Understanding the Insider Threat
Proceedings of a March 2004 Workshop

Richard C. Brackney, Robert H. Anderson

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Prepared for the Advanced Research and Development Activity

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RAND NATIONAL SECURITY RESEARCH DIVISION
Preface

The Advanced Research and Development Activity (ARDA) within the U.S. intelligence community (IC) has several research "thrusts," including one on advanced Information Assurance (IA) headed by Richard C. Brackney. On March 2–4, 2004, an unclassified workshop was held at the offices of McAfee Security (a division of Network Associates, Inc.) in Rockville, MD. The topic was "Understanding the Insider Threat."

The format of the workshop combined plenary sessions and four "breakout" groups, whose specialized topics were the following:

- Intelligence Community (IC) System Models
- Vulnerabilities and Exploits
- Attacker Models
- Event Characterization.

The workshop brought together members of the IC with specific knowledge of IC document management systems and IC business practices; persons with knowledge of insider attackers, both within and outside the IC; and researchers involved in developing technology to counter insider threats.

These proceedings contain an overview of the findings from this workshop and the display charts from briefings given to workshop participants. This document should be of interest to researchers investigating methods for countering the insider threat to sensitive information systems, and to members of the intelligence community concerned with the insider threat and its mitigation.

The RAND Corporation's research for ARDA's IA thrust is conducted within the Intelligence Policy Center (IPC) of the RAND National Security Research Division (NSRD). RAND NSRD conducts research and analysis for the Office of the Secretary of Defense, the Joint Staff, the Unified Commands, the defense agencies, the Department of the Navy, the U.S. intelligence community, allied foreign governments, and foundations.

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Summary

A major research thrust of the Advanced Research and Development Activity (ARDA) of the U.S. intelligence community (IC) involves information assurance (IA). Perhaps the greatest threat that IA activities within the IC must address is the "insider threat"—malevolent (or possibly inadvertent) actions by an already trusted person with access to sensitive information and information systems.

This unclassified workshop, held March 2-4, 2004, focused on the insider threat and possible indicators and warnings, observables, and actions to mitigate that threat. The ARDA researchers participating gave special attention to the activities, processes, and systems used within the intelligence community.

A combination of plenary and breakout sessions discussed various aspects of the problem, including IC system models, vulnerabilities and exploits, attacker models, and characterization of events associated with an insider attack. A set of presentations by members of the IC and its contractors on Intelink (Appendix G) and such research activities as the development of "Glass Box" software (see Appendix H) and ARDA's "Novel Intelligence from Massive Data" (NIMD) research program (Appendix I) aided the workshop discussions. The present workshop built upon the availability of materials generated in an earlier workshop focused on the insider threat (Appendix F).

Several overall themes emerged from these deliberations, discussed below under the headings of "Research Questions and Challenges" and "Databases Needed" (by researchers).

Intelligence Community System Models

The overall intelligence process involves requirements, collection, processing and exploitation, analysis and production, dissemination, and consumption, with feedback loops at all steps, as shown in Figure S.1.

Variant models, such as the NSA Reference Model (NRM), also exist. Of key concern to this group of researchers was the question: What "observables" can be obtained at all stages of this process that would allow comparison of normal analyst activity with abnormal activity—which is potentially, but not necessarily, malevolent? Figure S.2 provides an indication of the richness of the concept of "observable"; it is a taxonomy developed by the earlier insider threat workshop cited above. Similar taxonomies characterize IC "assets" and "users."

1 An observable is anything that can be detected with current technology. A number of workshop participants argued that this definition should be broadened to include foreseeable future technological developments.
Vulnerabilities and Exploits

What types of exploits\(^2\) might an insider use to obtain information, alter its integrity, or deny its availability to those who need it? This workshop concentrated on cyber-related

\(^2\) The noun *exploit* is often used within the intelligence community to mean the development of a plan (and, usually, its subsequent execution—often surreptitiously) to obtain information or an advantage.
exploits because they were felt to be potentially the most damaging and most likely to increase in the future, as a new generation of analysts emerges with more computer skills than the previous generation.

Workshop participants generated a list of 33 example exploits. For each they listed a brief description, preconditions that would allow the exploit to happen, observables that might be generated during the exploit, and effects of the exploit (usually one of the following: a breach of confidentiality, integrity, or availability, or an enabler of other exploits). The short titles of the vulnerabilities are listed in Table S.1. Further details may be found in Chapter Three.

Attacker Models

Figure S.3 shows an overall model of the steps involved if a malevolent insider were to “mount an attack” against an IC asset. The attack might be as simple as obtaining access to information he or she does not have a need to know or as complex as disabling a key intelligence collection/processing/dissemination system.

Another way of depicting attacker actions is shown in Figure S.4. Here the attacker steps—motivation, benefit/risk assessment, acquiring the “client,” collecting payment—were...
Figure S.3  
Spiral Model Flowchart

![Spiral Model Flowchart](image)

Figure S.4  
Insider Attack Actions (white items not cyber observable)

<table>
<thead>
<tr>
<th>Attack</th>
<th>Benefit/Risk Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>M O T I V A T I O N</td>
<td></td>
</tr>
<tr>
<td>Access</td>
<td>Acquire Client</td>
</tr>
<tr>
<td></td>
<td>Entrenchment</td>
</tr>
<tr>
<td>Exploitation</td>
<td></td>
</tr>
<tr>
<td>Recon</td>
<td>Extraction</td>
</tr>
<tr>
<td></td>
<td>Exfiltration</td>
</tr>
<tr>
<td></td>
<td>Communication</td>
</tr>
<tr>
<td></td>
<td>Collect Payment</td>
</tr>
</tbody>
</table>

Countering CI

deemed not to generate cyber observables (that is, they would not be detected by information systems now in use or with enhancements planned by researchers and developers).

Given the various steps an attacker follows, as shown in Figure S.4, which steps are candidates for using the vulnerabilities and exploits shown in Table S.1? The answer is shown in Figure S.5, where the unitalicized insider actions have parenthesized numbers linking them to numbered entries in Table S.1. The parenthesized suffix letters C, I, A, E indicate whether the actions would lead to a breach of information Confidentiality, Integrity, Availability, or would be an Enabler of other attacks.
Figure S.5
Insider Actions Taxonomy Cross-Referenced with Vulnerabilities and Exploits (V&E) List

<table>
<thead>
<tr>
<th>Access</th>
<th>Reconnaissance</th>
<th>Entrenchment &amp; Extraction &amp; Exploitation</th>
<th>Communication Manipulation</th>
<th>Counter Other Cyber Intelligence Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Web/file browsing</td>
<td>Download, media import, or email virus/trojan (1E,23A)</td>
<td>Standard encrypted email</td>
<td>Look over shoulder</td>
</tr>
<tr>
<td></td>
<td>DB searches</td>
<td>Keystroke logger (13CE)</td>
<td>Simple coded messages</td>
<td>Cover story</td>
</tr>
<tr>
<td></td>
<td>Unusual searching (17)</td>
<td>Import published attack (4E,8E)</td>
<td>Wireless usage (15C)</td>
<td>Unusual file deletion</td>
</tr>
<tr>
<td></td>
<td>Scanning (steamy)</td>
<td>Install unauthorized software</td>
<td>Custom encrypted email</td>
<td>Block admin access (2AE)</td>
</tr>
<tr>
<td></td>
<td>Authorized account</td>
<td>Sabotage patch system (9E)</td>
<td>Steganography (21C)</td>
<td>Search CI case files (17)</td>
</tr>
<tr>
<td></td>
<td>Orphan account</td>
<td>Replace device drivers/analysis tools</td>
<td>Covert Channels (21C)</td>
<td>Disk/file erase/wipe</td>
</tr>
<tr>
<td></td>
<td>Unlocked, unattended terminals (11CIA)</td>
<td>Printing/Copy machine</td>
<td>Altering authorized information (291,301,321)</td>
<td>Modify CI case files</td>
</tr>
<tr>
<td></td>
<td>Physical (pick up printout)</td>
<td>Removable media (5C,25C)</td>
<td>Upgrading classification</td>
<td>Modify audit logs</td>
</tr>
<tr>
<td></td>
<td>Accidental/Incidental</td>
<td>Manual classification downgrade</td>
<td>Database modification (121)</td>
<td>Normal drift</td>
</tr>
<tr>
<td></td>
<td>Document control</td>
<td>(18C,22C)</td>
<td>Corrupt protections-virus (10A)</td>
<td>Replace device drivers/analysis tools</td>
</tr>
<tr>
<td></td>
<td>Safe storage</td>
<td>Downloads</td>
<td>Corrupt infrastructure (23,28,31,321)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Two party rule</td>
<td>Masqueraded media</td>
<td>Pornography</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social engineering (3CE)</td>
<td>Downgrading classification (18C)</td>
<td>Gambling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shoulder surfing (24)</td>
<td>Stolen laptop (6CA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Password guessing (3CE)</td>
<td>Wireless usage (15C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Need-to-know violations (28)</td>
<td>Steganography (21C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>File permissions</td>
<td>Duplicate db/log file backup (14C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Password cracking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Privilege escalation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Missing: 7, 16, 19, 20, 26, 27, 33
V&E row # in (); no match in V&E

**Event Characterization**

As attacker actions generate observables through the operation of “detectors” of those observables, indicators of possible abnormal activity are generated. Those indicators can form a report; multiple reports can be fused into an “incident”; and multiple incidents then fused into a “case” of one or more incidents. That process is shown graphically in Figure S.6.

**Research Questions and Challenges**

Each breakout group tried to formulate a set of research questions arising from its deliberations. Some groups stated these questions in the form of “grand challenges” to be addressed. We summarize the key questions and challenges below.

**Six Categories of Research Questions**

Research issues tended to fall within six categories:

1. User roles
2. Actions

---

3 We assume that a “case” may be merely a collection of incidents having some commonality to be watched, or it could be the result of a post-facto analysis of source, cause, damage, etc.
3. Observables (events)
4. Sensors
5. Fusion and analysis (both spatial and temporal)
6. “Triggers” (priorities, and level of certainty).

The first four categories each require languages to describe them, and means for mapping each into the next (i.e., from a description of user roles to a set of described user actions, which in turn lead to a set of potential observables. Those observables are then sensed and the sensed signals fed into fusion and analysis programs, which in turn create actions and alerts within the system).

An additional common thread is the need for correlation and management tools to correlate multiple events or triggers with an incident, to correlate multiple events with a case, and to correlate multiple cases into a coordinated attack.

The topic of sensors (item 4 in the above bulleted list) requires substantial research in at least the following areas:

- Identification of information that should go into an event record
- Development of sensors specific to particular applications
- Standardization of event record syntax and semantics; scales of severity and confidence; system interfaces; and means for establishing an involute “chain of evidence”
- Detection of “low and slow” attacks
- Optimization of selection, placement, and tuning of sensors
- Tradeoffs in adaptability: How do you recognize legitimate changes in user behavior? How do you resist the “conditioning” of sensors by a malicious insider (through a pattern of actions that “migrate” the sensor from a nominal setting to one that won’t recognize the attack)?
- Development of validation and test data and techniques (see “Databases Needed,” below).
Challenges
Participants stated several "grand challenges" for researchers:

• Define an effective way of monitoring what people do with their cyber access, to identify acts of cyber espionage. Focus on detection, not prevention. Such monitoring (or the perception of monitoring, which may suffice in some cases) can be an effective deterrent.

• Develop policies and procedures to create as bright a line as possible between allowed and disallowed behaviors (i.e., reduce the ambiguity).

• Consider sociological and psychological factors and create better cooperation between information systems personnel and human resources personnel (including security, medical, financial, and other support services). In short, broaden oversight of all aspects of a user’s background and behaviors.

• Combine events from one or more sensors (possibly of various types or different levels of abstraction) to facilitate building systems that test hypotheses about malicious insider (MI) activity, to detect MI activity that is not detectable using a single event record, to develop a "calculus of evidence," to develop metrics for comparing and weighting diverse inputs, and to determine how "this fusion" can be used to create useful synthetic/compound events.

