status of the appliance to the homeowner via SMS. This system provides remote access to control and monitor home appliances. This necessitates formulating an appropriate method to make sure that devices are set up according to the preferred commands. In addition, a response circuit is designed for sensing the current flow of device and to inform the system whether the device is OFF or ON.

Xuehua [9] implemented a methodology to remotely control the home appliances based on GSM technology by establishing communication between AT89S52 MCU and mobile phones through SMS. Common AT commands are used to read SMS of mobile phones and delete messages as well. In this system, mobile user sends operating commands in the form of text messages to the cell phone attached with the terminal controller via GSM network. The received commands are stored in SIM card of the terminal controller cell phone which are read and analyzed by the microcontroller connected with the terminal controller cell phone. The microcontroller executes controller commands and after executing the commands, a feedback is send to the user and the message is deleted from SIM card of the terminal controller cell phone. The content size of message for both sending and receiving is strictly limited.

Wang [10] designed the remote control system for monitoring remote appliances and sending messages of the machine to its supervisor automatically. The system uses ARM (advanced RISC machine) processors based embedded systems and GSM technologies. This remote control system has three main parts: sensors, ARM microcontroller and GSM modem. Sensors are used to monitor the machine and send monitoring signal via serial port to the ARM microcontroller. ARM processor controls GSM modem through the serial port (RS232). In case an abnormal condition happens, sensors detects it and GSM modem is triggered by the ARM microcontroller and a suitable SMS is sent to the supervisor by using the AT command. On receiving SMS, supervisor can take appropriate actions to resolve the problem.

Remotely home automation based on GSM is proposed in [11] in which the controller controls home appliances through TC35 module at any time and from anywhere. And the structure of this system is not complex, it's a composition of cellular phone, GSM module, relays and MCU. The communication between home appliances and user is being cognizant of GSM. The different control actions can achieve by MCU according to the user supplied SMS which can be one of four different formats. The first format is used to set information between power devices like AC and relays to facilitate power operation. The second message format relates to password controller. The third format is used to change password whenever user wants, and the fourth format is used for authentication mechanism is implemented for operating the power

system, and to operate the power. Common AT commands are used to read short text messages of mobile phones and delete messages as well.

Xu and Du [12] designed remote control system based on GSM, which is composed of GSM technique and advanced MCU. Two main hardware components, one is MCU (89C51) microcontroller and second is TC35, and MCU 89C51 microcontroller is the main control unit and TC35 is the system's external unit, and it gets control system commands which are received by TC35. Then, it controls the relays to execute the instructions. When new message is received by TC35, the MCU microcontroller firstly extracts the message sender number, and then checks message content, if the sender number is designated, and if it is a control system command, the MCU microcontroller controls the relays according to the instruction and replies to user with an "Operation Successful" message. If it is not the case, then MCU skips the text message and replies the user with "Operation Failed" message.

GPS-GSM based tracking system is design and developed by Khan and Mishra [13] which finds the object position *i.e.*, vehicles or other assets etc, and informs remote user via GSM modem. Object motion is reported by a short text message. This real time monitoring system is able to detect object's current position using GPS and informs the vehicle owner via GSM. Owner has rights to stop the motion of object like bus or taxi using short text message. This system provides real time control, and is able to monitor objects in real time mode. The main purposes of this proposed system are real time tracking, object location information identification, tracking driver's activity *etc.* It is consistent and cost effective and has the ability of accurate tracking. This proposed system is also useful for theft prevention of object, user can track stolen vehicle with the help of tracking reports. Tracking reports contain detailed information of object like where your object is, and where it has been, how long it has been etc. The system gets geographic position and time information from the GPS Satellites. The system uses three components 32 bit ARM controller, GPS and GSM modem. The core functionality of the system is to monitor and analyze the vehicle position using GPS satellite and send the time, longitude and latitude and information to the user.

Humidity remote monitoring and control system is developed by Ramamurthy *et al.*, [14], which scrutinizes and controls the humidity from the remote location. When the level of humidity crosses the predefined limit; the processor sends a SMS to the concerned person using GSM network. The user can now accesses the system through the cell phone by sending AT commands to a GSM modem. The system also provides password security to prevent unauthorized access to the system, and uses GSM technology by providing full access to the system for security, analysis and control of humidity by HMCS (Humidity monitoring and control system).

