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Guideline Model for Digital Forensic Investigation

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ABSTRACT

This paper proposes a detailed guideline model for digital forensics; the proposed model consists of five main phases, Preparation phase, Physical Forensics and Investigation Phase, Digital Forensics Phase, Reporting and Presentation Phase, and Closure Phase.

Most of the existing models in this field do not cover all aspects of digital forensic investigations, as they focus mainly on the processing of digital evidence or on the legal points. Although they gave good information to base on it a guide, but they are not detailed enough to describe fully the investigative process in a way that can be used by investigators during investigation.

In this model detailed steps for each phase is given, so it can be used as guidance for the forensic investigators, and it can assist the development of new investigative tools and techniques.

Keywords: digital forensics, computer forensics, digital investigation, forensic model, reference framework.

1. INTRODUCTION

Digital forensics is the science of acquiring, retrieving, preserving and presenting data that has been processed electronically and stored on digital media. Digital forensic science is a relatively new discipline that has the potential to greatly affect specific types of investigations and prosecutions (Asian School of Cyber Laws 2006; Hall & Wilbon 2005). To be able to perform digital forensics investigation, the organization providing this service must be capable of having the capability means that helps an organization to be prepared to detect and counter cyber crime incidents in a skilled and efficient manner. Such capability is the combination of technically skilled people, policies and techniques to constitute a proactive way for handling cyber crime incidents. The general procedures that should be followed to have these capabilities are and not limited to:

- Provide Proper training for personnel of teams.
- Ensure that personnel are aware of the types of evidence usually encountered and the proper handling of the evidence.
- The lab should be equipped with the proper up to date equipments and forensic tools required for all operating systems and all system files for investigation.

In this paper a comprehensive and complete model is discussed, which proposes detailed steps for each phase, so it can be used as a reference frame work or it can support training of investigators and

tool development.

This model depends on previous existing models as well as physical forensic models so that it can meet the challenges from the nature of electronic evidences to make it admissible in courts. To meet these challenges follow the forensic procedures proposed in this paper in which it can be applied for any case according to but not limited to these five phases these phases, knowing that each phase can change according to the case nature.

These phases are: Preparation phase, Physical Forensics and Investigation phase, Digital Forensics phase, Reporting and Presentation phase and Closure phase.

The rest of the paper is divided into 4 sections. The first section [Section 2] presents previous existing models. Section 3 gives an overview on the proposed phases of this model. Section 4 discusses the detailed proposed digital forensic model with its steps. And the last section [Section 5] is model discussion and conclusion.

2. EXISTING MODELS

The procedures for accomplishing forensics are neither consistent nor standardized. A number of people have attempted to create rudimentary guidelines over the last few years, but they were written with a focus on the details of the technology and without consideration for a generalized process (Association of Chief Police Officers).

There are several models for investigation, most of them restrict themselves in the investigation of the crime scene and evidence and does not represent a detailed steps that can be used in guiding investigators. Some of these models are:

1. The U.S. Department of Justice published a process model in the Electronic Crime Scene Investigation: A guide to first responders (National Institute of Justice 2001) that consists of four phases: Collection, Examination, Analysis and Reporting.

There are several other models that have phases similar to this model, such as the framework from the Digital Forensic Research Workshop Research Roadmap (Palmer 2001) they are not covered here due to their similarity.

In this model few details of the Examination and Analysis phases are given (Carrier 2006) .The analysis phase of this model is improperly defined and ambiguous. It for instance emerges as an interpretation of the results from the examination phase, and in the process confuses analysis with interpretation despite these being two distinct processes (Baryamureeba & Tushabe 2004). At the same time the analysis and examination phases concentrate on computer crime and don't go though network crimes (Carrier & Spafford 2003).

2. An Abstract Digital Forensic Model (Reith & Gunsch 2002) proposes a standardized digital forensics process that consists of nine components: Identification, Preparation, Approach strategy, Collection, Examination, Analysis, Presentation and Returning evidence.

This model solved some of the problems in the previous model but , there are some criticism. The Identification phase should be after the preparation phase , and the team must be ready before any incident , and its third phase [the approach strategy] is to an extent a duplication of its second phase [the preparation phase]. This is because at the time of responding to a notification of the incident, the identification of the appropriate procedure will likely entail the determination of techniques to be used (Baryamureeba & Tushabe 2004).

3. Brian Carrier and Eugene Spafford (Carrier & Spafford 2003) proposed The Integrated Digital Investigation Model that organizes the process into five groups consisting all in all 17 phases. Readiness phases, Deployment phases, Physical Crime Scene Investigation phases, Digital Crime Scene Investigation phases, and Review phase

Although this model is generally a good reflection of the forensic process, it is open to some criticism; for instance it depicts the deployment phase which consists of confirmation of the incident as being independent of the physical and digital investigation phase. In practice however, it seems impossible to confirm a digital or computer crime unless and until some preliminary physical and digital investigation is carried out. Secondly, it does not offer sufficient specificity and does not, for instance, draw a clear distinction between investigations at the victim's [Digital crime] scene and those at the suspect's [physical crime] scene. Neither does it reflect the process of arriving at the latter. Since a computer can be used both as a tool and as a victim, it is common for investigations to be carried out at both ends so that accurate reflections are made (Baryamureeba & Tushabe 2004).