Databases Needed
Breakout sessions considered what databases would aid in this research if they were available. Researchers need databases containing examples of specific attacks, the characterization of normal behavior for users in different roles (including that of a system administrator), and artificial or real sensor data that include a mix of legitimate and malicious activity. Potential sources for the development of such datasets include a MITRE dataset of normal, and "insider threat" network activities; data from the ARDA NIMD study; data obtained from use of the Glass Box software; synthetically generated data from a simulator; and individual datasets developed by researchers that might be traded among projects.

A Concluding Remark
During a concluding plenary session, a senior member of the intelligence community, hearing the results from the various breakout session deliberations, made the comment, "What you're doing is important, but don't forget that IC analysts are people, too, and need a good work environment in which to stay motivated in their stressful jobs. When considering 'observables' and sensors and other means of keeping track of the activities of 'insiders,' please ask yourselves, 'Would I want to work in that (resulting) environment?'" It's important to keep this in mind, in the research enthusiasm for what might be monitored, and observed, and data-correlated. We must strike a balance between effectiveness in thwarting

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4 See Appendix I for information about the ARDA "Novel Intelligence from Massive Data" (NIMD) research thrust.
5 See Appendix H for information about the "Glass Box" research effort.
insider exploits against intelligence assets and effectiveness in the process of generating and disseminating that intelligence information itself.
A three-day intensive workshop such as the one documented here requires substantial planning. The planning committee for this Insider Threat workshop consisted of Richard Brackney and John Farrell (ARDA), John C. Davis (Mitretek), Lisa Yanguas (NSA/R6), Paul Esposito (NSA/Defensive Computing Research Office), Tom Haigh (Adventium Labs), and Robert H. Anderson (RAND). Tom Haigh provided substantial help in organizing the summary of overall research issues and challenges emerging from the workshop.

Hosts for the workshop, providing excellent services and facilities, were Erik G. Mettala and David Sames (McAfee Research).

The organizers of the workshop also greatly appreciate the time and attention of senior members of the intelligence community who gave briefings on various aspects of the intelligence process and on research underway.

RAND colleague Diane C. Snyder provided very useful comments on a draft of this report.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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</thead>
<tbody>
<tr>
<td>ACS</td>
<td>Automated Case System (FBI)</td>
</tr>
<tr>
<td>API</td>
<td>Application Program Interface</td>
</tr>
<tr>
<td>ARDA</td>
<td>Advanced Research and Development Activity</td>
</tr>
<tr>
<td>CD</td>
<td>compact disk</td>
</tr>
<tr>
<td>CD-ROM</td>
<td>compact disk–read-only memory</td>
</tr>
<tr>
<td>COI</td>
<td>community of interest</td>
</tr>
<tr>
<td>COMINT</td>
<td>communications intelligence</td>
</tr>
<tr>
<td>DCI</td>
<td>Director of Central Intelligence</td>
</tr>
<tr>
<td>DIA</td>
<td>Defense Intelligence Agency</td>
</tr>
<tr>
<td>DoS</td>
<td>denial of service</td>
</tr>
<tr>
<td>EUID</td>
<td>electronic user identification</td>
</tr>
<tr>
<td>HUMINT</td>
<td>human intelligence</td>
</tr>
<tr>
<td>H/W</td>
<td>hardware</td>
</tr>
<tr>
<td>IA</td>
<td>information assurance</td>
</tr>
<tr>
<td>IC</td>
<td>intelligence community</td>
</tr>
<tr>
<td>IR</td>
<td>infrared</td>
</tr>
<tr>
<td>LAN</td>
<td>local area network</td>
</tr>
<tr>
<td>MASINT</td>
<td>measurement and signatures intelligence</td>
</tr>
<tr>
<td>MI</td>
<td>malicious insider</td>
</tr>
<tr>
<td>NIMD</td>
<td>Novel Intelligence from Massive Data</td>
</tr>
<tr>
<td>NRM</td>
<td>NSA Reference Model</td>
</tr>
<tr>
<td>NSA</td>
<td>National Security Agency</td>
</tr>
<tr>
<td>NT</td>
<td>Windows NT (operating system)</td>
</tr>
<tr>
<td>OS</td>
<td>operating system</td>
</tr>
<tr>
<td>PBX</td>
<td>private branch exchange (telephone control)</td>
</tr>
<tr>
<td>PDA</td>
<td>personal digital assistant</td>
</tr>
<tr>
<td>PKI</td>
<td>public key infrastructure</td>
</tr>
<tr>
<td>QoS</td>
<td>quality of service</td>
</tr>
</tbody>
</table>
RF  radio frequency
RFID  radio frequency identification
RUID  radio frequency user identification
SAM  surface-to-air missile
SCIF  secure compartmented information facility
S/W  software
tcpdump  transmission control protocol dump (program)
TS/SI  top secret/special intelligence
URL  universal resource locator
USB  universal serial bus (computer port)
WMD  weapons of mass destruction
The operations and analyses of the United States intelligence community (IC)\(^1\) are based heavily on a set of information systems and networks containing extremely sensitive information. Most observers believe that the greatest threat to the integrity, confidentiality, and accessibility of the information in these systems is the “insider threat.”\(^2\) This phrase usually refers to a malicious insider, acting either alone or in concert with someone “on the outside” of these systems. However, one should also consider the possibility of unintentional actions by an insider that can have substantial adverse consequences or that draw attention to himself when innocent.

Discussions of the “insider threat” raise many questions: Who, exactly, is an insider? Anyone with physical or electronic access to these networks, including maintenance and custodial personnel? How much sophistication (if any) does it take to compromise the information within these systems? What defenses, including “indicators and warning,” might be instituted to guard against this insider threat?

To address these questions, the Information Assurance (IA) research thrust of the IC’s Advanced Research and Development Activity (ARDA) held a workshop on March 2–4, 2004. Participants included ARDA contractors working on the insider threat to information systems and members of the U.S. intelligence community with knowledge about its systems and networks. It was held at the offices of McAfee Security, a division of Network Associates, Inc., in Rockville, MD. The stated objectives of this workshop were:

---

1. The agencies normally considered to constitute the IC are the office of the Director of Central Intelligence, the Community Management Staff, the National Intelligence Council, a set of Defense Agencies (Defense Intelligence Agency; National Security Agency; National Reconnaissance Office; Army Intelligence; Coast Guard Intelligence; Navy Intelligence; Air Force Intelligence; Marine Corp Intelligence; National Geospatial-Intelligence Agency—formerly the National Imagery and Mapping Agency), and the non-Defense agencies (Central Intelligence Agency; Federal Bureau of Investigation; Advanced Research and Development Activity; and portions of the Department of Treasury, Department of Energy, and Department of State.)

2. As evidence for this statement, consider the following excerpt from a presentation on the Robert Hanssen case presented during the opening plenary session: (1) “Since the 1930s, every U.S. agency involved with national security has been penetrated by foreign agents, with the exception of the U.S. Coast Guard” (Webster Commission, 2002); (2) 117 American citizens have been prosecuted for espionage between 1945 and 1990 (or there is clear evidence of their guilt). Money appears to be the main factor; most spies volunteered their services. Prominent examples of insider spies include:

- \textit{Aldrich Ames}, CIA counterintelligence officer (nine years as spy)
- \textit{Ronald Pelton}, former intelligence analyst for NSA
- \textit{Jonathan Pollard}, military intelligence analyst, gave Israel 800 classified documents, 1,000 cables
- \textit{John Walker}, retired naval officer, with son and brother, supplied the Soviets with cryptographic material.
• To generate and capture domain knowledge that will benefit the broad base of researchers studying the Insider Threat. This includes, but is not limited to, knowledge about:

— Inside attacker characteristics, including the vulnerabilities they tend to exploit, and the attack methods they use.
— Attack characterization, including the necessary or likely preconditions for an attack, the observables generated during an attack, and the effects of the attack.
— The electronic network and application systems used by the IC for document management, including the mechanisms used to protect the systems and data.
— IC business models for generating and controlling access to documents.

• To foster cooperation among researchers by developing, to the extent it is practical, methods for describing common aspects of their work, such as event characterization, attack and attacker classification, etc.

• To focus researchers on specific systems and problems of interest to the IC. We expect these to take the form of challenge problems.

As can be seen from the above description, researchers investigating means to counter the insider threat formed the “target audience” for the workshop: its purpose was to supply them with relevant knowledge about the workings of the IC, the types of document or information processing used by IC analysts, and the architecture of the IC’s underlying information networks.

The workshop was unclassified, requiring that only generic information about some aspects of IC information processing activities were transmitted to researchers. The intent throughout the planning for this workshop was that the information generated (and as captured in this present document) should be widely available to anyone working on the insider threat problem, without restrictions.

The remainder of this document consists of the results of the deliberations of the four breakout groups. (Those results were originally presented to the workshop on PowerPoint charts; they have been converted to a prose form for greater readability and uniformity of presentation in these proceedings.) The descriptions and charters given to those breakout groups were as follows:

• **IC Systems and Business Models** for generating and controlling access to documents. This group will capture core knowledge about the business processes and the supporting network and application systems used by the IC for document management (creation, update, and dissemination). This includes the physical, procedural, and technical mechanisms used to protect the systems, services, and information. Since the systems are highly heterogeneous, with different processes and mechanisms, depending on specific system functions, we expect this group will generate a family of system models reflecting current IC systems practices and anticipating future IC systems and practices.

• **Vulnerabilities and Exploits.** This group will collect and organize knowledge about the ways insiders have attacked systems in the past and the ways they might attack them in the future. The group will identify ways that insiders have exploited technical and procedural vulnerabilities in the past to compromise classified information or
to affect the integrity of critical information. The group will identify the necessary or likely preconditions for an attack, the observables generated prior to and during an attack, and the effects of the attack. It is important to emphasize that the charter of this group goes beyond studying and describing technical exploits that an attacker could use to "hack" the system. In the past many of the most damaging exploits have resulted from legitimate use of system accesses for illegitimate purposes.

- **Attacker Models.** This group will direct its attention to identifying and understanding the relevant behavioral characteristics of inside attackers. Examples of these characteristics are attacker objectives, level of system knowledge and access, level of patience, tolerance for detection risk or attack complexity, social engineering skills, and technical capabilities. The working group will not concern itself with underlying psychological, political, or economic factors that might motivate some of the attacker's behavioral traits. An important part of this group's effort will be to understand how the attacker's observable behavior can be used to identify him as an attacker.

- **Event Characterization.** This group will identify the key elements necessary to characterize events associated with insider attacks, to facilitate tracking and interpreting a potential insider attacker's activities. This will assist researchers who are trying to integrate input from a variety of sensors to assess the likelihood of attacker activity and likely attacker intent. It will also help sensor researchers know what capabilities to include in the sensors they define.

The appendices contain the invitation to the workshop, the agenda, a set of links to relevant "read-ahead" material, and a list of participants. We also include PowerPoint charts used in the following plenary presentations made by members of the intelligence community and their contractors:

- An overview of the results of a recent ARDA workshop on Cyber Indications and Warning, by Mark Maybury, MITRE Corporation
- **Intellink Factoids,** by Peter Jobusch, Intellink Management Office
- **Glass Box Analysis Project,** by Frank L. Greitzer, Battelle, Pacific Northwest Division
- **Interacting with Information: Novel Intelligence from Massive Data (NIMD),** by Lucy Nowell, ARDA.
Relevant Taxonomies

This breakout group began by reviewing a set of taxonomies developed in a previous ARDA "Indicators and Warning" workshop (see Appendix F), shown in Figures 2.1 through 2.3. These figures list a set of "observables" that might be used to determine abnormal behavior of an insider or of IC documents, "assets" within the IC that might be tracked, and a list of the different categories of "users" (insiders) within the IC community.

Figure 2.1
OBSERVABLES TAXONOMY

Participants were Paul Esposito, Chris Geib, Joseph Giampapa, Alexander Gibson, Terrance (TJ) Goan, Clarence Jones, Jr., Linda (Miki) Kiyosaki, Sara Matzner, Mark Maybury, James Newton, David Sames, and Thomas Shackelford.
Figure 2.2
Assets Taxonomy

Figure 2.3
IC Users Taxonomy

The remainder of the group's deliberations then concentrated on a description of the intelligence process as it relates to a document life cycle, and a reminder that there are other systems involved to be considered: policy, personnel, physical security, etc.
Definition of the Term “Document”

The group developed the following definition of “document,” to be used in describing IC system and process models:

- Any collected artifact that is used to convey information.
- Ultimate purpose is to inform decisions at various levels:
  - Strategic
    - Military
    - Legislative
    - Political
  - Tactical
- Can be electronic or physical
- Can be structured or unstructured
- Image, voice, text, other
- Attributes
  - Owned, managed, protected.