J2ME based cellular application for remote administration of a server using GPRS technology is designed and developed by Kulkarni *et al.*, [15], and the main purpose of this solution is to remotely access and control different applications such as launching games, wordpad, winamp, or other similar application. Administrator can shutdown, restart or logoff remote server, and also administrator can access database including query processing and viewing the results. This application is implemented in java 2 platform, micro edition (J2ME), and it is robust and secure platform. Architecture of this application is classified in 3 categories, j2me client, http server, and computer with static IP (internet protocol).

Vehicle disturbance and theft control system based on GSM and GPS developed by Mustafa [16], to determine the physical position of object, vehicle and an asset. The tracking device is attached with the object and using GSM technology the information

is transmitted to the remote user controlling the attached automated device in an object (vehicle, asset *etc*). One of the illustrious features that system provides, it allows the user to take quick action via SMS from a far-off place like cause an engine to seize or gear locking *etc*. This system provides vehicle latitude and longitude information to user. Mercury sensors are used for sensing purpose, if anyone intrude the stationary state of the vehicle it inform microcontroller to take an action. It gives incessant readings to the microcontroller on the basis of which decisions are taken. A set of predefined actions inform of messages are stored and each for a prompt a particular action. The methodology used in the proposed model is that a GPS module, GSM module, and an interface of mercury switches are being implemented with a microcontroller. The microcontroller incessantly receives data from the GPS module and mercury switches, and takes decision on the basis of the collected data onto the microcontroller. If someone disturb the vehicle, Microcontroller will generate a message to the user and send the current location of the vehicle and what sort of an disturbance has been made, such as, has it been made with doors, or trunk or bonnet. User will have the option to take an action from a far off place.

GPS-GPRS based Object Tracking System implemented by Hasan *et al.*, [17], it allows user to view the current and past location of recorded object through internet on Google map. System identified the current position of object using GPS, and send data to user via GPRS. Data is stored in MySql database for past and current tracking. A web application is implemented using JavaScript, Ajax, PHP, and MySql database with the Google Map embedded. It is cost effective solution and good for vehicle theft situation.

Automatic Meter Reading system is proposed by Jain [18] *et al.*, this proposed system give the information of meter reading, total load used, power cut, tempering, and power disconnect.

Iqbal *et al.*, [19, 20] proposed performance metrics for software design and software project management. Process improvement methodologies are elaborated in [21, 22] and Khan *et al.*, [23] carried out quality assurance assessment. Amir *et al.*, [24] discussed agile software development processes. Rehman *et al.*, [25] and Khan *et al.* [26] analyzed issues pertaining to requirement engineering processes. Umar and Khan [27, 28] analyzed non-functional requirements for software maintainability.

Khan *et al.*, [29, 30] proposed a machine learning approaches for post-event timeline reconstruction. Khan [31] suggests that Bayesian techniques are more promising than other conventional machine learning techniques for timeline reconstruction. Rafique and Khan [32] explored various methods, practices and tools being used for static and live digital forensics. In [33], Bashir and Khan discuss triaging methodologies being used for live digital forensic analysis.

3. Critical Analysis

The framework proposed by Vougioukas and Rouincliotis [7] operates under light resources as the system is multi-threaded. Therefore, network related commands which may involve big timeout will not affect system performance. It is complicated to execute network related command like telnet and perform network reconfiguration due to poor GUI of cellular phones, a possible solution to cater for caveats of poor GUI is to use WAP protocols; however, WAP services are quite expensive.

Remote controlling home appliances system proposed and implemented by Xuehua [9], the cost of this proposed solution is not very high. The system is flexible, convenient, uncomplicated and user friendly as it meets the users requirements. Remote

power controller for home automation has some advantages, like easy usage, reliability, low cost, and wide coverage [11].