4. A Hierarchical, Objectives-Based Framework for the Digital Investigations Process (Beebe & Clarke 2004) is another model that proposed a multi-layer, Hierarchical frame work to guide investigators. It has six phases which are: Preparation, Incident Response, Data Collection, Data Analysis, Findings Presentation and Incident Closure.

This model is more detailed than the previous models but it has some points subjected to criticism as; It is not clear if the filtering process required to extract data is simply more general than the filtering that occurs during examination. The survey phase in this model has a clear goal of analyzing the data abstractions and their characteristics (Carrier 2006) .The proposed model was not very complete and it only gave second tier or details for analysis phase only, which cannot be used to guide the forensic investigators thought their whole process.

As discussed above most of the previous models in this field do not cover all aspects of cybercrime investigation; they focus mainly on the processing of digital evidence. Although they gave good information to base on it a guide, but they are not detailed enough to describe fully the investigation process in a way that will assist the development of new investigative tools and techniques (Ciardhuain 2004).

3. THE MODEL PHASES OVERVIEW

3.1 Preparation Phase

This is the first stage of incident handling procedures, which must be applied before handling any investigation, the purpose of this phase is make sure that the operation and infrastructure can support the investigation.

Preparation phase is divided into Pre-preparation, Case evaluation, Preparation of detailed design for the case, Preparation of investigation plan and Determination of required resources.

3.2 Physical Forensics and Investigation Phase

The goal of this phase is to collect, preserve, analyze the physical evidences and reconstruct what happened in the crime scene.

Physical forensics and investigation phase can be subdivided into Physical preservation, Preliminary survey on physical scene, Evaluate the physical scene, Initial documentation, photographing and narration, Search and collection of physical evidence and Final survey for physical crime scene.

3.3 Digital Forensics Phase

This phase starts according to the case, as in network attacks it works in parallel with the physical forensics and investigation phase, while in other attacks it can start after it is done. The goal of this phase is to identify and collect the electronic events that occurred on the system and analyze it, so that it can be used with the results of the previous phase to reconstruct events.

Digital forensics phase includes sub phases which are Evaluation and Assessment, Acquisition of digital evidences, Survey the digital scene, Digital Evidence Examination, Reconstruction of extracted data and Conclusion.

3.4 Reporting and Presentation phase

This phase though is based entirely on policy and law of each country, which are different for each setting. This phase presents the conclusions and corresponding evidence from the investigation.

In a corporate investigation, the audience typically includes the general counsel, human resources, and executives. Privacy laws and corporate policies dictate what is presented. In a legal setting, the audience is typically a judge and jury, but lawyers must first evaluate the evidence before it is entered (Carrier 2002).

3.5 Closure Phase

The Closure Phase involves reviewing the whole investigation procedures, examining how well each of the physical and digital investigations worked together, and whether the evidences collected were enough to solve the case, and ensures returning of the physical and digital properties back to its owner.

4. THE PROPOSED DIGITAL FORENSIC GUIDANCE MODEL DETAILS

In this Model details for each sub phase is given in points, so it can be used as guidance for forensic investigators while investigation, and provide an easy way to train them.

4.1 Preparation Phase

4.1.1 Pre-preparation

1. Detect and identify the incident and make risk assessment of vulnerabilities and threats.
2. Discuss the search with involved personnel before arriving at the scene, if possible (Federal Bureau of Investigation 2003).
3. Establish a command headquarters for communication and decision making in major or complicated crime-scene searches (Federal Bureau of Investigation 2003).
4. Make preliminary personnel assignments before arriving at the scene, while the assignments are keeping with the attitude, aptitude, training, and experience of search personnel.
5. Person in Charge must be assigned knowing his responsibilities such as more:
    a. Secure the scene.
    b. Prepare administrative log, and narrative description.
    c. Resolve problems.
    d. Make final decisions.
6. Develop legal activities coordination plan (Federal Bureau of Investigation 2003), obtain a search warrant, if necessary and obtain written and signed permissions from the concerned authorities to proceed.
7. Prepare the paperwork to document the search (Federal Bureau of Investigation 2003).
8. Provide all the needed requirements such as protective clothing, communication, lighting, transportation, equipment, food, etc.

4.1.2 Case Evaluation

1. Initial case assessment: investigators should perform initial assessment about the case by for example: asking questions related to the rule of computer /network in question and evidence related to the case.

2. Identifying the case Requirements : which involves outing details of the case in systematic order such as:

    a. Situation of the case: A case can be violation of company policies by employee or identity theft, etc.

    b. Nature of the case: personal work on employer's computer or on a whole network or unknown criminal, etc.

    c. Specifics about the case: for example the role of computer or employee in question.

    d. Type of evidence: can be hard disk, floppy, CD, etc.

    e. Operating system used by the suspect if possible.

    f. Knowing disk format: can be FAT16, FAT32, NTFS, EXT3, etc.

    g. The motive of the suspect: try to find motive of the crime and develop a general theory of the crime.

4.1.3 Preparation of Detailed Design for The Case

The general outline to investigate the case, in which detailed steps are prepared taking into account the estimated time, resources and money required to complete each step.

4.1.4 Preparation of Investigation Plan

1. Develop an onsite plan which must include policies, procedures, personnel assignments, and technical requirements.

2. Plan for what to look for during searching.

3. Approach strategy for both evidence collection and preservation.

4. Steps for evidence examination and analysis should be predefined.

4.1.5 Determination of Required Resources

1. Determine kind of software and hardware for investigation according to suspect operating system.

2. Specify tools that are accepted by courts [tested].

3. Accumulate evidence collection and packaging materials and equipment.

4.2 Physical Forensics and Investigation Phase

4.2.1 Physical Preservation

Preservation is an ongoing process through the whole forensic procedures.