Characterization of the Intelligence Process

The group characterized the intelligence production process in terms of the diagram in Figure 2.4, involving requirements generation, collection, processing and exploitation, analysis and production, dissemination, and consumption, with various feedback loops.

In describing the terminology in Figure 2.4, the group also referred to the “NSA Reference Model” (NRM), which comprises the following steps:

- Signal, data information, knowledge, intelligence
- Collection gathers signals and data
- Processing and exploitation transform signals and data into information
- Analysis and production transform information into knowledge and intelligence
- Intelligence is consumed.

The following subsections describe each of these processes in more detail.

Figure 2.4
Intelligence Process

![Feedback Diagram](attachment:image.png)
Requirement
A requirement is a statement of need by a consumer in the form of a formalized request. There are two types:

- **Standing requirement.** It is vetted by a consensus process, formalized by a memo, entered into a database, and is persistent.
- **Ad hoc requirement.** Anyone can submit an ad hoc requirement to a specific agency. It is stored in a database.

Some additional attributes of requirements are that they involve checks and balances, with multiple levels of vetting (e.g., committee meetings of analysts); there are potential vulnerabilities (e.g., the ability to change and modify requirements); the internal threat level is high; cyber or non-cyber attacks are possible on the database of requirements; and indications and warning of attacks on requirements could be derived from database audit logs.

Collection
The collection process was described as acquisition of raw data, which may include construction of new systems for performing the acquisition.

Its major components are all the “INTs” (e.g., COMINT, HUMINT, MASINT).

Additional attributes of the collection process include the existence of checks and balances, such as attribution of the source, techniques to preserve the integrity of collected data, and legal restrictions derived from government policy; potential vulnerabilities, such as degradation of collected data (including integrity issues), intercepts and eavesdropping, and denial of service from collecting and sending back what was collected; the insider threat level is considered to be “less likely”; and the potential for collusion was deemed to be “none.”

Processing and Exploitation
The group defined processing and exploitation as selecting, filtering, and rendering the collected information into a human-usable form. It involves converting technically collected information into intelligence. Filtering is often involved and may be performed by individuals, software, or groups.

Analysis and Production
All IC member organizations perform analysis. Analysis is the transformation of information to knowledge. Production is the formalization of knowledge into a document or product.

The major components of analysis and production were listed as

- office automation tools
- secure document management systems
- specific analysis tools
- working aids, such as software search, visualization, and other programs
- communities of interest (COIs)
- other networked and local databases.

The process involves checks and balances, including hierarchical reviews for accuracy, consistency, accountability, attribution, security (e.g., assuring that proper markings are pre-
sent); collaborative production (not necessarily co-located); a coordination process involving interpretation and enforcement of policies; and authorizations.

The group felt that the analysis and production process had potential vulnerabilities, mainly to working documents and software programs constituting the working aids.

**Dissemination**

Dissemination is the distribution of intelligence to the requesters and authorized consumers. The group concentrated on electronic dissemination methods, with the following characteristics.

Its major components are chat, e-mail, and communities of interest. It uses both synchronous and asynchronous notifications and partial dissemination.

The group listed attributes of the dissemination process as

- checks and balances for dissemination, which are well-defined for paper-based documents and may use electronic watermarks for trace-back
- potential vulnerabilities including breach of confidentiality, denial of access to distribution lists, and distribution beyond intended consumers
- both the internal threat level and collusion level were considered to be high
- both cyber and non-cyber means of dissemination were considered to have vulnerabilities; cyber dissemination techniques were deemed to be less uniform
- indications and warning are to be considered on a per-dissemination channel basis.

**Consumption**

Consumption of intelligence is the use of produced intelligence by authorized users to support decisionmaking.

The main components of consumption (on the individual level) were stated by the group to be the five human senses.

Checks and balances in consumption include traditional security procedures and enforcement of policy. Potential vulnerabilities lurk during consumption, with the possibility of exfiltration, leaks, misuse, misinterpretation, and withholding.

An important research topic exists within the consumption process: finding ways to inject checks and balances within that process to provide observables.

The internal threat level related to consumption was deemed high; the collusion potential was deemed medium.

Although much dissemination is electronically based, consumption tends to remain primarily non-cyber, using low tech and traditional means (although the role of chat and e-mail is growing).

One indicator and warning of misuse of the consumption process is that restricted-dissemination data show up in the public press.

**Definitions**

The discussion group used the following definitions in describing the intelligence process:
• **Insider**: Anyone with access, privilege, or knowledge of information systems and services\(^2\)

• **Malicious insider (MI)**: Motivated to intentionally adversely impact an organization’s mission (e.g., deny, damage, degrade, destroy)

• **Observable**: Anything that can be detected with current technology\(^3\)

• **Sensor**: Measures an observable (e.g., login, print, delete)

• **Sensor logs**: Recording of observables

• **Sensor stream**: Series of observables from a sensor

• **Indicator**: Identifiable event based on sensor output logs

• **Detect**: Determines an event based on processing of indicators

• **Report**: Indications and warnings of malicious insider behavior

• **Incident**: Related set of events

• **Fusion**: Processing multiple sensor outputs to provide an enhanced result (e.g., more abstract or more concrete; higher confidence)

• **Case**: One or more incidents that share common attributes, and are deemed to be (potentially) related.

**Reference**

The group cited Lowenthal (2003) as a reference for information about the intelligence process.

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\(^2\) Note that we do not say “legitimate access.” Someone (e.g., a janitor, a service technician) may be given access accidentally or inadvertently but nevertheless have access to certain “insider” privileges.

\(^3\) Since we are concerned with research on automated detection of insider threats, we do not include here observables that are only human-detectable, unless that observer acts like a sensor and records the observation for subsequent processing steps.
CHAPTER THREE

Vulnerabilities and Exploits

Group Focus

This breakout group\(^1\) stated that their focus was on ways insiders attack information systems, including

- Preconditions for attack
- Observables
- Effects.

The group included illegitimate use of authorized access and focused on threats and vulnerabilities to IC networks. Because this was an unclassified workshop, certain vulnerabilities may be known at a classified level that cannot be described here; they will be described only at a generic level.

Overview of Group Deliberations

The group decided its limited time was best spent on the following activities:

- Look at some real life "war stories" about insider threats to critical information systems
- Decompose those and similar events to determine
  - preconditions (involving both physical and logical access)
  - observables (that could have been used to thwart the attack)
  - effects (of the attack).

"War Stories"

The group started by asking, "Has this ever happened in your world?" and gave these as examples. (The contributors vowed that all have been seen "in practice" in the real world, except for the second one, which was used in a test only.)

\(^1\) Participants were Robert Anderson, Philip Burns, Matthew Downey, Jeremy Epstein, Dana Foat, Steve Harp, Dennis Heimbigner, Kevin Killourhy, Vincent Lee, Mark Morrison, Mike Pelican, and Brad Wood.
• An insider walks into the secure compartmented information facility (SCIF), pulls out from under his coat a freshly burned CD, sticks it into his classified workstation, and then selects RUN.
• An insider locks administrators out by making multiple attempts against their passwords until the system locks out their passwords.
• A user calls the help desk: “Hello, this is Major Smith—can you reset my password?” And the help desk doesn’t verify that it’s really Major Smith who’s calling.
• An insider finds a nifty attack on the Internet. He asks himself, “Gee, I wonder if this will work on our LAN?”
• The business portion of the agency was sent a system patch, but they didn’t give it to the security guys. The system didn’t get patched.
• An insider modifies a valid system patch, which then gets distributed to the whole “world” of that agency via LiveUpdate.
• What if . . . someone modified a planning database to change the coordinates for SAM sites 2.0 km to the south, and make them SAM-2 instead of SAM-5 missiles (so that they were believed to have shorter range). Pilots would get shot down. All this requires is access to a database in Microsoft Access, Excel, etc.
• A malicious insider copies a TS/SI file from his classified workstation onto a USB port “flash drive,” moves it over to his unclassified system, and mails it out, all within the same office.
• Another insider installs a keystroke logger to get a few passwords to another computer in the same office.
• A database administrator makes an extra copy of the database files, but says the tapes are bad. He/she then carries the tapes out, and no one is the wiser.
• An insider has a wireless transceiver in his unclassified system, to transmit files after they have been moved from his classified workstation to his unclassified one (see “USB flash drive,” above).

**Attack Actions, Observables, Effects**

Having “warmed up” on the above examples, the group then attempted to develop a more complete listing of “discrete attack actions” (many of which could be combined in various ways into more complete attack scenarios). In creating this list, the group used the following definitions:

- **Attack action**: Any nefarious activity undertaken by an adversary. (It does not have to result in a loss of confidentiality, integrity, or availability.) The group also intends to focus on “atomic” attacks that would be part of a larger campaign.
- **Observable**: Anything that could be detected with current technology, or with any other technology that might be considered possible. (Note that this definition extends the definition cited by the “IC System Models” group [Chapter Two]).

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2 The reference is to a very small keychain device that plugs into a computer’s USB port and acts like a removable disk. At this writing (October 2004) they are available in sizes ranging from at least 32 KB to four gigabytes.
Table 3.1 at the end of this chapter contains the group’s expanded list of “discrete attack actions.” The table gives a name for each of the 33 attack mini-scenarios listed, some scenario details, preconditions, expected observables, and likely effects.

Reviewing the attacks listed at the end of this chapter, the group made the following general observations:

- Many are just enablers for chains of attacks.
- Access (either logical or physical) is a prerequisite condition for all attacks.
- Some attacks have no observables. It’s an important research question to consider how that can be fixed.

In discussing the list of 33 attacks in a plenary session, the recommendation was made by a participant that this list should have an added column: “Existing remediation.” That column would contain information on what measures are in place today, in various IC enclaves, to thwart the attacks listed. We recommend this as a useful piece of additional research to be performed. There was insufficient time for this group to investigate that issue and add the column during the workshop itself.

Another group used the listing in Table 3.1 and integrated these results into its own taxonomy (see Figure 4.11 in Chapter Four, “Attacker Models”).

Roles

The group observed that the attacker’s access and perspective vary depending on his role in the enterprise. Insiders could be system administrators, users, managers, analysts, linguists, “geeks” (computer specialists), or others.

In response to comments from the larger workshop that the attacks look technical, this group responded, “They’re [the attacks are] actually brain-dead!” The group emphasized that although the attacks may look sophisticated to a “traditional” analyst, the next generation of analysts will have grown up with computers, cyber games, and the like, and all this will be second-nature to them. We need to think about future malicious insiders and not be overly influenced by previous attacks.

Grand Challenges

Each group attempted to formulate a set of “grand challenges” for research in discovering and mitigating the insider threat. The challenges listed by the “threats and vulnerabilities” group were the following:

- Create effective deterrents to cyber espionage.
  - We need better ways to enforce and monitor the deterrents to put the “fear of God” in cleared people.
  - The IC may not even need real monitoring; just the perception of monitoring may be enough (similarly, some states use cardboard state troopers to slow down traffic).
• Define an effective way of monitoring what people do with their cyber access, for purposes of identifying acts of cyber espionage.
  — Focus on detection, not prevention (in the post-9/11 world, we need to allow everyone access to “everything”; instead, develop filters to find the nefarious acts).
• We need policies and procedures to create as bright a line as possible between allowed and disallowed behaviors to reduce the ambiguity.
  — If the rules aren’t realistic, then they dilute the overall impression of enforcement.
  — The IC should therefore adjust the rules to be realistic and focus on what is important instead of trying to stop all disallowed behaviors equally.
• Consider sociological/psychological factors, and create better cooperation between information systems personnel and human resources personnel (to include security, medical, financial, and other support services). In short, broaden oversight of all aspects of a user’s background and behaviors.
  — Identify precursors to changes in an insider’s “moral compass”—can this be modeled? Focus limited resources on insiders who present a greater risk.
  — The clearance personnel should tell the cyber personnel who the risky people are (or what risky behavior is), and vice versa.
  — We need multidisciplinary research teams (not just geeks) investigating what we should look for as indicators of possibly malevolent behavior.