GPS-GSM based tracking system [13] to determine the physical position of object, vehicle and an asset, the tracking device is attached with the object and using GSM technology the information is transmitted to the remote user controlling the attached automated device in an object (vehicle, asset *etc*). This system provides vehicle latitude and longitude information to user. The GSM system can monitor the location, position and can track it easily. The system consists of various features like remote tracking system, easy installation and simple implementation. This system is cost effective, flexible and user friendly to be used by any individual any where any time. It allows the system to track vehicle and provides the current object information about ongoing trips. This system can resolve many problems like assigned route information, time constrains issues *i.e.*, late arrival to scheduled *etc*. it can lead to better traffic flow modeling.

Table I. Critical Analysis

Ref	solution	Strength	Weakness	Suggestive Improvements
[7]	The network management system based on GSM technology that supports multi-user, multi-session and a two-way network management, it also provides remote network access to administrator. User can execute predefined network related command on remote server	Multi-user, multi-session and a two-way network management, it operates under light resources as the system is multi-threaded and network related commands which may involve big timeout will not affect system performance	System support 160 char command, poor GUI of cellular phones makes it difficult to execute telnet command and perform network reconfiguration	A possible solution to cater for caveats of poor GUI is to use WAP protocols; however, WAP services are quite expensive.
[8]	Home appliances automation using GSM technologies and it facilitate to user to control and monitor house electrical device remotely.	Make home automation more convenient and accessible on the basis of 24/7 from anywhere at any time. Remote home automation Performance and system operation have been successful	Limited users can access system simultaneously, and 8-bits microcontroller has less ports and we don't expand its memory, and it is also less peripherals	Increase the number of users who can access system simultaneously, and replace 8-bits microcontroller with 32-bits technology and through this system performance will increase
[9]	Remotely control the home appliances based on GSM technology by establishing communication between AT89S52 MCU and mobile phones through SMS	Increase the monitoring range and cost effective solution, flexible and simple method.	8-bits microcontroller has less ports and we don't expand its memory, and it is also less peripherals	Replace 8-bits microcontroller with 32-bits technology and through this system performance will increase
[10]	Remote control system for	Monitor machines and Cost effective solution	Chinese words are used	Short message should contain English words

	monitoring remote appliances			instead of Chinese.
[11]	Remotely home automation based on GSM	Easy usage, cost effective, and high reliable	Password characters are limited, only 3 characters password is used in this system, it represent the weak security.	This wireless remote controller proposed solution will have more application viewpoint in the remote managing area.
[12]	Wireless remote control system based on GSM	Low cost solution and high reliable.	Sim space to store SMS is limited	Siemens GSM phone is much cheaper than TC35 GSM modem, and we can replace GSM modem with Siemens phone to decrease cost.
[13]	GPS-GSM Based Tracking System	Cost effective, most secure and adaptive for different application. Scalable, Robust and Reliable accurate tracking and useful for theft prevention	User doesn't have any option to take some action on object like vehicle etc from far-off place	Add some new features that User can take an action non object like vehicle etc from a far-off place like gear lock, engine seize etc.
[14]	Humidity remote monitoring and control system using GSM technologies	Cost effective, safe and sound, remotely accessible, monitored and controlled solution, It reduce the user efforts and increase productivity	-	=
[15]	J2ME based cellular application for remote administration of a server using GPRS technology	Faster and decentralized decision making. Increased productivity, secure and reliable. J2ME application which is compatible with all mobile which support java applications.	Dedicated server required with live IP, and its maintenance cost is high	J2ME have many disadvantages, and android overcome that disadvantages, and android keep on growing, Developing an application for android devices is simple, easy etc... should develop this application in android, android SDK is free, and this will reduce the system cost and increase the application efficiency.
[16]	Vehicle Intrusion and Theft Control System Using GSM and GPS	User will have the option to take an action from a far off place like gear lock, engine seize etc.		Vehicle intrusion and theft control system solution will have more application viewpoint in the remote managing area.
[17]	Cost Effective GPS-GPRS Based Object Tracking System	Good for vehicle theft situation, Provide accurate 3D information and Integrated with Google map and Google map service is free. Security feature is also implemented	Dedicated server required with live IP, that is expensive part. This system using http 80 port for post request, this is not secure port	https 443 port is more secure than http 80, and should replace the http port with https port for improving the security

[18]	Design and Development of GSM based Energy Meter	Reduce labor cost and increase meter reading accuracy, Limited resource used to operate, It provides features like Disconnect power supply due to outstanding dues, and reconnect action. Security feature is also implemented to prevent unauthorized accessed		
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4. Conclusion

The implementation of advanced bi-directional communication media, such as GSM and GPRS, it allows the system to make data transmission easy, quicker with more precision, and the system can incorporate into any existing management and control system. This helps to reduce the labor cost, increase the statistic load usage and profile accuracy, and increase data reading.