1. Take extensive notes all the time and for everything and consider the safety of all personnel (Federal Bureau of Investigation 2003).

2. Secure the physical crime scene:
    a. Follow jurisdictional policy for securing the crime scene, This would include :
        i. Ensuring that all persons are removed from the area in which evidence is to be collected (National Institute of Justice 2001).
        ii. Do not alter the condition of any electronic devices: If it is off, leave it off. If it is on, leave it on (National Institute of Justice 2001).
    b. Take immediate control on the scene by keeping out unauthorized personnel and record who enters and leaves.
3. Determine the extent to which the scene has been protected and get information about who have knowledge about the original condition.
4. Make interviews: (National Institute of Justice 2001)
    a. Separate and identify all persons [witnesses, subjects, or others] at the scene and record their location at time of entry.
    b. Consistent with departmental policy and applicable law, obtain from these individuals information such as:
        i. Owners and/or users of electronic devices found at the scene, as well as passwords, user names, and Internet service provider.
        ii. Any passwords required to access the system, software, or data. [An individual may have multiple passwords, e.g., BIOS, system login, network or ISP, application files, encryption pass phrase, e-mail, access token, or contact list].
        iii. Purpose of the system.
        iv. Any unique security schemes or destructive devices.
        v. Any offsite data storage.
        vi. Any documentation explaining the hardware or software installed on the system.
5. Place labels over all the drive slots and over the power connectors.

4.2.2 Preliminary Survey on Physical Scene

1. Select a narrative technique [written, audio, or video], and start taking preliminary photographs (Federal Bureau of Investigation 2003).
2. Delineate the extent of the search area. Usually expand the initial perimeter (Federal Bureau of Investigation 2003).
3. Identify and protect transient physical evidence.
4. Document physical and environmental conditions of the scene and all personnel movements.
5. Detect any unauthorized activity and then report it to the proper authority. (Beebe & Clark 2004).
6. Identify telephone lines attached to devices such as modems and caller ID boxes, if a telephone connection is present, attempt to identify the telephone number.
7. Document, disconnect and label each telephone line from the wall not from the device.

4.2.3 Evaluate the Physical Scene

1. Validate the incident, assess damage/impact via interviews of technical/business personnel, review of pertinent logs, review of network topology, etc. (Beebe& Clark 2004).
2. Ensure that the collection and packaging materials and equipment are sufficient.
3. Ensure the protection of Non digital evidences such as finger prints.

4. Search the easily accessible areas and progress to out-of-view locations while looking for hidden items.
5. Evaluate whether evidence appears to have been moved or used.
6. Identify the number and type of computers, and determine if a network is present.
7. Prioritize the evidence [e.g., distribution CDs versus user-created CDs].
    a. Location where evidence is found.
    b. Stability of media to be examined (National Institute of Justice 2004).
8. Identify both internal and external storage devices that need to be seized.
9. Determine exactly where each device is physically located and label its location using labels.
10. Identify any application and/or users that are affected by a problem.
11. Determine which devices are on the network and determine which devices connect this network to the internet and systematically search each part of the network for problems.
12. Determine how the devices are configured (Schweitzer 2003).
13. Make a complete evaluation of the crime scene (what was found and its state…).
14. Test the design: The decision made or steps taken should be reviewed. By reviewing the investigator can find out whether these steps are correct or need to be adjusted.

4.2.4 Initial Documentation, Photographing and Narration

1. Nothing is insignificant to record if it catches one's attention (Federal Bureau of Investigation 2003).
2. Initial documentation
    a. Document everything
    b. Observe and document the physical scene, such as the position of the mouse and the location of components relative to each other [e.g., a mouse on the left side of the computer may indicate a left-handed user] (National Institute of Justice 2001).
    c. Document the condition and location of the computer system, including power status of the computer (National Institute of Justice 2001).
    d. Identify and document electronic components that will not be collected.
    e. Take written notes on what appears on the monitor screen (National Institute of Justice 2001).
    f. Active programs may require videotaping or more extensive documentation of monitor screen activity (National Institute of Justice 2001).
    g. Use case management system so that the written data are protected and made available to a database of case information. With the case management system create three log files:
        i. Search and Seizer evidence log that include brief descriptions of all computers, devices or media located during the search for evidence. It should also document the date and time of the investigation, the names of all people who are involved with investigative activities (Wright 2001) and timestamp of the whole processes.
        ii. Lab evidence log that includes: date and time of arrival of the Seized evidence at the lab, a brief description of the evidence, the condition of the evidence upon arrival, name and signature of the investigator checking in the evidence (Wright 2001), then it will include details about the examination processes and who perform it and timestamp for each process.

iii. Collection log file which includes details about collection steps in digital forensic phase and also includes image of the collected data , the check sum or md5 sum of the original and collected data and the investigators details including digital signatures and timestamp .