Surprising Lessons Learned

Each group was asked, “What are the most surprising findings that came out of your deliberations?” This group answered:

• Espionage case history does not cover cyberspace. Most case histories do not involve interesting cyber exploits that we know could be used. Looking backward at case histories doesn’t prepare us for what is coming with a more computer-savvy generation of analysts.
• Things are looser than we might have expected.
  — Life is not as structured on the IC networks as we thought.
  — Policy and practice aren’t always the same (fewer people are searched, even sporadically and randomly, than expected).
  — Our insiders are really trusted.

  There is no practical way to prevent exfiltration by even a moderately determined adversary, especially given modern technology. For example, USB flash drives and CD-ROMs can hold huge amounts of data in a small space that can be hidden.

• COTS software is a real threat developed off-shore by uncleared foreign nationals.

Datasets Required

Another question asked of all groups was, “What datasets do you need for your research?” This group’s responses were:
• The MITRE dataset might be extended to be more useful.
  — Example: Record more things at the host level and more things outside the cyber
domain beyond badge logs (e.g., where people are, use of photocopiers, phone
records).
  — "You don’t need just one dataset—we need lots of them."
• Data from ARDA NIMD study3 (recording “normal” analyst activity) seem very
promising.
• Enhance the NIMD study with a different fictitious set of insiders (e.g., using some
of the attack actions listed in Table 3.1) with other areas of interest and roles.
  — Maybe leverage Glass Box software.4

Measures for Success

During their deliberations, this group asked themselves, “What are the measures by which
we can judge success?” That is, how can we know that we have been successful at the end of
the workshop? They decided on two criteria:

• We have identified observables that have not yet been highlighted by researchers
• We have developed a list of “challenge problems” based on the real threat to IC
  information systems.

Based on those criteria and the material in this chapter, the group felt its delibera-
tions had been successful.

Table 3.1
Attack Actions, Preconditions, Observables, and Effects

<table>
<thead>
<tr>
<th>Attack Action</th>
<th>Scenario Details</th>
<th>Preconditions</th>
<th>Observables</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Virus-laden</td>
<td>Malicious insider (MI) puts viruses or other malware on removable media, carries</td>
<td>No physical checks on inbound materials;</td>
<td>Physical observation of media movement; evaporated tape over media slots;</td>
<td>Enabler for numerous other attacks</td>
</tr>
<tr>
<td>CD and/or USB flash</td>
<td>it into an IC environment, and inserts it into a system. Depending on the</td>
<td>physical and logical access to machine;</td>
<td>closed-circuit camera, NT event log will show media access (but big impact</td>
<td></td>
</tr>
<tr>
<td>drive and/or floppy</td>
<td>malware being introduced, it may impact confidentiality, integrity, and/or</td>
<td>media on machine</td>
<td>on performance)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>floppy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Administrator</td>
<td>MI finds names of administrators, and then tries to log in as the administrator</td>
<td>Login access (remote or local), no multi-factor authentication,</td>
<td>Log entry for account lockout; log entry for admin lockout; repeated</td>
<td>Enabler for numerous other attacks plus availability attack on SysAdmins</td>
</tr>
<tr>
<td>lockout</td>
<td>(knowing that after some number of failures the admin will get locked out).</td>
<td>machine set to lock out after failed login attempts; names of admin user logins</td>
<td>lockouts of any user over a short period of time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Once all administrator accounts are locked out, the MI can perform attacks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>knowing that the admin is unlikely to be able to log in and detect or solve the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>problem.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3 See Appendix I for information about the ARDA “Novel Intelligence from Massive Data” (NIMD) research thrust.
4 See Appendix H for information about the “Glass Box” research effort.
Table 3.1—Continued

<table>
<thead>
<tr>
<th>Attack Action</th>
<th>Scenario Details</th>
<th>Preconditions</th>
<th>Observables</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Social engineer pass-</td>
<td>MI calls up the help desk and says “Hi, I’m Major Smith, I forgot my password.”</td>
<td>Help desk doesn’t have a way to</td>
<td>Trouble ticket monitoring; integration with</td>
<td>Enabler for numerous other attacks plus</td>
</tr>
<tr>
<td>words</td>
<td>Tries to convince help desk to reset or tell him/her the password.</td>
<td>absolutely authenticate request.</td>
<td>badging system to detect whether in building.</td>
<td>confidentiality attack against the password</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>itself</td>
</tr>
<tr>
<td>4. Retry Internet attacks</td>
<td>Attack scripts, worms, viruses, etc. from various websites in cyberspace are</td>
<td>Patches not installed promptly; if</td>
<td>Alien software installed on hosts; intrusion</td>
<td>Enabler</td>
</tr>
<tr>
<td></td>
<td>downloaded and executed on local secure LAN</td>
<td>attack is trivial, network access,</td>
<td>detection systems that monitor commands,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>or if not, same as virus-laden CD</td>
<td>system calls, URLs, etc.; frequency of patch</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>or USB flash drive</td>
<td>installation; patches don’t fix problems (hard</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>to tell if up to date)</td>
<td></td>
</tr>
<tr>
<td>5. Smuggling out flash</td>
<td>USB flash drive on keychain, or hidden on body during ingress and egress to</td>
<td>Insufficient physical checks on</td>
<td>NT event log shows media access; physical check</td>
<td>Confidentiality</td>
</tr>
<tr>
<td>drive or other media</td>
<td>controlled area</td>
<td>outbound; physical and logical</td>
<td>on egress</td>
<td></td>
</tr>
<tr>
<td>(exfiltration)</td>
<td></td>
<td>access to machine; media on machine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. “Missing” laptops/</td>
<td>A laptop, personal digital assistant (PDA) or other device is removed from a</td>
<td>Insufficiently protected data</td>
<td>RFID on hardware devices (but also helps</td>
<td>Confidentiality + Availability</td>
</tr>
<tr>
<td>hardware</td>
<td>secure facility; the MI can gain access to its contents</td>
<td>on machine; physical access; aperiodic</td>
<td>adversaries); failed physical inventory check; network census failure</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>inventory checks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Targeted acquisition</td>
<td>Bad guys buy surplus equipment from government agencies at auctions (perhaps</td>
<td>Insufficient sanitation process;</td>
<td>“For sale” ad on eBay... Confidentiality</td>
<td></td>
</tr>
<tr>
<td>of surplus equipment</td>
<td>tipped off by insider), and search disks for sensitive information</td>
<td>physical access to equipment</td>
<td>photo with classified sticker</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>8. Unpatched systems</td>
<td>An insider takes advantage of knowledge that sensitive info systems aren’t</td>
<td>Patches available but not installed</td>
<td>Time interval between patching of operating</td>
<td>Enabler</td>
</tr>
<tr>
<td></td>
<td>patched promptly, and uses a recent attack method to gain root access to a server</td>
<td>promptly</td>
<td>systems, applications, etc.; vulnerability</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>checkers</td>
<td></td>
</tr>
<tr>
<td>9. Sabotaged patches</td>
<td>MI alters a patch to be disseminated to all LAN systems in the secure facility,</td>
<td>Ability to alter patches; patch</td>
<td>Integrity check with vendor to ensure patches</td>
<td>Enabler</td>
</tr>
<tr>
<td></td>
<td>enabling a trapdoor to permit greater access; that patch then gets installed</td>
<td>distribution system</td>
<td>are unchanged</td>
<td></td>
</tr>
<tr>
<td></td>
<td>automatically on all systems within the enclave</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. False positives on</td>
<td>MI creates a file containing the signature of a known virus, and distributes it</td>
<td>Ability to create a virus signature</td>
<td>Abnormally high number of virus infection</td>
<td>DoS/Availability</td>
</tr>
<tr>
<td>antivirus</td>
<td>within the enclave. Virus detection software sends alerts and restricts access,</td>
<td>(DoS attack)</td>
<td>indicators on atypical files</td>
<td></td>
</tr>
<tr>
<td></td>
<td>causing denial of service</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Use of unattended</td>
<td>While a user is absent from his terminal, MI accesses his/her files, which are</td>
<td>Physical access; no timely</td>
<td>Abnormal signature from terminal</td>
<td>Confidentiality/ Integrity/ Availability</td>
</tr>
<tr>
<td>terminal</td>
<td>more sensitive and restricted than those to which he has normal access</td>
<td>screen saverlockout; insufficient</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>authentication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Targeting database</td>
<td>MI makes subtle changes to data within a key (e.g., targeting) database, causing</td>
<td>Database access; knowledge of</td>
<td>Transaction log indicating change</td>
<td>Integrity</td>
</tr>
<tr>
<td>&quot;adjustments&quot;</td>
<td>inaccuracy in subsequent field operations</td>
<td>database layout/semantics; no</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>integrity checks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attack Action</td>
<td>Scenario Details</td>
<td>Preconditions</td>
<td>Observables</td>
<td>Effects</td>
</tr>
<tr>
<td>---------------</td>
<td>------------------</td>
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</tr>
<tr>
<td>13. Keystroke logger</td>
<td>MI installs a keystroke logger hardware or software on an associate’s computer within the enclave; later retrieves password information from it</td>
<td>Physical or logical access (depending on type of logger); may require unmonitored access</td>
<td>Physical tamper indicator for physical logger; Tripwire-type software</td>
<td>Confidentiality + Enabler</td>
</tr>
<tr>
<td>14. Extra copy of DB back-ups</td>
<td>MI writes a backup copy of a sensitive database to tape; declares the backup or tape “bad,” and reperforms backup. Removes extra copy of backup tape from the facility</td>
<td>Ability to make extra backup, physical access; no monitored egress; no accountability on media</td>
<td>Backup log (or change to backup log), # of tapes used, destruction evidence (not logs)</td>
<td>Confidentiality</td>
</tr>
<tr>
<td>15. Wireless transmissions</td>
<td>MI uses a wireless PC card, USB device, or other device to send wireless signals out of a sensitive enclosure, to an associate or device outside the facility</td>
<td>Ability to install or enable wireless; small wireless transceiver; enclosure isn’t sufficiently shielded (IR, 802.11, other?)</td>
<td>Picking up wireless signals (RF), some optical techniques to detect IR (monitoring IR in an enclave might be enhanced by adding reflectors)</td>
<td>Confidentiality</td>
</tr>
<tr>
<td>16. Cellular/voice recorder in classified meeting</td>
<td>Modern cellphones and PDAs are sufficiently small that they can be brought surreptitiously (or even accidentally) into a secure facility unnoticed; they can be put into “record” mode to capture voice recordings (e.g., into voice message files)</td>
<td>Insufficient physical monitoring; insufficient shielding; insufficient RF monitoring</td>
<td>Metal/device detector in/out of SCIF; RF detector in facility</td>
<td>Confidentiality</td>
</tr>
<tr>
<td>17. Suspicious activity on real systems (e.g., searching own name in databases)</td>
<td>Robert Hanssen periodically queued the FBI info systems for his own name, plus “dropbox” and other keywords, to see if he was being discovered</td>
<td>No monitoring of activity (capture and analysis of audit trails)</td>
<td>“Adversary activity” detected in audit logs</td>
<td>May implicate adversary</td>
</tr>
<tr>
<td>18. Mislabeled paper</td>
<td>A sensitive document has its header and foot labels changed (e.g., by using a word processor) to indicate a lesser (or no) degree of classification or sensitivity, is then printed</td>
<td>Possible to change markings on page; reliance on page markings as authorization for removal</td>
<td>No cyber observable! (maybe some cyber observable if there are highly instrumented applications/OS-level)</td>
<td>Confidentiality</td>
</tr>
<tr>
<td>19. Netmeeting/WebEx controls</td>
<td>Software such as “Netmeeting,” “WebEx,” or “Timbuktu” allows one user’s display to be linked to, and slaved onto, another’s. Can this be done surreptitiously without the first person’s knowledge (e.g., when they’re away from their terminal)? If so, all documents, e-mail, etc. displayed on the first terminal are mirrored onto the second one</td>
<td>Existence and default enablement of tools within enclave</td>
<td>Test if tool installed/enabled; test if tool active; indicate who is using tool (attribution). Determine what traffic is being exchanged using that tool</td>
<td>Enabler</td>
</tr>
<tr>
<td>20. Zero day attacks based on source</td>
<td>Major portions of source code for an earlier version of the Microsoft Windows operating system have become available on the Web. An MI uses knowledge gained from the source to craft a new attack, and uses it within the secure enclave. It is called “zero day” because it has never been used before, and hence no monitors are configured to detect it</td>
<td>Disclosure/knowledge of source code; tools to search for vulnerabilities; assumption that obscurity is significant source of security</td>
<td>No direct cyber observables; some derivative observables based on undesirable applications behavior; knowledge that source code has been disclosed</td>
<td>Enabler</td>
</tr>
</tbody>
</table>
## Table 3.1—continued