GSM is an international standard for wireless communications, with wide-ranging roaming facilities for both voice and data services. GSM data offers mobile users to use anytime, anywhere facilities, than by fixed telephone networks. The cost of using GSM data services is reducing over time. GSM data resolutions work with all GSM networks (DCS-1800, GSM-900 and PCS-1900).

References

- [1] Y. J. Lin, "A power line Communication Network Infrastructure for the Smart Home", IEEE Wireless Communications, (2002) December, pp. 104-111.
- [2] C. Pancu, A. Baraboi, M. Adam and A. Plesca, "GSM Based Solution for Monitoring and Diagnostic of Electrical Equipment", ICC'09 Proceedings of the 13th WSEAS international conference on Circuits, (2009), pp. 58-63.
- [3] L. Shijun, "Long-range Emergency calling system based on GSM short message", Computer and Telecommunication, vol. 8, (2008), pp. 41-43.
- [4] Y. Danxia and WangJiali, "Application of GSM module TC35 in Remote monitor system", Modern Electrical Technique, vol. 5, (2005), pp. 62-67.
- [5] M. Xu and J. Du, "Design & Development of a GSM Based Vehicle Theft Control System", Advanced Computer Control, ICACC '09. International Conference, (2009) January, pp. 148-152.
- [6] Q. Qu, Z. Guohao and W. Baohua, "Design of home safeguard system based on GSM technology", Electronic engineer, vol. 11, (2006), pp. 76-78.
- [7] S. Vougioukas and M. Rouincliotis, "A System for Basic-Level Network Fault Management Based on the GSM Short Message Service (SMS)", EUROCON'2001, Trends in Communications, International Conference, vol. 1, (2001) July, pp. 218-222.
- [8] A. R. Al-Ali, "GSM-based wireless home appliances monitoring & control system", Information and Communication Technologies: From Theory to Applications, 2004, Proceedings. 2004 International Conference, (2004) April, pp. 237-238.
- [9] X. Jiang, "Research and implementation of remote controlling based on SMS technology", Advanced Computational Intelligence (ICACI), 2012 IEEE Fifth International Conference, (2012) October, pp. 1021-1024.
- [10] W.-L. Wang, "Design of embedded remote control system", Information Security and Intelligence Control (ISIC), 2012 International Conference, (2012) August, pp. 41-44.
- [11] G. Cao and T. Xu, "A GSM-based wireless remote controller", Electronics, Communications and Control (ICECC), 2011 International Conference, (2011) September, pp. 2431-2416.
- [12] M. Xu and J. Du, "Design of SMS-based Remote Control System Using TC35 and MCU", Internet Computing & Information Services (ICICIS), 2011 International Conference, (2011) September, pp. 393-395.
- [13] A. Khan and R. Mishra, "GPS-GSM Based Tracking System", International Journal of Engineering Trends and Technology, vol. 3, no. 2, (2012) December.

