Digital Investigations & Forensics Analysis Practices and Technologies

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Introduction
Stages of IT Security

- **Attack prevention**
  - Pre-incidence measures
    - Access control, security policy, intrusion detection, ...

- **Attack tolerance**
  - During-incidence measures
    - Honeypots, intrusion tolerance, sabotage tolerance, ...

- **Attack aftermath**
  - Post-incidence measures
    - CERT, forensics analysis, ...
Headline Archives

CYBER BANKING FRAUD
Global Partnerships Lead to Major Arrests

10/01/10

The cyber thieves were smart. Instead of targeting corporations and large banks that had state-of-the-art online security, they went after the accounts of medium-sized companies, towns, and even churches. Before they were caught, members of the theft ring managed to steal $70 million.
Over 85% of cases prosecuted involve digital evidence

Meadaris, K., “Grants to help develop ways to improve digital evidence collection”, Purdue University, October 2006.

50% of all cases handled by the FBI to involve at least one computer forensic examination


Global digital-forensics market is estimated to be $1.8 billion by 2011 (~ 1/3 of this market share will come from US)

PC Pro Magazine - 21 Jan 2010
http://www.pcpro.co.uk/news/260227/dell-delves-into-digital-detective-work

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Computer Forensics Emerges as an Integral Component of an Enterprise Information Assurance Program

By Douglas Barbin, CISSP, CPA, CFE, and John Patzakis

Imagine restricting an internal company audit or investigation to allow the review of only 10 percent of all documents relevant to that investigation. As recent university studies reveal, more than 90 percent of all information is now created in digital form. Therefore, when company auditors ignore computer evidence, they essentially limit themselves to 10 percent of the available information. For this reason, the burgeoning practice of computer forensics has become synonymous with computer investigations and audits.

Computer forensics is the collection, preservation, analysis and court presentation of computer-related evidence. In addition to civil and criminal jury trials, computer evidence often is presented in arbitration, administrative and mediation proceedings, congressional/government hearings and presentations to corporate management. Accordingly, the proper collection and analysis of computer evidence through accepted computer forensic protocols is a critical component to any internal investigation or audit where the results have at least the potential to be presented in legal proceedings.

Computer forensics ensures the preservation and authentication of computer data, which are fragile by nature and easily can be altered, erased or subject to claims of tampering without proper
Digital Forensics
Definition - Digital Forensics Science

- Forensic science is the application of natural science to matters of law
- Forensic science seeks to find the root cause of an event
- “To be considered a discipline, Digital Forensic Science must be characterized by the following associated entities:
  - **Theory**: a body of statements and principles that attempts to explain how things work
  - **Abstractions and models**: considerations beyond the obvious, factual, or observed
  - **Elements of practice**: related technologies, tools, and methods
  - **Corpus of literature and professional practice**
  - **Confidence and trust in results**: usefulness and purpose
- The current state of Digital Forensic Science exhibits only some of these characteristics and they are not tied to specific disciplinary practices considered by any group as scientifically rigorous.”*


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“The use of scientifically derived and proven methods toward the preservation, collection, validation, identification, analysis, interpretation, documentation and presentation of digital evidence derived from digital sources for the purpose of facilitating or furthering the reconstruction of events found to be criminal, or helping to anticipate unauthorized actions shown to be disruptive to planned operations.”

Digital Forensics Events Management

Preparation ➔ Detection ➔ Containment ➔ Analysis ➔ Eradication ➔ Recovery ➔ Follow-up

Feed Back

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An Example of Forensic Investigation

- **Identification**
  - Call received

- **Preservation**
  - Case file opened
  - Server imaged
    - Image in chain of custody
  - Server logs preserved
  - Entry in case file

- **Collection**
  - SafeBack used
  - Policies reviewed for authority to proceed

- Began interviews
- Event described
  - Unavailable mortgage database
  - Server checked: db gone
  - Observed action by admin including remote login
  - Restore from backup unsuccessful - data bad

- Entry in case file

An Example of Forensic Investigation

- **Examination**
  - Data recovered from server drive
    - Database deleted and partially overwritten
    - Placed in chain of custody
    - Entry in case file
  - Data recovered from server logs
    - Login by admin from a network connection
      - Gateway address
      - Attack PC address and name
  - Placed in chain of custody
  - Entry in case file
  - Data recovered from gateway logs
    - Time & date of access to gateway by attack PC
    - IP address of attack PC
    - Entry in case file
    - Placed in chain of custody