<table>
<thead>
<tr>
<th>Attack Action</th>
<th>Scenario Details</th>
<th>Preconditions</th>
<th>Observables</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>21. Covert channels through steganography</td>
<td>An MI hides sensitive information within a picture or other digital unclassified document, and removes it from the secure facility</td>
<td>Technology to allow encoding and decoding (including ability to install software)</td>
<td>Information content analysis results</td>
<td>Confidentiality</td>
</tr>
<tr>
<td>22. Copy and paste between classifications (from high to low)</td>
<td>An MI uses “copy” and “paste” between two windows on his/her PC, allowing one or more paragraphs from a highly sensitive document to be placed in a less-sensitive one, then removes the latter document</td>
<td>Ability to copy and paste between classification levels</td>
<td>Applications/OS instrumentation only (difficult problem)</td>
<td>Confidentiality</td>
</tr>
<tr>
<td>23. Internal e-mail that performs attacks</td>
<td>MI creates and sends e-mail within the secure facility that has JavaScript or an attachment with content that installs trapdoors or creates other vulnerabilities</td>
<td>E-mail agent processes scripting without user approval or knowledge</td>
<td>E-mail download with content; executable content; indication of whether the content/execution parsing agree; indication of whether the parsed content is nefarious (hard problem)</td>
<td>None</td>
</tr>
<tr>
<td>24. Wireless cameras to shoulder surf</td>
<td>Installs a small, wireless video-camera in the ceiling above another user's workstation to capture keystrokes and obtain passwords</td>
<td>Ability to install camera and exfiltration (via wireless or media)</td>
<td>RF emissions</td>
<td>Confidentiality</td>
</tr>
<tr>
<td>25. Telephone tap recording onto removable media</td>
<td>A telephone tap is installed within a secure facility that records information on a CompactFlash card or other removable medium</td>
<td>Plain-text voice transmission; access to telco media</td>
<td>None</td>
<td>Confidentiality</td>
</tr>
<tr>
<td>26. Telephone tap via hacking PBX</td>
<td>Modern PBXs are computers. They can be “hacked” via default maintenance passwords or other means, to gain access to telephone conversations</td>
<td>Plain-text voice transmission; access to telco media; physical or logical access to PBX/distribution</td>
<td>Depends</td>
<td>Confidentiality</td>
</tr>
<tr>
<td>27. Analyst changes workflow to exclude other analysts (dissemination)</td>
<td>MI surreptitiously changes dissemination instructions (e.g., in software) to exclude some analysts from obtaining information they need, thereby harming the resulting intelligence product</td>
<td>Analyst ability to change/determine workflow for intelligence product (management authority)</td>
<td>Actual product workflow</td>
<td>Integrity/Availability</td>
</tr>
<tr>
<td>28. Analyst changes workflow to include himself/herself</td>
<td>MI surreptitiously adds himself/herself to dissemination instructions to become aware of sensitive information without need to know</td>
<td>Analyst ability to change/determine workflow for intelligence product (management authority)</td>
<td>Actual product workflow</td>
<td>Integrity</td>
</tr>
<tr>
<td>29. Insert bad content into report upon inception (e.g., translation)</td>
<td>MI involved with the creation of intelligence information (e.g., during a translation process) alters its content, thereby harming the intelligence product</td>
<td>Translation authority (ability to create source report)</td>
<td>Inspection of product; comparison of product to raw data</td>
<td>Integrity</td>
</tr>
<tr>
<td>30. Delete/withhold content into report upon inception</td>
<td>MI involved with the creation of intelligence information (e.g., during a translation process) deletes key portions of its content, thereby harming the resulting intelligence product</td>
<td>Translation authority (ability to create source report)</td>
<td>None (probably); comparison to redundant report</td>
<td>Integrity</td>
</tr>
<tr>
<td>Attack Action</td>
<td>Scenario details</td>
<td>Preconditions</td>
<td>Observables</td>
<td>Effects</td>
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<td>---------------</td>
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</tr>
<tr>
<td>31. Redirect analyst resources to support some agenda</td>
<td>MI obtains access to software or other procedures by which analyst resources are allocated, and redirects them for own purposes</td>
<td>Analyst ability to change/determine workflow for intelligence product (management authority)</td>
<td>Collection does not meet exact requirement</td>
<td>Integrity/Availability</td>
</tr>
<tr>
<td>32. Poor quality analysis/results/reports</td>
<td>MI involved in intelligence analysis deliberately creates faulty or misleading reports</td>
<td>Translation authority (ability to create source report)</td>
<td>None/few; customer feedback; job performance reviews</td>
<td>Integrity</td>
</tr>
<tr>
<td>33. Get IC asset to collect information that benefits an unauthorized party</td>
<td>MI obtains access to the process by which IC assets are tasked, and alters the tasking so that information of use to the MI (but not the U.S. intelligence effort) is obtained</td>
<td>Tasking authority</td>
<td>Lack of requirement for Availability the collection activity.</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.1—continued
CHAPTER FOUR
Attacker Models

Group Focus

This breakout group\(^1\) began its deliberations by stating some broader concerns:

- Are attacker models providing too much information to the bad guys on what we look for?\(^2\)
- Can individual-level activity monitoring cause the malicious insider to change but not limit his activity while causing the benign insider to restrict his creativity?
- How should we reconcile the need to collaborate more with better security?

The group then listed the following more specific questions about modeling attackers as important items to discuss:

- What are the defining characteristics and reasonable values for attacker models?
- What are the *observables* (actions, artifacts) that an insider generates and how can they be used to determine benign or malicious behavior?
- How could an attacker "cover his trail" of observables?
- What is the overall scope of activities that a malicious insider might undertake and what role do environmental factors play?
- Can we create a taxonomy of security controls, and how can we correlate these controls with detected observables to tune and manage responses?
- How can we generate models of normal behavior as well as malicious behavior, and how can we generate data to test the models?
- How can we find signs of malicious insider behavior in unusual environments, such as high-performance machines or massive visualization data transport?
- How do insiders seek information and how can researchers use context to determine if the information seeking is benign or malicious?

---

\(^1\) Participants were Matthew Downey, Tom Haigh, Steve Karry, Van Leptien, Rich Neely, Greg Stephens, Frank Greitzer, Thomas Hetherington, Stephen Laird, Tom Longstaff, Marisa Reddy, and Edward Wright.

\(^2\) This was one of the few instances during the workshop in which counterintelligence effects of insider threat research were explicitly highlighted.
A First-Cut Notional Insider Model

Figure 4.1 represents a top-level view of an insider attacker model used by the group.

The group then compared this model to the known Robert Hanssen case history (see Appendix E for details). The Hanssen case was summarized as shown in Figure 4.2.

The group then elaborated the attacker model into the “spiral model” shown in Figure 4.3.

Figure 4.1
Notional Insider Model

Figure 4.2
Hanssen Case History

1. Pre-violation - Granted Access
2. Trigger - Financial Status
3. Spiral Model (zero or more occurrences of each step, one or more events per attack)
   1. Identify Consumer / Recruitment / Motivation
      1. Search - Known (OJT)
      2. Contact - Approached
         1. Anonymous
         2. Attributed
      3. Negotiation - Handler / Instruction
   2. Identify Asset
   3. Look for Detection (assess risk)
   4. Obtain Asset
   5. Exfiltrate / Delivery
   6. Cover Tracks
   7. Collect Payment / Reward / Satisfaction
4. Exit
A user "case" was then abstracted into a set of actions occurring over time, as shown in Figure 4.4.

Figure 4.3
Spiral Model Flowchart

Figure 4.4
Insider Attack "Case" Actions Over Time
In contrast, normal user actions within an IC environment were diagrammed as in Figure 4.5.

The normal model (Figure 4.5) contains “base” behavior, and will continue while hostile activity is being done. It should be noted that normal behavior will be incorporated into most attacks. Normal behavior has analogues in hostile behavior—distinguishing the two can be a very hard problem.

Given the attack model in Figure 4.4, which of those actions generate “observables” that might be detected? Figure 4.6 shows that same model, with unobservable actions in white.

Another view of an attacker model is that the insider has certain attributes that are perhaps measurable. Attacks have certain observables, and the type of outcome can be placed in several categories. Figure 4.7 lists the attributes and categories itemized by this group’s deliberations.

The group then created a modified taxonomy of insider actions, listing a number of possible actions that might be taken in the following categories:

- obtaining access
- reconnaissance
- entrenchment and exploitation
- extraction and exfiltration
Figure 4.7
Top-Level View of Model

<table>
<thead>
<tr>
<th>Insider (metrics)</th>
<th>Attacks (observables)</th>
<th>Outcome (damage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge, Skill, Ability</td>
<td>Technology, Risk, Reward</td>
<td>Leak</td>
</tr>
<tr>
<td>Motivation</td>
<td>Increasing over time?</td>
<td>Source Identification</td>
</tr>
<tr>
<td>Moral Compass</td>
<td>Sophistication</td>
<td>Mis-information</td>
</tr>
<tr>
<td>Level of Access</td>
<td>Low</td>
<td>Sabotage</td>
</tr>
<tr>
<td>Personality</td>
<td></td>
<td>(Normal)</td>
</tr>
<tr>
<td>Social Engineering</td>
<td>Remove print / media</td>
<td></td>
</tr>
<tr>
<td>Risk Tolerance</td>
<td>Masqueraded media</td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>High Steganography</td>
<td></td>
</tr>
</tbody>
</table>

- communication
- manipulation
- counterintelligence.

It could also include other cyber-related activities. The group indicated the level of sophistication for each action: low, medium, or high.

The group then compared this taxonomy with the set of “attack actions” produced by the “Vulnerabilities and Exploits” group (listed in Table 3.1), resulting in the listing shown in Figure 4.8. In this figure, row numbers from Table 3.1 are shown for all exploits from that table. Exploits that do not appear in Table 3.1 are italicized, and seven exploits (numbers 7, 16, 19, 20, 26, 27, 33) in Table 3.1 did not have a place in this group’s taxonomy.\(^3\) The parenthesized suffix letters C, I, A, E in Figure 4.8 indicate whether the actions would lead to a breach of information Confidentiality, Integrity, Availability, or would be an Enabler of other attacks.

Definitions

As mentioned earlier, each group was asked to be clear about the definitions of key terms it used. This group listed the following definitions, which cover a number of terms not defined by the IC System Models group (Chapter Two):

- **Threat:** A potential for deliberate attack or an inadvertent compromise of an organization’s mission
- **Attack:** A deliberate attempt to compromise an organization’s mission
- **Case:** All events and states in the world associated with a related set of attacks. A case may also be a set of other cases.