3. Additional documentation of the system will be performed during the rest of phases. Documentation is an ongoing process through the whole forensic phases. Therefore document each and every step done by the investigator or examiner and document anything that is found.
4. Use photographs and sketches to supplement, not substitute for, the narration (Federal Bureau of Investigation 2003).
5. Do not collect evidence or touch anything during the narration.
6. The narration should include the following: (Federal Bureau of Investigation 2003)
    a. Case identifier.
    b. Date, time and location.
    c. Identity and assignments of personnel.
    d. Condition and position of evidence.
7. Prepare a photographic log that records all photographs, description and location of evidence and then include it in the search and seizer log file.
8. Photograph all stages of the crime-scene investigation, including discoveries (Federal Bureau of Investigation 2003).
9. Photograph the condition of evidence before and after examination.
10. Complete room should be recorded with 360 degrees of coverage, if possible, and photograph the front of the computer as well as the monitor screen and other components. (National Institute of Justice 2001).

4.2.5 Search and Collection of Physical Evidence

According to the case and depending on the initial case evaluation and plan , these steps can change , for example for seizure of the computer itself or leaving it depends on the case , It depends whether the system should be shutdown or not. Taking this decision depends on the case and should be taken with utmost care.

These are general steps for searching for physical evidences such as PCs or other equipments that can be used by the suspect:

1. Start the search and seizure evidence log in the case management system to document all devices state.
2. Search from the general to the specific for evidence and be alert for all evidence makes sure to protect the integrity of the evidence.
3. Wear latex or cotton gloves to avoid leaving fingerprints (Federal Bureau of Investigation 2003).
4. Search entrances and exits, and photograph all items before collection and notate the photographic log, and mark evidence locations on the sketch (Federal Bureau of Investigation 2003).
5. Complete the evidence log with notations for each item of evidence. If possible, have one person serve as evidence custodian (Federal Bureau of Investigation 2003).

6. Two persons should observe evidence in place, during recovery and being marked for identification. Mark directly on the evidence when necessary, but first attempt to place identifying marks on evidence containers (Federal Bureau of Investigation 2003).
7. To avoid damage to potential evidence, remove any floppy disks that are present, package the disk separately, and label the package and do not remove CDs or touch the CD drive (National Institute of Justice 2001).
8. Identify storage devices that need to be seized, these devices can be internal, external, or both.
9. Observe the monitor and determine if it is on, off, or in sleep mode. Then decide which of the following cases applies and follow the steps for that case:
    a. **Case 1**: Monitor is on and desktop is visible.
        i. Photograph screen and record information displayed (National Institute of Justice 2001).
        ii. Records make, model and serial numbers (National Institute of Justice 2001).
        iii. Photograph and diagram the connections of the computer and the corresponding cables (National Institute of Justice 2001).
        iv. Label all connectors and cable ends (including connections to peripheral devices) to allow for exact reassembly at a later time (National Institute of Justice 2001).
        v. Isolate the network [Depends on the case as mentioned before].
        vi. Perform order of volatility and collect the volatile data that would be lost when the system is turned off and identifying any suspicious processes that are running on the system then follow digital evidence acquisition procedures which will be discussed later in the digital forensic phase.
        vii. Record in notes all actions taken and any changes that observed in the monitor, computer, printer, or other peripherals that result from the performed actions (National Institute of Justice 2001).
        viii. Remove the power source cable from the computer not from the wall outlet [Decision of shutting down the computer depend on the case] and then start packaging procedures.
    b. **Case 2**: Monitor is on and screen is blank [sleep mode] or screen saver [picture] is visible.
        i. Move the mouse slightly [without pushing buttons]. The screen should change and show work product or request a password (National Institute of Justice 2001).
        ii. If mouse movement does not cause a change in the screen, don't perform any other keystrokes or mouse operations (National Institute of Justice 2001).
        iii. Continue with all the steps of case 1.
    c. **Case 3**: Monitor is off.
        i. Document that the monitor is off, then turn the monitor on, then determine if the monitor status is as described in either case 1 or 2 above and follow those steps.
        ii. If the computer itself is off then start packaging procedures.
10. Packaging procedure:
    a. Ensure that all collected electronic evidence is properly documented, labeled, and inventoried before packaging (National Institute of Justice 2001).
    b. Pack magnetic media in antistatic packaging [paper or antistatic plastic bags](National Institute of Justice 2001).
    c. Avoid using materials that can produce static electricity, such as standard plastic bags (National Institute of Justice 2001).

   d. Avoid folding, bending, or scratching computer media.
   e. Ensure that all containers used to hold evidence are properly labeled (National Institute of Justice 2001).
   f. Label each package with a unique label [Association of Chief Police Officers], which must include some details as name of the person and organization that packed the material , the content of package , the place where it is going to be packed and from where it was taken, and the time and date of packing.
11. Transportation procedure:
   a. Keep electronic evidence away from magnetic sources such as radio transmitters.
   b. Don't store electronic evidence in vehicles for long periods of time as different temperature and weather conditions can damage evidence.
   c. Ensure that computers and other components that are not packaged in containers are secured in the vehicle to avoid shock and excessive vibrations (National Institute of Justice 2001).
   d. Maintain the chain of custody on transported evidence.
12. Storage procedure: Store evidence in a secure area away from temperature and humidity extremes. Protect it from magnetic sources, moisture, dust and other harmful particles or contaminants. (National Institute of Justice 2001).
13. Seal all evidence packages at the crime scene.
14. Identify and document the types and volume of media, including removable media and make sure to document the location from which the media was removed.