- [14] B. Ramamurthy, S. Bhargavi and R. ShashiKumar, "Development of a Low-Cost GSM SMS-Based Humidity Remote Monitoring and Control system for Industrial Applications", *International Journal of Advanced Computer Science and Applications (IJACSA)*, vol. 1, no. 4, (2010) October.
- [15] S. Kulkarni, S. Diwan and N. K. Bansode, "Device Independent Mobile Application Controller for Remote Administration of a Server over a GPRS Link using a J2ME Cellular", *IEEE India Annual Conference 2004, INDICON*, (2004), pp. 498-500.
- [16] A. Mustafa, H. Jameel, M. Baqar, R. Ahmed Khan, Z. M. Yaqoob, Z. Rahim and S. Khan, "Vehicle Intrusion and Theft Control System Using GSM and GPS", *Asian Journal of Engineering, Sciences & Technology*, vol. 2, no. 2, (2012) September.
- [17] K. Shajadul Hasan, M. Rahman, A. L. Haque, M. Abdur Rahman, T. Rahman and M. Mahbubur Rasheed, "Cost Effective GPS-GPRS Based Object Tracking System", *International MultiConference of Engineers and Computer Scientists*, vol. 1, (2009) March.
- [18] K. Abhinandan Jain, D. Kumar and J. Kedia, "Design and Development of GSM based Energy Meter", *International Journal of Computer Applications*, vol. 47, no. 12, (2012) June.
- [19] S. Iqbal, M. Khalid and M. N. A. Khan, "A Distinctive Suite of Performance Metrics for Software Design", *International Journal of Software Engineering & Its Applications*, vol. 7, no. 5, (2013).
- [20] S. Iqbal and M. N. A. Khan, "Yet another Set of Requirement Metrics for Software Projects", *International Journal of Software Engineering & Its Applications*, vol. 6, no. 1, (2012).
- [21] M. Faizan, S. Ulhaq and M. N. A. Khan, "Defect Prevention and Process Improvement Methodology for Outsourced Software Projects", *Middle-East Journal of Scientific Research*, vol. 19, no. 5, (2014), pp. 674-682.
- [22] M. Faizan, K. M. NA and S. Ulhaq, "Contemporary Trends in Defect Prevention: A Survey Report", *International Journal of Modern Education & Computer Science*, vol. 4, no. 3, (2012).
- [23] K. Khan, A. Khan, M. Aamir and M. N. A. Khan, "Quality Assurance Assessment in Global Software Development", *World Applied Sciences Journal*, vol. 24, no. 11, (2013).
- [24] M. Amir, K. Khan, A. Khan and M. N. A. Khan, "An Appraisal of Agile Software Development Process", *International Journal of Advanced Science & Technology*, vol. 58, (2013).
- [25] T. U. Rehman, M. N. A. Khan and N. Riaz, "Analysis of Requirement Engineering Processes, Tools/Techniques and Methodologies", *International Journal of Information Technology & Computer Science*, vol. 5, no. 3, (2013).
- [26] M. N. A. Khan, M. Khalid and S. ulHaq, "Review of Requirements Management Issues in Software Development", *International Journal of Modern Education & Computer Science*, vol. 5, no. 1, (2013).
- [27] M. Umar and M. N. A. Khan, "A Framework to Separate Non-Functional Requirements for System Maintainability", *Kuwait Journal of Science & Engineering*, vol. 39, no. 1B, (2012), pp. 211-231.
- [28] M. Umar and M. N. A. Khan, "Analyzing Non-Functional Requirements (NFRs) for software development", In *IEEE 2nd International Conference on Software Engineering and Service Science (ICSESS)*, (2011), pp. 675-678.
- [29] M. N. A. Khan, C. R. Chatwin and R. C. Young, "A framework for post-event timeline reconstruction using neural networks", *Digital investigation*, vol. 4, no. 3, (2007), pp. 146-157.
- [30] M. N. A. Khan, C. R. Chatwin and R. C. Young, "Extracting Evidence from Filesystem Activity using Bayesian Networks", *International journal of Forensic computer science*, vol. 1, pp. 50-63.
- [31] M. N. A. Khan, "Performance analysis of Bayesian networks and neural networks in classification of file system activities", *Computers & Security*, vol. 31, no. 4, (2012), pp. 391-401.
- [32] M. Rafique and M. N. A. Khan, "Exploring Static and Live Digital Forensics: Methods, Practices and Tools", *International Journal of Scientific & Engineering Research*, vol. 4, no. 10, (2013), pp. 1048-1056.
- [33] M. S. Bashir and M. N. A. Khan, "Triage in Live Digital Forensic Analysis", *International journal of Forensic Computer Science*, vol. 1, (2013), pp. 35-44.