\(^3\) It would have been desirable to resolve such mismatches among the various taxonomies used by different breakout groups, but the workshop schedule did not permit it. Reconciliation of the various definitions and taxonomies in this report would be a useful follow-on research activity.
Figure 4.8
Insider Actions Taxonomy Cross-Referenced with Vulnerabilities and Exploits List

Entrenchment & Communication
- Access & Manipulation
  - Access
    - Web/file browsing
    - DB searches
    - Scanning (stealthy)
    - Authorized account
    - Orphan account
    - Unlocked, unattended terminals (11CIA)
    - Physical (pick up printout)
    - Accidental
    - Document control
    - Safe storage
    - Two party rule
    - Social engineering (3CE)
    - Shoulder surfing
    - Password guessing
    - Password cracking
    - Privilege escalation
    - Printing/Copy machine
    - Removable media (5C, 25C)
    - Unauthorized software
    - Physical (pick up printout)
    - Accidental

Extraction & Other Cyber Intelligence
- & Exploitation
  - Reconnaissance
    - Unusual searching
    - Scanning (stealthy)
    - Authorized account
    - Orphan account
    - Unlocked, unattended terminals (11CIA)
    - Physical (pick up printout)
    - Accidental
    - Document control
    - Safe storage
    - Two party rule
    - Social engineering (3CE)
    - Shoulder surfing
    - Password guessing
    - Password cracking
    - Privilege escalation
    - Printing/Copy machine
    - Removable media (5C, 25C)
    - Unauthorized software
    - Physical (pick up printout)
    - Accidental

Exfiltration
- Communication & Manipulation
  - Download, media import, or email virus/trojan (1E, 23A)
  - Keylogger (13CE)
  - Import published attack (4F, 8E)
  - Install unauthorized software
  - Sabotage patch system (9E)
  - Replace device drivers/analysis tools
  - Standard encrypted email
  - Simple coded messages
  - Wireless usage (15C)
  - Custom encrypted email
  - Steganography (21C)

Sophistication:
- Low - Work entirely within the normal confines of the existing system
- Medium - Push the limits of the existing system ("bend but don't break")
- High - Use tools/technology to break the existing system

V&E row # in (); no match in V&E

Event:
- Something that happens in the world. There are atomic events, and logical collections of events can also be events.

Model:
- An abstract representation of some portion of the world (examples: sensor model, attack model, user model, infrastructure model)

Observable:
- Any event or state element that can (or could) be measured

Sensor:
- Measures an observable. Some sensors include Level 1 fusion, and so may also generate a detection.

Observation:
- The output of a sensor. May be a raw signal, a detection, or both.

Detection:
- A decision based on processing of observations (or collections of observations)

Fusion Level 0:
- Raw (signal) output from a sensor

Fusion Level 1:
- Processed (analyzed) sensor output, often includes an initial detection.

Grand Challenges—Research Issues

The group stated as its overall objective, “We are not building a giant Intrusion Detection System; we are trying to build a set of tools to produce indicators to help the organization investigate anomalous patterns of behavior. We want to shorten the time from defection to detection.”

With this in mind, the group listed the following as research issues:

- Extend the taxonomy of insider actions to include, among other things,
— mappings from user roles to expected actions and to permitted actions. (The first helps characterize normal behavior; the differences between the two mappings help characterize malicious behavior.)
— mappings from actions to observables and observables to sensors. (This should include both existing sensors and desirable new sensors. One approach would be to work with CI experts to identify sensors that would detect the events and extract the information that they use.)

• Develop a characterization of normal system administrator behavior, possibly using Glass Box software (see Appendix H).
• Develop techniques for identifying triggers that distinguish between normal and malicious behavior.
• Develop techniques to identify multiple cases with a common objective.
• Build a library of attacks (scenarios) that researchers can use to train and test their anomaly detection systems.

The first research issue is related to the question of what datasets the researchers need to pursue their research. Some researchers said they could use a realistic document corpus, possibly the NIMD (see Appendix I) WMD corpus. There were several researchers working on methods for anomaly detection, and they all agreed that they need data having sets of attacks interleaved with normal user activity. They need preliminary datasets to train their anomaly detection systems and more sophisticated datasets to validate and tune their systems.

There were five proposals for how to generate the datasets, listed below in approximate order of preference:

A. The existing data from the MITRE workshop might be adequate as a starter set.
B. It might be possible to use existing Glass Box data as a source of normal activity. It would be good to find a way to inject attack data, from the library generated above, into these existing data.
C. An alternative would be to seed the Glass Boxed environment with some attackers in the future. These attackers could mount attacks from the library while other users are going about their normal activities. Glass Box could collect the data and provide them to the researchers.

Both B and C depend on a positive assessment of Glass Box data by the researchers. Right now, it is not known for sure if Glass Box provides what they need, but participants are hopeful.

D. It would be possible to develop a simulator to generate the required datasets. The initial datasets could be fairly simple, requiring a simple simulator. The hope would be that the simulator's capabilities would grow in a manner and at a rate compatible with the expanding needs of the researchers.
E. If none of the above worked out, it would be possible for the researchers to share the datasets they create for themselves.
Whichever approaches are chosen, it will be necessary to define the information needed and a data schema and format so that the researchers can share the datasets.

**Surprising Lessons Learned**

In concluding its deliberations, the group listed the most surprising outcomes from its discussions as the following:

- Workshop participants still don't have a good understanding of what is important to look for as opposed to what is not (but perhaps they just didn't focus attention on this issue).
- They became aware of the availability of NIMD data and tools, which are seemingly relevant and were previously unknown to them.
- The group was struck by the lack of clear event models.
CHAPTER FIVE
Event Characterization

Terminology

This breakout group\(^1\) started by asking, "What is an event?"

- An event is an occurrence in a system that is \textit{directly observable}.
- It does not reflect judgment or interpretation (by contrast with detection).
- It is \textit{discrete} (atomic) at the chosen level of abstraction.
- Events are \textit{composable} into higher-level events.
- \textit{Inline} or \textit{mediating sensors} are useful for exposing events in real-time.
- Events can be characterized by data of varying degrees of \textit{fidelity}.

Considering event modeling, there are two kinds of models: models characterizing expected (normal) behavior and malevolent insider (MI) behavior models. A \textit{significant event} fits or deviates from one of these models. That raises the following questions:

- How should we characterize events so that we can determine that they are significant?
- What information needs to be captured when an event occurs so that we can determine if the event fits or deviates from a model?

The set of \textit{relevant events} is influenced by (but should not be limited by) the models being fit.

Events—Considerations

The group then discussed \textit{host-based events} as having the following characteristics:\(^2\)

- Action by a subject involving an object
- Action is then defined as request for or the result of a system service or high-level application activity
  - Can be high or low-level
  - Characterized by time, arguments, return value, status, etc.

\(^1\) Participants were Bruce Gabrielson, Greg Kipper, Elizabeth Liddy, Roy Maxion, Kymie Tan, Lisa Yanguas, Dennis Heimbigner, Scott Lewandowski, David Mankin, T. J. Smith, and Feiyi Wang.

\(^2\) The general issue of event characterization has been studied by others. The group used (but was not limited to) past work in this area by Price (1997) and Doyle et al. (2001).
Subject is defined as the user and the process acting on behalf of the user
— Characterized by user name, identifiers (e.g., electronic user identification [EUID], radio frequency user identification [RUID], impersonation token, etc.), group membership identifiers, process identifiers, terminal identifiers, etc.

Object is considered to be: a protected system resource
— Can be physical or logical
— Characterized by names and/or identifiers, type, access permissions, locations, owner, etc. (information available varies greatly)
• If an action changes the object’s attributes, the old and new information should be recorded.

With this terminology in hand, the question then becomes, “How can it be determined if an event is significant?” The group believed that for each event, there are two hypotheses to be tested:

• The event is the result of/indicator of/caused by the activities of a malicious insider (MI), or
• The event is not the result of/indicator of/cause by the activities of an MI.

What can be observed to test these hypotheses? The group listed four possibilities:

• Things that we currently observe (can and do observe)
• Things we would like to observe (can but do not observe)
• Things we cannot observe, even in principle (e.g., intent)
• Things we can indirectly observe (i.e., inferences from observations).

An event “life cycle” was characterized as

• the recording, or sensing, of events
• interpretation activities—fitting events to models, to determine if they were really caused by an MI and to correlate them (or at least attempt to attribute them to the same insider)
• analysis of “significant” events to learn about the MI: identify his goals, infer the past and predict future activity, and assess damage, both performed and potential.

Data Collection

The group then developed the following “waterfall” diagram (Figure 5.1) to indicate processes that data about an event undergo, and indicating that steps further toward the upper right will lead to increasing probability that the hypothesis being tested about an event will test as “true.”
Collection and Analysis

The diagram in Figure 5.1 lists six categories of data. But what processes create one form of data from another? Given an event (the leftmost box in Figure 5.1), the group characterized the collection effort as having the steps shown in Figure 5.2, involving the actions of sensors and detectors in converting raw events into indicators or reports (boxes 3 and 4 in Figure 5.1).

Then, given a report, the additional data boxes in Figure 5.1 are created through "fusion" actions or analysis steps (which themselves may access various models as part of their processing), as shown in Figure 5.3.

In this manner (as shown in Figures 5.2 and 5.3), raw events are transformed through a series of processing steps into a case, or set of incidents (the rightmost box in Figure 5.1).
Observables

The group then turned its attention to the observables resulting from events caused by malicious insiders. Its general approach was to create a taxonomy for the insider, including his/her goals, actions to support those goals, and observables associated with the actions.

Then, for each observable, the questions are

- Which are detectable and which are undetectable?
- What new/improved sensors are required to adequately capture the observable?
- What information must be included in reports regarding these observables for the reports to be useful?

The group decided to focus on cyber events only (that is, information that information assurance researchers and operators could provide to counterintelligence personnel), and to disregard most physical observables, even if they can be converted into cyber observables.

In briefing these results, the group felt it had made a good start on this effort, but that more work would be required to complete the task.

Observables from Attacks on Confidentiality

Regarding attacks on the confidentiality of information, the group felt there were two means by which those attacks could be detected:

- Identify data access consistent with the MI threat.
- Detect any exfiltration (with the need for special exceptions for moving data among organizations or among security levels).

Disclosure of confidential information could be performed by a malicious insider through a number of means:

- Accessing legitimately
- Violating "need to know"
- Stealing/using another identity
- Exploiting a misconfiguration
- Exploiting an application vulnerability
- Violating access control (e.g., via privilege escalation).
Malicious insider access to the confidential data could create observables in the following areas:

- Host activity (system calls, resource utilization, etc.)
- Host, operating system (OS), middleware audit/log data
- Host activity records (e.g., browser cache)
- Network activity
- Application records of access (but probably does not apply to exploitation of an application vulnerability).

Exfiltration of confidential data obtained in an exploit could then be achieved by

- writing the data to various media
- media/HW insertion
- network activity (e-mail, scp, ftp, replication, print, etc.)
- context switches
- application-level commands
- host, application, and server print logs
- unobservable techniques: memorize, create images (camera), direct broadcast.

**Observables from Corruption of Information**
The group indicated that, for automated systems, the distinction between overt/blatant and covert/subtle changes to intelligence data or information is not relevant; it requires human judgment to make that distinction.

The observables that might be detected resulting from adding, changing, or deleting data might be

- data inconsistency (to the extent that consistency can be codified in a model)
- host activity (system calls, resource utilization, etc.)
- host, OS, middleware audit/log data
- host activity records (e.g., browser cache)
- network activity
- application records of access (hopefully characterized in semantic terms, e.g., a global find/replace).

**Observables from Degradation of Availability/Access to Information**
A third type of attack on intelligence data involves denying others access to critical, relevant information. Access might be degraded or denied to networks, hosts, applications, or by changes in system policy (e.g., as recorded in online distribution and dissemination lists). Observables resulting from attempts at such denial are as follows:

- Degrade networks
  — Network infrastructure audit/log data
  — Host, OS, middleware audit/log data (e.g., broken/denied connections) that is causing or resulting from the denial
  — Direct network measurement (e.g., tcpdump).
• Degrade hosts
  — Host, OS, middleware, application audit/log data (e.g., process accounting, general host statistics)
  — Application indicators (e.g., misbehaving applications).
• Degrade applications
  — An open challenge
  — Requires an application specification (may be able to check against a quality of service [QoS] model/guarantee).
• Invoke system policy change or exploit system policy (e.g., cause a user to be locked out)
  — Host, OS, middleware, application audit/log data
  — Problem ticket trends.

Observables from Pre-Attack Activities
Finally, the group listed several categories of observables from an attacker’s reconnaissance or discovery activities, or activities to obtain access to a system or resource:

• Reconnaissance/discovery
  — Network activity (e.g., probes)
  — Host, OS, middleware audit/log data
  — Honeypots (special role)
• Acquire access or control of a system/resource (lifecycle or post-deployment attacks)
  — Host, OS, middleware audit/log data.