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An Example of Forensic Investigation

- **Examination cont.**
  - Data recovered from attack PC
    - SafeBack used
    - Placed in chain of custody
    - Policies reviewed for authority to proceed
    - Login info re: victim recovered

- Authentication data for victim recovered
- Attack PC username recovered: suspect identified
- Suspect logged in at time of event
- Entry in case file


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An Example of Forensic Investigation

- **Examination cont.**
  - Data recovered from floor swipe card access log
  - Placed in chain of custody
  - Entry in case file
  - Witness interviews
    - Co-workers in physical proximity place suspect at desk within 1 hour of event
    - Supervisors places suspect at desk within 3 minutes of event

- **Analysis**
  - Timeline of events created
  - Evidence linked and traceability established
  - Entry in case file

Presentation

• Timeline and chain of evidence documented in final report
• Suspect interviewed and presented with conclusions and evidence
• Entry in case file

• **Decision**
  • Suspect confesses

• **END**
Formal Expression
Digital Investigation Process Language

• Started with the Common Intrusion Specification Language (CISL)
  • Derived from LISP
    • Formal language proven using the Lambda Calculus
  • A “language that can be used to disseminate event records, analysis results, and countermeasure directives amongst intrusion detection and response components.”
    • Found by Doyle at MIT to be inadequate for that task - however, offers a very rich language for forensic digital analysis
      - Still requires some extensions

Developing the Process Language

- CISL structure
  - S-expressions
    - Data structure developed by Rivest in 1997 that is “...suitable for representing arbitrary complex data structures.” (Rivest, S-Expressions, 4 May 1997)
    - May be byte strings or lists of simpler S-expressions
  - Semantic Identifiers (SIDs)
    - Tags added at the beginning of an S-expression that give a semantic clue to the interpretation of the rest of the S-expression
      - Verb SIDs
      - Role SIDS
      - Atom SIDS
      - Conjunction SIDs
      - Referent SIDs

Typical CISL S-Expression

(OpenApplicationSession
   (When
      (Time 14:57:36  24 Feb 1998)
   )
   (Initiator
      (HostName 'big.evil.com')
   )
   (Account
      (UserName 'joe')
      (RealName 'Joe Cool')
      (HostName 'ten.ada.net')
   )
   (Receiver
      (standardTCPPort 23)
   )
)

Interpretation

At 14:57:36 on 24 Feb 1998, someone at big.evil.com opened a telnet session on ten.ada.net logging in as username: joe, real name: Joe Cool.

Fragment of Earlier Example Expressed in DIPL

Identification
Call received

(And
  (Report
    (Initiator
      (RealName ‘Joe Operator’)
    )
  )
  (Observer
    (RealName ‘Peter Stephenson’)
  )
  (AttackNickName ‘access denied to a file or object’)
  (FileName ‘Mortages.db’)
  (Target
    (HostName ‘Server1’)
  )
)

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Fragment of Earlier Example Expressed in DIPL

Preservation
Case file opened
Server imaged
Image in chain of custody
Server logs preserved
Entries in case file

(ManageCase
  (Initiator
    (RealName ‘Peter Stephenson’)
  )
  (CaseName ‘Case123’)
  (BeginTime 16:35 1 Jan 1998)
)
(ManageImage
  (Initiator
    (RealName ‘Peter Stephenson’)
  )
  (Tool
    (ProgramName ‘SafeBack’)
    (VersionNumber ‘3.0’)
  )
  (BeginTime 17:00 1 Jan 1998)
  (EndTime 20:14 1 Jan 1998)
  (Target
    (HostName ‘Server1’)
  )
  (ReferAs 0x12345678)
)

Fragment of Earlier Example Expressed in DIPL

Preservation

Server logs preserved

(PreserveCustody
  (Evidence
    (ReferTo 0x12345678)
  )
)

(ManageCase
  (Initiator
    (RealName ‘Peter Stephenson’)
  )
  (CaseName ‘Case123’)
  (BeginTime 20:25 1 Jan 1998)
)

(ExtractData
  (Evidence
    (FileName ‘server.log’)
    (ReferAs 0x87654321)
  )
  (Target
    (ReferTo 0x12345678)
  )
  (PreserveCustody
    (Evidence
      (ReferTo 0x87654321)
      (BeginTime 20:45 1 Jan 1998)
    )
  )
)