15. Constantly check paperwork, packaging and other information for errors.

4.2.6 Final Survey and Reconstruction for physical crime scene

1. Discuss the search with all personnel, then ensure all documentation is correct and complete (Federal Bureau of Investigation 2003).
2. Photograph the scene showing the final condition (Federal Bureau of Investigation 2003).
3. Ensure all evidence is secured, ensure all equipment is retrieved and ensure hiding places or difficult access areas have been fetched (Federal Bureau of Investigation 2003).
4. Analyze any Non digital evidence that can help in the case [as Finger prints, paper, etc.].
5. Reconstruct the events that occurred at the crime scene by using the crime scene appearance, the locations and positions of the physical evidence, the forensic laboratory analysis results, and the scientific method.

4.3 Digital Forensics Phase

4.3.1 Evaluation and Assessment

1. Determine the evidence that was seized.
2. Determine additional information regarding the case as e-mail accounts, e-mail addresses, Internet Service Provider [ISP] used, names, network configuration and users, system logs, passwords, user names.
3. Assess the skill levels of the computer users involved knowing that skilled users can use complex ways to cover their crime.
4. Prioritize the order of evidence examining (Federal Bureau of Investigation 2003).
5. Determine if additional personnel or equipment will be needed.
6. Identify and evaluate storage locations in which the evidences were stored.
7. Identify proprietary software and the operating system in question.
8. Ascertain the condition of the evidence as a result of packaging, transport, or storage (National Institute of Justice 2004).
9. Assess the need to provide continuous electric power to battery-operated devices (National Institute of Justice 2004).

10. Verify operation of the examiner's computer system to include hardware and software (National Institute of Justice 2004).

4.3.2 Acquisition of digital evidences

Collecting of data can be done on a life system or on a shutdown system.

1. **Life System Case :**
   a. Prepare an order of volatility: An order of volatility should be prepared which ensures the order of collection. The order should be from most volatile to the least. Order of volatility can be:
      i. Registry, cache.
      ii. Routing Table, ARP cache, Process table, Kernel statistics.
      iii. Memory.
      iv. Temporarily internet file.
      v. Disk.
      vi. Remote logging and monitoring data that is relevant to system in question.
      vii. Physical configuration, network topology.
      viii. Archival media…

   b. Prevent outside interference and prevent execution of programs on a crime scene computer.

   c. Start collection log file and create in it sub-directory to hold the evidence image.

   d. Document the details of the investigation in the log file including investigator details, case background details, investigation dates and investigators digital signatures.

   e. Document details of the disk media including investigator name and organization, case number, media evidence number, date and time imaging was done, name, model and serial number of computer, Internet Protocol [IP] and system host name, make model, and serial number of hard disk [HD], internal storage devices and hardware configuration and scope of investigation.

   f. Capture an accurate image of the system as soon as possible with minimum tampering or change in the system.

   g. Command line tools are preferred than GUI tools and use safe and tested tools.

   h. Collect volatile data present on registry as:

      i. System time and date and running processes.

      ii. Currently open sockets, application listening on open sockets, current users logged on and system currently or recently connected.

   i. Use cash monitoring tools to view real time state cash and document it then dump memory information using tools running from CD and save the result on floppy or another CD.

   j. Use network monitors, system monitors, surveillance cameras for activity monitoring.

   k. Obtain network-based evidence from sources such as intrusion detection systems, routers, firewalls, log servers, etc; make sure that time is synchronized between of all logs and systems.

   l. Before imaging use write protectors or write blocker tools to insure the integrity of information gathered from disk.

m. In this case the subject computer will be used to acquire digital evidence, attach the examiner's evidence storage device [e.g., hard drive, tape drive, CD-RW].

   i. Ensure that the examiner's storage device is forensically clean when acquiring the evidence (National Institute of Justice 2004).

   ii. Investigate the geometry of any storage devices to ensure that all space is accounted for, including Host protected area [HPA] data and device configuration overlay option [DCO] (National Institute of Justice 2004).

   iii. The examiner should calculate a mathematical value for the subject evidence before acquiring the evidence as performing an independent cyclic redundancy check [CRC] or hashing.

n. Acquire data of the disk by making bit stream copy of the original storage medium[snap shot], which is an exact duplicate of the original disk and this is also done for all evidence storage medium as HD and floppy disks, which is done by using one of these methods:

   i. Creating a bit stream disk to image file: which is the most common type, as it provide the investigators the ability to make many copies of the digital evidence acquired, and also this image can be used with a lot of applications and other tools to continue the forensic stages.

   ii. Making bit stream disk to disk copy: Used if the investigator is unable to create bit stream disk to image file.

o. Acquire the subject evidence to the examiner's storage device using the appropriate software and hardware tools, such as: (National Institute of Justice 2004)

   i. Stand-alone duplication software.

   ii. Forensic analysis software suite.

   iii. Dedicated hardware devices.

p. Verify the integrity of the information gathered by making hash values and checksums for both the image and the original data and comparing them.

q. Change the read-write permission of the image to read only.

r. Retrieve configuration information from the suspect's system through controlled boots (National Institute of Justice 2004).

s. Perform a controlled boot to capture CMOS/BIOS information and test functionality (National Institute of Justice 2004).

   i. Boot sequence [this may mean changing the BIOS to ensure the system boots from the floppy or CD-ROM drive].

   ii. Time and date and then document it.

   iii. Power on passwords.

t. Disconnect storage devices then perform a second controlled boot to test the computer's functionality and the forensic boot disk (National Institute of Justice 2004).