Research Issues and Questions
This group’s “grand challenge” research questions were the following.

Research Issues—Event-Related
• An adequately expressive language for describing and recognizing patterns and events is needed
  — To facilitate identification/classification of user behavior
  — To codify tell-tale signs of insider activity
  — Requires multilevel abstractions and mechanisms
  — To express uncertainty in characterizing events
  — Requires features like landmark times, temporal intervals, and temporal and state relationships.
• Examples of event reporting language research efforts exist that might be built upon and instructive, such as
  — STATL (attack recognition, including sequential, iterative, and conditional events)
  — CISL (ID reporting; useful lessons learned from CIDF)
  — CYCL (knowledge representation and reasoning, very general)
  — P-BEST (Emerald recognition and correlation)
  — IDMEF (Intrusion Detection Message Exchange Format).
The implications of varying levels of abstraction must be recognized (and addressed).
— There are difficulties to be overcome in unifying/flattening or decomposing event records.
— Some detectors (e.g., some data fusion systems) may require a single level of abstraction.

Can events be associated with MI attack phases or goals?

What is an effective way to prioritize events, incidents, etc., for human analysis?
What information needs to be captured to perform the prioritization and to give the human analysts a good starting point?

Research Issues—Creating Useful Sensors

What capabilities and attributes should sensors have?

Some novel sensor ideas are worth exploration:
— Honeytokens
  • Simple and relatively easy to deploy
  • Major drawbacks: “bad” (inaccurate) data are introduced into the system
  • Often, may be rejected by certain IC organizations
  • Effectiveness against sophisticated (especially malicious insiders) is questionable
— Bloom filters: highly compressed signatures (e.g., for a document)
  • Example: Trace denial of service (DoS) attacks using packet signatures
— Social network analysis: Watch for changes in user and system communication patterns.
  • Need models of what analysts should be doing.
— Semantic analysis: Watch for changes in a user’s “topic of interest.”
  • Need to model a user’s data flows (e.g., e-mails, queries, etc.) semantically.

What information needs to be recorded in an event record?
— What context is required?
— What constitutes a meaningful event record?

What standards and specifications would be useful for ensuring that sensor reports are accurate and that sensors can be easily integrated into new systems (e.g., a common interpretation of terms, a commonly agreed upon scale for severity and confidence, etc.)?
— What standard reporting formats, syntaxes, and methods for recording meaning (semantics) are required?
— What does it mean for a sensor to be “self-describing”? Is this a necessary and/or useful capability?

What can be done to protect sensor systems from attack and ensure sensor outputs are trustworthy?

How can applications be instrumented to extract useful data?

What must be done to meet “chain of evidence” requirements?

Research Issues—Sensor Applications

How can collaborative processing (combining evidence by using multiple sensors in concert to gain higher overall confidence in sensor reports) be formalized?
— What is required so that differing sensors can participate in a collaborative processing system?
— How should individual sensor inputs be weighted?
— Can “fusion” be used to create useful synthetic/compound events?
— Which techniques are most amenable to scaling to large datasets associated with “low and slow” attacks?

• What sensor data or metadata are required to detect changes in a user’s/machine’s logical identity (i.e., his/its role)? Can events be matched to role-based access control models “in the background” to detect when users/machines switch roles?
• How can trends be identified and represented in sensor reports?
• How can models and/or policy be used to enhance what has been observed (by refining observation streams via noise reduction)? For instance, if policy disallows port scans, all port scans merit investigation.
• How can false alarms and false positives be identified?
  — How should detectors be tuned, and what issues affect the tuning?
  — Tuning must be continuous, and needs to accommodate “model drift” (e.g., changes in traffic, data, and other behaviors) but cannot be exploitable by an adversary.

Research Issues—Building and Working with Models
• How should models be expressed?
  — How can events be related to those models?
  — Parameterization of model impacts its performance (e.g., a neural network has learning and momentum constants but users don’t understand them).
• How can degree of fit to or deviation from the model be measured?
  — How much deviation merits treating an event as “significant?”

Research Issues—Testing and Evaluation
• What datasets are required to test sensors?
  — What metrics are relevant to datasets?
  — What metadata (e.g., ground-truth) need to be associated with the dataset? Where do these metadata come from?
• What tools are required to manipulate datasets into a form that can be processed?

Research Issues—Miscellaneous
• To support analysis, the state of the subject and object when an event occurred needs to be available—how should this be done?
  — Explicitly: Record system state data directly in the event record.
  — Implicitly: Recreate the state of the system from other recorded observations (some of which may be in prior event records).
  — What are the pros and cons of self-contained versus cumulative audit records?
    What are the pros and cons of the associated redundancy?
• When should audit records be generated for an action? (Consider non-atomic actions: What are the pros and cons of auditing before and after the action is completed?)
• How should the level of attacker sophistication impact sensor development and research?
• How can sensor information be shared effectively?
  — How can sensors be most effectively used, deployed, and directed? What feedback can be used to help with these tasks?
• How can backward chaining from a hypothetical attack to the events that comprise the early stages of the attack be accomplished in an automated manner?
  — We need to determine if events are indications and warning of that attack at the time they are observed.

Grand Challenge Research Problems

The group concluded its deliberations by creating problem descriptions and research challenges for two “grand challenges.”

Challenge 1: Combining Events

Problem Description. Combine events from one or more sensors (possibly of various types and/or different levels of abstraction) to facilitate building systems that

• test hypotheses about MI activity
• gain higher overall confidence in sensor reports
• detect MI activity that is not detectable using a single event record
• reduce data without adversely impacting detection.

Challenge. Determine what is required so that arbitrary sensors can participate in a collaborative processing system. This involves the following:

• Developing a “calculus of evidence” (Does your evidence support your hypothesis?)
• Dealing with metrics (e.g., normalization, new metrics, meta-metrics, finding a common frame of reference, weighting of individual inputs, syntax and semantics of metric reports, dealing with multiple levels of abstraction)
• Identifying and expressing relationships among pieces of evidence
• Determining how “fusion” can be used to create useful synthetic/compound events
• Identifying techniques that can scale to large datasets associated with “low and slow” attacks.

Challenge 2: Exploiting Models and Policies

Problem Description. Improve detection performance by using models and policies.

• Models
  — Run-time: Focus attention on the most significant observations (feature extraction).
  — Design-time: Reason about users and systems to recognize observations that are not currently receiving focus (this can guide development of novel policies and detection methods).
• Policies
  — Run-time: Policy violations are strong indicators of unauthorized behavior.
  — Design-time: Direct the deployment of sensors (to observe all policy violations).

Challenges.

• How should models and policies be expressed, monitored, measured, etc.?
• How can events be related to models and policies?
• How can machines (software programs) understand the implications of policies?
• How do we design models that are usable by "regular users?"
• What sensor data and metadata are required to detect changes in a user's/machine's logical identity or role?
February 2, 2004

Dear Colleague,

Public concern for information security has been focused on the problem of preventing harm resulting from the actions of an outside attacker. However, there is greater risk of damage due to hostile actions performed by insiders, possibly in collaboration with agents of an outside organization. One insider may transmit large volumes of sensitive information outside the organization with little risk of detection. Another insider might make subtle, or not so subtle, modifications to a critical database, resulting in large losses in human or financial terms. These behaviors are especially insidious if the insider installs software that could perpetuate this behavior even after the attacker has left the organization.

The risk of insider attacks is greatest for systems that contain high value, mission critical data. These high value targets may be classified or unclassified Government systems or systems in the private sector. They all tend to attract the attention of well-funded organizations, including foreign governments, that are willing to recruit insiders in an effort to mount sustained, well-planned penetrations into an organization’s cyber assets.

The sorts of attacks mounted by these adversaries depend on many factors, including motivation and objectives, level of knowledge about the system, authorized access to the system, tolerance for risk, and specific computer skills, including the skills of outside collaborators working with the insider. Effective defense against insider attacks must be based on a realistic understanding of the behaviors that different classes of insiders are likely to exhibit.

ARDA invites you to participate in a workshop on “Understanding the Insider Threat.” This three day workshop will bring together members of the Intelligence Community (IC) with specific knowledge of IC document management systems and IC business practices, individuals with knowledge of inside attackers, both within and outside the IC, and researchers who are involved in developing technology to counter insider threats. The objectives of the workshop are:
• To generate and capture domain knowledge that will benefit the broad base of researchers studying the Insider Threat. This includes but is not limited to knowledge about:
  — Inside attacker characteristics, including the vulnerabilities they tend to exploit, and the attack methods they use,
  — Attack characterization, including the necessary or likely pre-conditions for an attack, the observables generated during an attack, and the effects of the attack.
  — The network and application systems used by the IC for document management, including the mechanisms used to protect the systems and data.
  — IC business models for generating and controlling access to documents.
• To foster cooperation among researchers by developing, to the extent it is practical, methods for describing common aspects of their work, such as event characterization, attack and attacker classification, etc.
• To focus researchers on specific systems and problems of interest to the IC. We expect these to take the form of challenge problems.

We are looking forward to a fruitful discussion on these important topics. ARDA intends to document the results of the workshop in a RAND report.

Enclosed is additional information regarding the workshop format, logistics, and some important pre-work we would like each of you to do prior to the meeting.

**Workshop Location and Dates:**
The workshop will be held 2–4 March 2004 at McAfee Research, Network Associates, Inc., 15204 Omega Drive, Suite 300, Rockville, MD 20850. Office phone: 301-527-9500. See below for directions and hotel information.

**Workshop Format:**
As you can see from the appended agenda, this workshop will be less presentation-centric than many workshops. The approach is to have presentations by domain experts to provide background material and to then break into subgroups to discuss issues and approaches, followed by plenary sessions to compare results and synchronize the groups. When registering, please provide a prioritized list of the subgroup topics (identified in the agenda below) ranked according to your interests and expertise. We will use these lists to pre-assign attendees to breakout sessions.

**Pre-Workshop Material:**
Prior to the workshop we will distribute a package of reading material to help you prepare. We request that each of you please prepare (no more than 2 pages) some informal thoughts on the following topics as related to your area of expertise:

i. A description and assessment of the top two or three issues associated with understanding the Insider Threat,
ii. Your thoughts on how to address these issues, and
iii. Very brief descriptions of related efforts being pursued in your area of expertise.
Registration:
By Feb 10, please e-mail your registration information, or regrets, to research@mcafeesecurity.com. Include the following details:

- Full name
- Prefix (Mr. / Ms. / Dr. / military rank / etc.)
- Name for badge
- Organization
- Postal address
- E-mail address
- Telephone number
- Fax number
- Cell number
- Hotel (if applicable)
- Your prioritized list of subgroup topics ranked according to your interests and expertise

Meals / Refreshments:
Continental breakfast, lunch, afternoon snack, and drinks will be provided each day.

Workshop Fee:
There is a workshop fee of $75.00 to cover cost of meals, refreshments, and workshop supplies. By February 17, 2004, print a copy of your registration information and mail it, along with check or money order payable to Network Associates for your workshop fee, to Dana Coon, McAfee Research, 15204 Omega Drive, Suite 300, Rockville, MD 20850.

Information on Hotels:
There are rooms generally available at a wide variety and number of hotels in the area. Please make your reservations as soon as possible. Here are a few suggestions:

Homestead Gaithersburg/Rockville
2621 Research Blvd.
Rockville, MD
Tel: 301-987-9100

Courtyard by Marriott–Rockville
2500 Research Blvd.
Rockville, MD
Tel: 301-670-6700

SpringHill Suites Gaithersburg
9715 Washingtonian Blvd.
Gaithersburg, MD 20878
Tel: 301-987-0900
Van service available
Gaithersburg Marriott Washingtonian Center
9751 Washingtonian Blvd.
Gaithersburg, MD 20878
Tel: 301-590-0044
Rooms have not been blocked.

Directions to McAfee Research:
McAfee Research is located in the Rockville, MD, offices of Network Associates, in the greater Washington, DC metropolitan area, off Interstate 270.