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**Fragment of Earlier Example Expressed in DIPL**

**Collection**
Entry in case file
SafeBack used

(ManageCase
  (Initiator
    (RealName ‘Peter Stephenson’) )
  (CaseName ‘Case123’) (BeginTime 21:05 1 Jan 1998) )
(TraceAuthority
  (ApprovedSoftware
    (Tool
      (ProgramName ‘SafeBack’) (VersionNumber ‘3.0’) )
    (Citation
      (CaseName ‘joe v volcano’) )
  )
)

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Collection
Policies reviewed for authority to proceed

(ApprovedMethod
  (Certification
    (Certifier
      (RealName ‘NTI’)
    (CertType ‘NTI Training’)
    (CertNumber ‘Course 1-1-95’)
    (Observer
      (RealName ‘Peter Stephenson’)
    )
  )
)
)
)
)
)
)
)
)
)
)
)
)

(Policy
  (PolicyName ‘Information Privacy Policy’)
  (PolicyDate ‘1 Jan 1990’)
  (Observer
    (RealName ‘Peter Stephenson’)
  )
)
)
)
)
Fragment of Earlier Example
Expressed in DIPL

Collection
Entry in case file
Conduct interviews

(ManageCase
  (Initiator
    (RealName 'Peter Stephenson')
  )
  (CaseName 'Case123')
  (BeginTime 21:05 1 Jan 1998)
)
)

(Interview
  (Initiator
    (RealName 'Peter Stephenson')
  )
  (Subject
    (RealName 'Jane Sneaker')
  )
  (BeginTime 08:30 2 Jan 1998)
  (EndTime 10:45 2 Jan 1998)
)
(ManageCase
  (Initiator
    (RealName 'Peter Stephenson')
  )
  (CaseName 'Case123')
  (BeginTime 21:05 1 Jan 1998)
)
)
Benefits of the Formal Approach

- Describes a repeatable digital forensic process in a structured manner
- Allows independent analysis and verification of a forensic investigation including the interpretation of the attack process
- Formally documents the total investigative process
  - Pre-attack activities
    - As interpreted by the investigator
  - Investigative process
  - Attack activities
    - As interpreted by the investigator
  - Post-attack activities
    - As interpreted by the investigator
  - Documentation, evidence management, procedural issues
- Allows verification of the investigative process during the investigation and may help suggest ways to plug holes in the EEDI process
  - Gaps in the chain of evidence
- May be fed into a model checker for formal modeling of the process

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Analysis Technologies
Digital Forensics Tools

- Depending on the scope and requirements of the digital forensics analysis, a number of tools are used for each specific analysis. Most common features are:
  - Disk copying/imaging tools for copying the contents of hard and removable storage media drives.
  - Data recovery tools for restoring deleted data items.
  - Search and analysis tools for analyzing data under examination so as to locate specific content or event.

- Some commonly available tools are described in the following slides.
  - This is a non-exhaustive list of the available tools
  - No commercial interest is involved in the selection of these tools!
DRIVESPY is a forensic DOS shell. It is designed to emulate and extend the capabilities of DOS to meet forensic needs.

**Commercial Customers**

**SKU:** 31000  
**$249.95**  
**ORDER**

**Law Enforcement**

**Personnel / Agencies**  
**$199.95**  
**SKU:** 31050

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**About DriveSpy**

THIS PROGRAM IS A DOS APPLICATION THAT WILL NOT FUNCTION IN WINDOWS

Whenever appropriate, DRIVESPY will use familiar DOS commands (CD, DIR, etc) to navigate the system under investigation. When beneficial, DRIVESPY will extend the capabilities of the associated DOS commands, or add new commands as necessary. DRIVESPY provides a familiar DOS-like prompt during system navigation. (DRIVESPY does not use drive letters in the prompt, but rather a Drive/Path combination (i.e. "D: \WIN\SYSTEM") to eliminate confusion in the event where the resident operating system has not assigned a drive letter to the drive being processed (i.e examining a FAT32 partition under DOS 6.22)).

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04/13/01 - SC Magazine’s testing of Forensic Software identifies DRIVESPY as the ONLY product reviewed which found ALL the hidden information in their test suite. This included forensic software products costing almost 10 times as much as DRIVESPY!