   i. Ensure the power and data cables are properly connected to the floppy or CDROM drive.

ii. Place the forensic boot disk into the floppy or CD-ROM drive. Boot the computer and ensure the computer will boot from the forensic boot disk.

u. Reconnect the storage devices and perform a third controlled boot to capture the drive configuration information from the CMOS/BIOS (National Institute of Justice 2004).

i. Ensure there is a forensic boot disk in the floppy or CD-ROM drive to prevent the computer from accidentally booting from the storage devices.
ii. Drive configuration information includes logical block addressing [LBA]; large disk; cylinders, heads, and sectors [CHS]; or auto-detect.

v. Collect evidences from removable media sources such as backup tapes, floppy disks, etc.
w. Power system down by removing the power cable and then remove and acquire storage device of the suspect, if possible.
x. Exceptional circumstances, including the following, may result in a decision not to remove the storage devices from the subject system: (National Institute of Justice 2004)

i. RAID, removing the disks and acquiring it individually may not yield usable results.
ii. Laptop systems. The system drive may be difficult to access or may be unusable when detached from the original system.
iii. Hardware dependency [legacy equipment]. Older drives may not be readable in newer systems.
iv. Equipment availability. The examiner does not have access to necessary equipment.
v. Network storage. It may be necessary to use the network equipment to acquire the data.

y. Prepare chain of custody in which gathering process must be documented which should include timestamp, digital signatures and signed statements.
z. Duplicate the evidence disk drive, perform at least two copies.

2. Computer already shutdown:

Never turn on or operate suspects computer during investigation if it is off leave it off

a. Determine disk structure, model and size (National Institute of Justice 2004).
b. Before imaging use write protectors or write blockers tools to insure the integrity of information gathered from disk.
c. Remove and acquire storage device of the suspect using the examiner's system, then configure it on the examiner's system to be recognized.
d. Exceptional circumstances that may result in a decision not to remove the storage devices from the subject system are mentioned above in section x in the life system case.
e. Command line tools are preferred than GUI interface tools and use safe and tested tools.
f. Then Follow steps from n-q in the life system case.
g. Prepare Chain of custody in which gathering process must be documented which should include timestamp, digital signatures and signed statements.
h. Duplicate the evidence disk drive.

4.3.3 Survey the digital scene

Survey phase is performed on a live system or on the snap shot image. It can occur on a live system, similar to what occurs in the physical world. Mostly it is occurs in a lab using one of the digital crime scene replica images as it is preferred because it provides a controlled environment and the results can be repeated with another copy of the system

It examines the obvious locations for evidence and develops strategy for how to search the system for additional evidence, it also provides details and description about data as to be used in extraction activities and it shows the skill level of the suspect.

4.3.4 Digital Evidence Examination

The purpose of the examination process is to locate, extract and analyze digital evidence to reconstruct the crime scene.

Extraction refers to the recovery of data from its media. Analysis refers to the interpretation of the recovered data and putting it in a logical and useful format (National Institute of Justice 2004).

Examination of the evidence will involve the use of a potentially large number of techniques to find and interpret significant data, while doing so it must preserve the integrity of evidence and chain of custody to present it in court.

General forensic principles apply when examining digital evidence. Different types of cases and media may require different methods of examination. Persons conducting an examination of digital evidence should be trained for this purpose (National Institute of Justice 2004).

When conducting evidence examination, consider using the following steps:

1. **Preparation:** Prepare working directories on separate media to which evidentiary files and data can be extracted and recovered (National Institute of Justice 2004), and start the lab evidence log from the case management system to record details of examination and the state of evidence at arrival.
2. **Locating Evidence:** Making a checklist can help in the examination process, and can use it to double-check that everything is there.

This step depends on the case and the type of operating system used. There are some areas and files in each operating system that are recommended for evidence gathering, but also this depends on the case .The common areas are:

a. **Windows operating system:**

1. Files and file system: Using command lines tools can help investigator to ascertain and examine the time, date of installation of the operating system, service packs, patches and subdirectories like drivers that automatically update themselves
2. Hidden files: such as NTFS alternate data streams that can be detected by the help of tools searching on registry, locate data in hidden or masked file extensions.
3. Detect unusual or hidden files by modifying windows to display certain hidden file types.
    a. Compressed files.
    b. Misnamed files.
    c. Encrypted files.
    d. Password-protected files.
    e. File attributes.
    f. Marked bad clusters.
    g. Security ID : Microsoft Security ID are found on registry in profile list that holds profile list key for each user on computer
4. Slack space: The space existing at the end of the file of the last cluster that contains data from computer.

5. Windows registry: windows registry is a database where all the information about a computer is stored. It is used to store :
    a. Operating system configuration, application configuration information and hardware configuration information.
    b. User security information and current user information.
6. Locate evidence from the Windows print spooler and enhanced metafiles (EMF), even if a user never saved a word-processing document, temporary versions of word-processing documents sometimes remain on the hard drive.

b. Linux/ Unix operating system:

1. Mount the restored imaged working copy and start analyzing the contents.
2. Use the ls command to view the contents of the disk. [ls –alR to list all files including hidden files and list the directories recursively].
3. Make a list of all files along with access times, and search for likely evidence using grep command.
4. List unknown file extensions and changed file appearance.
5. Search in such areas:
    a. Syslog: This is the heart of Linux logging.
    b. File access time.
    c. Detect unusual or hidden files, compressed files, Misnamed files, Encrypted files and Password-protected files.