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**DriveSpy Processes**

- Cloned Hard Drive (Completely & 1:1)
The Hex Workshop Hex Editor by BreakPoint Software is a complete set of hexadecimal development tools for Microsoft Windows 2000 and later. Hex Workshop combines advanced binary editing and data interpretation with the ease and flexibility of a modern word processor. With the Hex Workshop, you can edit, cut, copy, paste, insert, fill and delete binary data. You can also work with data in its native structure and data types using our integrated structure view and smart bookmarks. Data editing is quick and easy with our extensive features that allow you to: jump to file or sector location, find or replace data, perform arithmetic and logical operations, binary compare files, generate checksums and digests, view character distributions and export data to RTF or HTML for publishing.
Up and running in 3 minutes!

Isn’t it crazy to know that you have a current backup but it’s going to take you nearly two days to get up and running again? SnapBack backups can be restored by a total novice in just a few minutes.

**SnapBack® Exact** is a server-based backup and restore program for Windows servers that features full open file management, remote administration and backup scheduling. It copies an actual byte-by-byte True Image® copy of the server hard drives to tape while the backup is running and files are open and being modified. With TapeDisk you can restore single files as easy as copying files from a CD-Rom and with the simple Disaster Recovery Disk you can be up and running again in minutes.

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**latest news**

**16th August 2007**
SNAPBACK EXACT 5.20b RELEASED
A point release of SnapBack Exact has been released - 5.20b. This version fixes a compatibility issue with Windows 2003 Server and is a strongly recommended upgrade. Read the Release Notes.

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**20th March 2006**
SNAPBACK EXACT 5.20a RELEASED
A major new version of SnapBack has been released - 5.20a.

**It is fully compatible with Windows 2003 as well as XP and 2000.**
Read the Release Notes

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Secure Computing Magazine said:

“SnapBack Live! is our other Recommended product, which again convinced us that it may provide that little bit of extra appeal from the administrator’s point of view.”
EnCase® Forensic

Solve More Cases with Digital Evidence
Increase your ability to investigate digital data with unmatched analytics, powerful scripting, and an active community of experienced users.

Unsurpassed Digital Data Collection and Analysis

From the simplest requirements to the most complex, EnCase® Forensic is the premier computer forensic application on the market. It gives investigators the ability to image a drive and preserve it in a forensic manner using the EnCase evidence file format (LEF or E01), a digital evidence container validated and approved by courts worldwide.

EnCase Forensic also contains a full suite of analysis, bookmarking and reporting features. Guidance Software and third party vendors provide support for expanded capabilities to ensure that forensic examiners have the most comprehensive set of utilities.

Key Benefits & Features

Key Benefits
- Unsurpassed court acceptance
- Recognized worldwide as the de facto standard for computer forensics
- Analyze target machines at a deeper level

Key Features
- Advanced search options
- Internet and email support
- Court validated Logical Evidence File format
- Native viewer
R-Tools Technology Inc. is the leading provider of powerful data recovery, undelete, drive image, data security and PC privacy utilities for the Windows OS family. Our mission is to give our customers around the world the system tools to bring about a visible and substantial increase in viability, production, and ease of use at the lowest possible cost to the customer.

Data Recovery
Our flagship self-service data recovery and undelete software products are the efficient alternative solutions to costly and time-consuming in-lab data recovery services. They allow our customers to recover data from all popular file systems in situations ranging from accidental file deletion, formatted hard drives, and damaged or deleted partitions to total erasure by a virus.

Drive Imaging and Backup
Based on the latest hard disk image creation technologies, our new R-Drive image product creates drive image files with various compression levels on the fly without leaving Windows OS. It is one of the best backup solutions your for preventing loss of your data after a fatal system failure.

Data Security and Privacy
PC privacy and disk cleaning software protects your PC from examination, spying, or simple snooping into your off-line and Internet activities and destroys the data of those activities beyond recovery by hardware or software tools. What's more, wiping and cleaning unneeded files dramatically free up hard drive space and speed up the system.

R-Tools also continued to buff and bolster the performance and features of other high-performance utilities in its line-up of recovery solutions. R-Crypto, is now available *free of charge* for home users.

This data encryption utility protects a user's confidential information and personal data against unauthorized access, whether on a desktop, notebook or removable data storage device.

We are committed to providing fast, efficient, and affordable software...
Forensic Toolkit® is recognized around the world as the standard in computer forensic investigation technology. This court-validated digital investigations platform delivers cutting-edge analysis, decryption and password cracking all within an intuitive, customizable and user-friendly interface. FTK® is built for speed, analytics and enterprise-class scalability. Known for its intuitive interface, email analysis, customizable data views and stability, FTK® lays the framework for seamless expansion, so your computer forensic solution can grow with your organization’s needs. Forensic Toolkit 3 is now the most advanced computer forensic solution available, providing functionality that normally only organizations with tens of thousands of dollars could afford. However, we are committed to making our technology available to all investigators and analysts, whether they are in law enforcement, education, a government agency, a Fortune 500 corporation, or practicing digital investigators as service provider.

**PRODUCT FEATURES**

**An Integrated Computer Forensics Solution**

- Create images, analyze the registry, conduct an investigation, decrypt files, crack passwords, identify steganography, and build a report all with a single solution.
- **Retrieve passwords** from 100+ applications; harness idle CPUs across the network to decrypt files and perform robust dictionary attacks.
- KFF hash library with 45 million hashes.

**Enterprise-class Architecture**
"For file server, mail server, production server acquisition F-Response has been a godsend. The ability to perform physical acquisition without interruption to a server is brilliant and it’s also come in very handy when we’ve encountered disks in servers that cannot be acquired with other tools. In fact, F-Response has pretty much become the first and foremost tool in my arsenal whenever I encounter file servers, raid arrays etc."

Chris Bowen, McGrath Nicol - http://www.mcgrathnicol.com/

F-Response - Extend Your Arsenal

The First Truly Vendor Agnostic Solution for Forensics and eDiscovery

F-Response provides read-only access to the full physical disk(s) of virtually any networked computer, plus the physical memory (RAM) of most Microsoft Windows® systems. F-Response enables Live forensics and eDiscovery to be conducted over IP networks, using the investigators tools of choice.

F-Response uses a patent-pending process based on well documented industry standards to create a secure, read-only connection between the examiner’s computer and the computer under inspection. F-Response was designed to be completely vendor neutral.

If your analysis software reads a hard drive, it will work with F-Response.

F-Response makes the storage devices on the computer under examination completely accessible to the examiner’s computer where they appear as local, raw, physical storage devices. The F-Response connection is completely read-only, providing zero effect on the computer’s forensic integrity.
Non-technical issues
Computer Crime

- Hard to predict for the following reason
  - Low computer literacy among lawyers, police agents, jurors, etc.
  - Tangible evidence like fingerprints and physical clues may not exist
  - Forms of asset different
    - Is computer time an asset?
  - Juveniles
    - Many involve juveniles

Source: “TEL2813/IS2820 Security Management” by James B D Joshi
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'Dangers' of a free market in forensic science

By Paul Burnell

Luke (not his real name) was sentenced to three years in jail when a court decided he had "kicked another man's head like a football".

Part of the evidence heard in court was based on the spots of the assaulted man's blood which were found on his shoe.

Luke claims he had gone to stop another man assaulting the victim, saying the blood on his shoe: "Put me at the scene of the crime, which I never denied anyway."

After his conviction, Luke's family hired private forensic science provider Forensic Access who carried out a further test and called a blood pattern analysis (BPA).

'Vital' test

According to Dave King, Business Manager of Forensic Access the test came to a stark conclusion. "We can see from photos in the case file there is only a small amount of blood," he says. "There is no way that piece of footwear could have made contact with somebody's head."

Mr King said that the BPA would have doubled the cost of the forensic evidence, adding it was why he believed the test was not
Some excerpts from a Belgian FCCU case-study
Who investigates ICT crime?

- Prosecutors / Examining Judges
- Specialised police forces (nat’l & Internat’l)
- Legal expert witnesses
- Specialised forensic units of consulting firms
- Associations defending commercial interests
Investigative problems - tracking

- Victims: **Unfamiliar** and fear for "Corporate image"
  => belated complaints – trashed / no more traces

- Rather "unknown" world for **police & justice**
  => Delay before involvement specialised units
  Limited ICT investigation capacity (technical & police skills)

- **Multiplication and integration** of
  services / providers / protocols / devices

- **Lack** of harmonised **international** legislation & instruments

- Anonymous / hacked connections – subscriptions - WIFI

- **Intermediate** systems often cut track to perpetrator
Investigative problems – evidence gathering

- **Delocalisation** of evidence
- Exponential growth of **storage capacity** => time consuming:
  - backups & verification processes
  - Analysis
- New legislation / jurisprudence imposes more **rigorous procedures** for evidence gathering in cyber space
- **Bad ICT-security**:
  give proof of the source and the integrity of evidence
Brussels, we have a problem ...