c. For both operating systems :

Search in such areas:

1. Temporarily internet files, cookies and batch files [*.bat].
2. Memory, it also identifies network logon names, passwords and other sensitive information.
3. Swap files: is space on a hard disk reserved for the operating system to do what's called paging and which is called virtual memory [the swap file is called win386.swp in windows, and in windows NT/2000/XP, it is called pagefile.sys].
4. Unallocated clusters, unused partitions, hidden partitions, HPA and DCO.
5. Destroyed or deleted partitions, files and data [The index application in windows locates data that has been destroyed].
6. Locate and retrieve e-mail evidence. E-mail messages can be found in a number of different places, such as the sender's e-mail inbox/outbox a network server's mailbox, or backup media.
7. Scan for backdoors and network sniffers.
8. Locate root kits or viruses.

3. **Extracting evidence:** There are two different types of extraction, physical and logical.

   a. **Physical extraction:**

During this stage the extraction of the data from the drive occurs at the physical level regardless of file systems present on the drive. This may include the following methods: keyword searching [make a list of keyword search], file carving, extraction of the partition table and unused space on the physical drive (National Institute of Justice 2004) and examining the partition structure which may identify the file systems present and determine if the entire physical size of the hard drive is accounted for investigation.

   b. **Logical extraction:**

During this stage the extraction of the data from the drive is based on the file system(s) present on the drive and may include data from areas as active files, deleted files, file slack, and unallocated file space (National Institute of Justice 2004), steps may include:

1. Extraction of the file system information to reveal characteristics such as directory structure, file attributes, file names, date and time stamps, file size, and file location (National Institute of Justice 2004).
2. Data reduction to identify and eliminate known files through the comparison of calculated hash values to authenticated hash values (National Institute of Justice 2004).
3. Extraction of files pertinent to the examination. Methods to accomplish this may be based on file name and extension, file header, file content, and location on the drive (National Institute of Justice 2004).
4. Recovery of deleted files and partitions.
5. Extraction of password-protected, encrypted, and compressed data as well as file slack and unallocated space.
6. Extract information from startup and configuration files.
7. Determine data relevance**,** keep in mind, however, that it needs to be fast; don't waste time collecting information that will be of no use to the case (Schweitzer 2003).
8. Extract IDS, Router, Firewall, application and authentication log files.
9. Extraction of e-mails and deleted e-mails from .pst **[**personal e-mail files**]** and .ost [offline e-mail files] files or from history, cookies and temporarily internet files.

4. **Reconstruction of extracted data:** Once the evidence is gathered and extracted, it can be used to reconstruct the crime to produce a clear picture of the crime and identify the missing links in the picture.

   There are three fundamentals of reconstruction for investigating crimes, which are: Temporal analysis, Relational Analysis and Functional Analysis.

   Temporal analysis tries to discover some factors such as what happened and who are involved, while relational analysis facilitate the reconstruction by correlating the actions of suspected victim, at the same time functional analysis discovers how the activities or actions actually happened and discovers the responsible factors.

   There are many analysis techniques used to present significance of evidences, it's not a must to use all these techniques in all the cases, but it depends on the case nature, some of these techniques are:

a. Timeframe analysis:

Timeframe analysis can be useful in determining when events occurred on a computer system, which can be used as a part of associating usage of the computer to an individual(s) at the time the events occurred. Two methods that can be used: (National Institute of Justice 2004)

1. Reviewing the time and date stamps contained in the file system metadata [e.g., last modified, last accessed, created, change of status] to link files of interest to the timeframes relevant to the investigation.
2. Reviewing system and application logs that may be present. These may include error logs, installation logs, connection logs, security logs, etc.

b. Data hiding analysis:

Digital systems can easily hide data. Using data hiding analysis can be useful in recovering some important information which may indicate knowledge or ownership... Methods that can be used include:

1. Correlating the file headers to the corresponding file extensions to identify any mismatches and analyze the file signatures to detect hidden data.
2. Analyze all password-protected, encrypted, and compressed files, knowing that the password itself may be as relevant as the contents of the file.
3. Gaining access to a HPA, the presence of user-created data in an HPA may indicate an attempt to conceal data. (National Institute of Justice 2004)

c. Application and file analysis:

Many programs and files identified may contain information relevant to the investigation and provide insight into the capability of the system and the knowledge of the user. Results of this analysis may indicate additional steps that need to be taken in the extraction and analysis processes (National Institute of Justice 2004). Some examples include:

1. File names may be evident and it may indicate content of file.
2. Examining file content which may contain evidence or indicates possession to a specific user.
3. Correlating the files to the installed applications (National Institute of Justice 2004).
4. Considering relationships between files. For example, correlating Internet history to cache files and e-mail files to e-mail attachments (National Institute of Justice 2004).
5. Examining the users' default storage location(s) for applications and the file structure of the drive to determine if files have been stored in their default or an alternate location(s) (National Institute of Justice 2004).
6. Examining user-configuration settings, analyzing file metadata, the content of the user-created file containing data additional to that presented to the user, typically viewed through the application that created it (National Institute of Justice 2004).

d. Log Files analysis:

1. Analyze network traffic and analyze each network packet.
2. Analyze IDS logs and monitor security events.
3. Perform Protocol analysis and content searching /matching for each packet.

4. Investigate and analyze Router logs:
    a. Syslog logging
    b. Buffer Logging
    c. Console logging
    d. Terminal logging
    e. SNMP logging
    f. Access Control List [ACL] logging
5. Investigate and analyze firewall and switch logs.
6. Investigate and analyze Application server logs.
    a. Errors generated and its time
    b. E-mail server logs
    c. Logins , executed commands
    d. Database logs
    e. Authentication Logs
    f. Operating system log files
7. Correlate log files to get the whole picture in case of network attacks.

e. Analysis of e-mail messages:

1. View e-mail header: which contain information email origin, how it reached and who send it [The header can be faked except the "received" portion-referencing.].
2. Trace email regarding internet domain using source IP address in header.
3. Verify the validation of e-mail path by checking in router [check ID of message] and firewall logs.
4. Analyze logs from e-mail server.
5. Contact the e-mail provider in the case of web based e-mail [source] to reveal suspects information.

f. Network analysis:

1. Analyze any abnormal system processes, port files and services using commands already on the system or third-party tools.
2. Analyze startup files to analyze any unauthorized system modification and check for unusual ports listening for connections from other hosts.
3. Inspect network configurations for unauthorized entries.
4. Identify initiating IP address, source port, service, date and time.
5. Identify unauthorized network trusts.

5. Conclusion: Results obtained from any one of these steps may not be sufficient to draw a conclusion (National Institute of Justice 2004).When viewed as a whole; however, associations between individual results may provide a more complete picture. As a final step in the examination Phase, consider the results from both physical and digital forensics phases,

and organize the analyses results from collected physical and digital evidences to link a person to the digital events.

4.4 Reporting and Presentation Phase

Reporting is a vital importance in digital forensic cases. Writing a good and comprehensive report increase the chance of convincing the judge and winning the case. Report does not only including communicating facts, but it also presents the expert opinion. The presentation(s) are intended to provide both detailed confirmatory and event reconstruction information (Beebe & Clark 2004). This report should:

- Document whether or not the allegations were substantiated.
- It must be organized in a way, so that anyone who reads it can understands it without reference to any other material, so while writing the report must include any related documents such as log files and pictures.
- It should present evidence as testimony. Also Fees paid for expert's service and list of all list of civil and criminal cases in which the expert has testified for the preceding four or five years must be included.

It is preferred to be in PDF format and it should be communicable. No assumptions should be made while writing the report. If something important is discovered include it in the report. Writing should be brief, grammar and spelling must be checked and repetition of word and difficult and slang words should not be used. A good report should have the following features:

- Reporting agency name and data.
- Case identifier or submission number (National Institute of Justice 2004).
- Identity of the both the submitter, the investigators and examiners of the case including their signatures.
- Date of both receipt and reporting.
- Description of collection and examination procedures.
- Descriptive list of items submitted for examination, including serial number, make and model.
- Brief description of steps taken during examination. (National Institute of Justice 2004).
- Providing uncertain and error analysis. (National Institute of Justice 2004).
- Explanation of results.
- Should include all log files generated by forensic tools.
- Summary and details of findings

Details of finding should describe in detail the results of the examinations and may include:

- Specific files related to the request and other files, including deleted files that support the findings (National Institute of Justice 2004).
- String searches, keyword searches and text string searches. (National Institute of Justice 2004).
- Internet-related evidence, such as web site traffic analysis, chat logs, cache files, e-mail, and news group activity. (National Institute of Justice 2004).
- Graphic image analysis. (National Institute of Justice 2004).
- Ownership indicators.

  - Data analysis and description of relevant programs on the examined items. (National Institute of Justice 2004).
  - Techniques used to hide or mask data, such as encryption, Steganography, hidden attributes, hidden partitions, and file name anomalies (National Institute of Justice 2004).

- Supporting materials: List supporting materials that are included with the report, such as printouts of particular items of evidence, digital copies of evidence, and chain of custody documentation (National Institute of Justice 2004).

4.5 Closure Phase

The closure phase involves at the beginning reviewing the whole case in which it reviews the investigation to identify areas of improvement. It also examines how well each of the physical and digital investigations worked together, and whether the evidences collected were enough to solve the case. The purpose of this phase is to:

- Review the entire process and investigation procedures.
- Collect and preserve all information related to the incident.
- Return the physical and digital properties to their owner.
- Determine what criminal activities must be removed.
- Eradicate system information and apply counter measures to prevent such crimes from happening again on the system.

The Closure documentation should be performed which include the time and date of release, to whom and by whom released.

5. MODEL DISCUSSION AND CONCLUSION

The problem of cyber crime is increasing rapidly, which requires increase in expertise in the digital forensic investigation area and requires guidance for these experts to perform the investigation without alerting the integrity of evidences.

This model offers unique benefits over other models as it gives a deep level of detailed steps for each phase. It is practical and involves steps that actually investigators do during investigation. It is general with respect to technology so that it won't be limited to present technologies at the same time it is specific enough so that each phase can be developed in future tools.

The proposed model also covers the most popular operating systems windows, UNIX and Linux, and it is technology neutral so it can be used in different platforms and on different cases. This model allows technical requirements for each phase to be developed and identifies interaction between physical and digital investigations. It is abstract enough that it can be applied to both law enforcement and corporate scenarios.

As digital evidence is challenged more in court, using standard procedures and models increase the court acceptance of the cases and by including already known and recognized procedures from physical forensics will add credibility to the analysis results from the digital world.

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