- Complainer
  - Hello, can you help?
  - We are a **Belgian hosting firm**
  - We have a problem
  - Our **webservers are hacked**
  - & several **websites** of our **Belgian customers** have been **defaced**

- Politie
  - OK
  - A few questions to start our file ...
  - Who, where, what, when ...
Who is where?
Who / where / what

- In Belgium
  - Hosting firm: nothing in Belgium
  - Customer: nothing in Belgium
  - Hacked firm: nothing in Belgium

- In the USA
  - Hacked webserver
  - Defaced website

- In the Netherlands
  - Hacked server

- In the UK
  - Hacker?

- In the Luxemburg
  - Hacker?
Digital Forensics in Corporate ICT Infrastructure
Corporate ICT Operations

1. Requirements Analysis
2. Design and Deployment
3. Auditing and Compliance
4. Business Operations
5. Business Discontinuity
6. Incident Management

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Operational Improvements by Digital Forensics

2 Design & Deployment
- Forensic-friendly
- Chain of custody
- Resilience planning
- ...

3 Auditing & Compliance
- Legal obligations
- Regulatory requirements
- Quality assurance
- ...

4 Business Operations
- Maintenance operations
- Upgrades & recoveries
- Equipment Management
- ...

6 Incident Management
- Collection & preservation
- Analysis & reporting
- Business continuity
- ...
Future Challenges
A real-life scenario

Forensics analysis methodologies for massive, highly distributed systems with dynamically changing boundaries

Identification & isolation/quarantine techniques to cordon-off the affected zone without disrupting the functioning of the cyberspace

Easy-to-use tools support for complex methodologies in the background
Potential Impact

• Nowadays
  • ENRON scandal*
  • FBI gathered and analyzed 31 TB of digital data
    • 1 TB = 250 million pages
    • 16 kilometers high stack if printed on both sides of the page.
  • FBI’s Computer Forensics Lab processed data from 130 computers, thousands of e-mails, and more than 10 million pages of docs.
  • Length of investigation = 5 years

• Tomorrow
  • Clouds, virtualization will drive cybercrime #
  • Businesses and law enforcement agencies can’t cope this wave with classical digital analysis approaches.
  • We have to address this shortcoming by enabling the security and forensics stakeholders to cope the post-accident scenario.
  • Beneficiaries will not only be the Cybercrime units but also the safeguarding of commercial and personal interests of the technology users.

* Statistics taken from the FBI website http://www.fbi.gov/page2/may07/rcfl050707.htm

# Trend Micro Report: The Future of threats and Threat Technologies – How the Landscape is Changing

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Novelty in the area of investigations

- Digital Forensics framework for the emerging infrastructures (Clouds, Future Internet, ...) by using virtualization techs.
  - Research on the ‘need to know’ parameters and their optimization
  - Development of corresponding tools
  - Auditing and compliance issues of Digital Forensics
- Tradeoff between privacy requirements and digital traces
  - Compliance with the EU Privacy directive and national laws
  - Harmonization of cross-border and cross-organizational issues of data access
- Collaborations with the stakeholders of the virtualization infrastructures
  - E.g. provision of finer grained details to a specific kind of public (such as CERTs, CSIRTs, CCUs, ...)
    - Something similar to mobile phone’s tracking
    - Study of the performance parameters

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Challenges of Digital Forensics in the Future Internet based Systems

- **Access Control**
  - Monitoring of access logs

- **Steganalysis**
  - Efficient data analysis tools

- **Multitenancy**
  - Isolation of software execution environments

...
Digital Forensics Framework for SMEs using Virtualization Technologies

- Tools support
  - General strategy

- Threats landscape
  - Preparation phase

- Reactivity
  - Detection phase

- Perimeter demarcation
  - Preservation phase

- Semantics support
  - Analysis phase

- Resilience
  - Recovery phase

- Feedback
  - Reporting phase

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“... when a person commits a crime something is always left at the scene of the crime that was not present when the person arrived.”

(Edmond Locard, 1910)
Thank you

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