From I-270 NORTH, take Exit 8 for Shady Grove Road WEST. Stay in the right lanes on the frontage road until it veers right, then stay in one of the left 2 lanes and proceed to the light. Make a LEFT onto Shady Grove Road. Cross over I-270. Turn RIGHT onto Research Boulevard. Turn LEFT onto Omega Drive. The Network Associates building is on the right.

From I-270 SOUTH, take Exit 8 for Shady Grove Road WEST. Stay in the right lanes on the frontage road until it veers right, and then stay in the right lane. Take the exit for Omega Drive in the far right lane. (If you miss the Omega Drive exit, you can still pick up the directions from I-270 NORTH above, starting with the point where you cross over I-270.) Turn LEFT onto Omega Drive. The Network Associates building is on the right.

Turn RIGHT into the entrance. The Network Associates building is now to your right front. A 4-foot cube-shaped sign with the Network Associates logo and name is in front of the building.

Enter the building into the lobby area through the double glass doors. Take an elevator located on your left to the third floor.

Parking
Parking is in the areas in front of, to the right of, and behind our building. You may ignore signs indicating permit parking. The only restrictions are marked handicap spaces.

Shuttle / Van Service
If you wish to use this service, contact your hotel desk for availability and procedure. Note that there may be a fee.

Contact Information—For more information, please contact:

**Technical:**
Dick Brackney: 301-688-7092
John Farrell: 443-479-4370

**Administrative/Logistics:**
Jack Oden: 301-947-7159, Cell: 703-402-8574
Dana Coon: 301-947-7275.
ARDA Understanding the Insider Threat Workshop Agenda

The general approach for the workshop will be to use the large group to provide background information to the participants, focus the group, and gather results, and to use a set of small-group breakout sessions to discuss the issues and recommend solutions or areas of needed research.

2 March 2004

The objective for this day is to establish a baseline context and knowledge set for you to use for the rest of the workshop. Speakers with domain knowledge will provide introductory presentations, and each of you will have the opportunity to state your priorities and to describe what you have to offer the group.

7:30 AM Continental Breakfast/Coffee

Session 1: Workshop Purpose and Context—Plenary Session

- 8:00 Welcome and Workshop Charge—Dick Brackney
- 8:15 Introductory Remarks—Sherrill Nicely, Information Assurance Director, IC CIO
- 8:30 Speaking with Analysts: Observations of Current Practices with Massive Data, William Wright, Oculus Info Inc.
- 9:10 IC Document Management and Dissemination Systems, speaker TBD
- 10:00 Break
- 10:30 Overview of the Hanssen case, Robert Anderson, the RAND Corporation
- 10:50 Insider Behavior—Speaker TBD

12:15 Lunch

Session 2: Identify Needs and Research Topics—Breakouts
1:30  Review agenda, expectations, and first breakout assignment  
     Break into subgroups: IC System Models, Attacker Models, Event Characterization, Vulnerabilities and Exploits

1:45  Review the pre-work (use to scope the issues)  
     Each Group Participant Lists (< 5 minutes each):  
     — Knowledge acquired to date  
     — Top needs  
     — Most promising sources and approaches for acquisition  
     — Summarize key points in Power Point file

3:30  Break

4:00  Report out to large group (15 minutes per group)  
     — Each group presents key points to large group  
     — Discuss for clarity  
     — Consolidate points where possible

3 March 2004

The objective for today is to identify, generate, and capture the knowledge that researchers need to work in this area. We expect this to happen through a dialogue between researchers, domain experts, and security practitioners. Tomorrow you will use this knowledge to define a set of challenge problems for the researchers.

7:30 AM Continental Breakfast/Coffee

Session 3: Generating the Knowledge

8:00  Review Agenda, expectations, and second breakout  
     Break into subgroups: IC System Models, Attacker Models, Event Characterization, Vulnerabilities and Exploits

8:15  Identify and address top knowledge needs  
     — Identify what is known: document sources  
     — Identify what else researchers need to know  
     • Work as team to fill knowledge gaps  
     • Identify approaches for further work  
     — Summarize key points in Power Point file

10:15  Break

10:45  Large group report out (15 min per group)  
     — Share results with large group & discuss  
     — Integrate results across groups

12:00 Lunch

Session 4: Organizing the Knowledge

1:15  Reconvene in Large Group: Review Agenda, expectations, and third breakout
Break into subgroups: IC System Models, Attacker Models, Event Characterization, Vulnerabilities and Exploits

1:30 Organize the knowledge identified in the AM session in a manner usable by researchers
   — Agree on principles for organization
   — Organize the knowledge
   — Identify and prioritize gaps
   — Fill in gaps where feasible

3:30 Break

4:00 Large group report out (15 min per group)
   — Share results with large group & discuss
   — Integrate results across groups

5:00 Adjourn for day

4 March 2004

The objective for this day is to define a set of research problems that are of interest to practitioners and to identify useful intermediate results that we can use to measure progress.

7:30 Continental Breakfast/Coffee

Session 5: Defining Measures of Success

8:00 Review results so far and set agenda for Day 3
   Break into subgroups

8:30 Identify research problems whose solution will benefit the security practitioners
   — Define the problems
     • Brainstorm, then pick the top two
     • Use the knowledge base developed yesterday
   — Explain the benefits to the practitioners of solving the problems
   — Identify useful partial results and their benefit to the practitioners
   — Identify remaining knowledge gaps and suggest ways to fill them
   — Summarize key points in Power Point file

10:30 Break

11:00 Large group report out (15 min per group)
   — Share results with large group & discuss
   — Integrate results across groups

12:00 Lunch

1:00 Wrap-up
   — Summary of results
   — Final opportunity to comment
   — Feedback from ARDA
   — Burn CD's and distribute to the participants

2:30 Adjourn
All workshop participants were provided links to the following materials, which were deemed relevant as background and "read-ahead" material.

**Reports**

- SecurityFocus Newsletter 132 (http://www.securityfocus.com/infocus/1546/)
- References in Characterizing Threat Paper

**Collections of Cases and Reports**

- DSS Employee Security Training
  — Spy Stories (http://www.dss.mil/training/csg/security/Spystory/Intro.htm)
  — Treason 101 (http://www.dss.mil/training/csg/security/Treason/Intro.htm)
- Federation of American Scientists Counter-Intelligence Operations (http://www.fas.org/irp/ops/ci/)
• CI Centre Counterintelligence Reference Materials (http://www.cicentre.com/LINKS_Reference_Material.htm)

Cases

• Robert Hanssen (FBI)
  — CI Centre Article (http://www.cicentre.com/Documents/DOC_Hanssen_1.htm)
  — Attorney General Webster Commission Report Commentary (same as above)
  — Hanssen Computerworld article (http://www.computerworld.com/securitytopics/security/story/0,10801,57889,00.html)
  — Webster Commission CI Center article (http://www.cicentre.com/Documents/DOC_Quotes_Webster_Report.htm)
• Moonlight Maze
• Ana Montes (DIA)
  — CI Centre Article (http://www.cicentre.com/Documents/DOC_Montes_1.htm)
• Harold James Nicholson (CIA)
  — Affidavit (http://www.fas.org/irp/offdocs/nicholson.htm)
• Brian Reagan (NRO)
  — CI Centre Article (http://www.cicentre.com/Documents/DOC_Regan_1.htm)
  — Washington Post article on discovery of documents.

Conferences

• IATF Forum (http://www.iatf.net/)
• Practical Counterintelligence Conference
• PACOM IA Conference (http://www.iaevents.com/)
APPENDIX D
Workshop Participants

Robert H. Anderson  RAND Corporation
Richard Brackney  ARDA
Philip Burns  Computer Technology Associates
Matthew Downey  Syracuse Research Corp
Jeremy Epstein  webMethods
Paul Esposito  Defensive Computing Research Office
John Farrell  ARDA
Dana Foat  Defense-wide Information Assurance Program
Bruce Gabrielson  Booz Allen Hamilton
Chris Geib  Honeywell Labs
Joseph Giampapa  Carnegie Mellon University
Alexander Gibson  Battelle Northwest Labs
Terrance Goan  Stottler Henke Associates
Frank Greitzer  Battelle Northwest Labs
Tom Haigh  Adventium Labs
Steven Harp  Adventium Labs
Dennis Heimbigner  University of Colorado
Thomas Hetherington  Applied Research Lab, University of Texas, Austin
William Hunteman  U.S. Department of Energy
Peter Jobusch  Intelink Management Office
Clarence Jones  NSA
Steve Karty  NCS
Kevin Killourhy  Carnegie Mellon University
Greg Kipper  MITRE Corporation
Linda Kiyosaki  NSA
Stephen Laird  Lockheed Martin Orincon
Vincent Lee  USG/CIO
Van Leptien  University of Colorado
Scott Lewandowski  MIT Lincoln Laboratory
Elizabeth Liddy  Syracuse University
Tom Longstaff  CERT Coordination Center
David Mankins  BBN Technologies
Sara Marzner  Applied Research Labs, University of Texas, Austin
Roy Maxion  Carnegie Mellon University
Mark Maybury  MITRE Corporation
Mark Morrison  MITRE Corporation
Richard Neely  Computer Technology Associates
Sherrill Nicely  CIA
Lucille Nowell  ARDA
Michael Pelican  Honeywell Labs
Marisa Reddy  U.S. Department of the Treasury
David Sames  McAfee Research
Thomas Shackelford  George Mason University
T.J. Smith  MCNC Research & Development Institute
Frederick Steinheiser  U.S. Government
Greg Stephens  MITRE Corporation
Kymie Mei Chen Tan  Carnegie Mellon University
Roshan Thomas  McAfee Research
Shambhu Upadhyaya  University of Buffalo
Feiyi Wang  MCNC Research & Development Institute
Brad Wood  BBN Technologies
Bill Wright  Oculus Information
Edward Wright  Information Extraction & Transport
Lisa Yanguas  NSA/R6
The Robert Hanssen Case:
An Example of the Insider Threat to Sensitive U.S. Information Systems

Information in this presentation is excerpted from the main report of the Commission for Review of FBI Security Programs ("Webster Commission"), March 2002, and unclassified, unrestricted portions of its Appendices A,B
Outline of presentation

- Background
- What did he do?
- How did he do it? What might be done?
- How could he? - problems in FBI infosec
- Relevant FBI systems and info architectures
- Commission recommendations on solution strategies
- Some possible conclusions for this workshop

Background

- Robert Hanssen, at the time of his arrest, was an FBI Supervisory Special Agent
- His treason is called "possibly the worst intelligence disaster in US history"
- Over 22 years, he gave the Soviet Union and Russia vast quantities of documents and computer diskettes filled with national security information
- This insider treason is part of a recurring pattern:
  - "Since the 1930s, every US agency involved with national security has been penetrated by foreign agents, with the exception of the US Coast Guard"
  - 117 American citizens have been prosecuted for espionage between 1945-1990 (or there is clear evidence of their guilt). Money appears to be the main factor; most spies volunteered their services. Prominent examples:
    - Aldrich Ames, CIA counterintelligence officer (9 years as spy)
    - Ronald Pelton, former intelligence analyst for NSA
    - Jonathan Pollard, military intelligence analyst, gave Israel 800 classified documents, 1000 cables
    - John Walker, retired naval officer, with son and brother, supplied the Soviets with cryptographic material
What did he do?

- **Downloaded** large quantities of information from the main FBI Automated Case Support system
- **Searched** the Bureau’s systems to see whether the FBI had identified his locations as drop sites
- **Searched** for his name in the system to see if he was the subject of an investigation
- **Installed** unauthorized software on his office computer
- **Hacked** into the computer of a Bureau colleague
  - “…purportedly to demonstrate security weaknesses in the computer system.” Although discovered, he was not punished for this.
- **Photocopied** documents at the Bureau, and walked out with them
- **Walked** into classified meetings uninvited (“habitually”)
- **Visited** former colleagues, discussed classified information
- **Borrowed** a TS/SCI document, **photocopied** it in the back seat of his car, then returned it

* “Non-technical methods”

How did he do it? What might be done?

- With one exception*, all his activities involved:
  - technical access for which he was authorized, or
  - “non-technical methods”
- What might be done (today)?
  - USB “thumb drives” -- a gigabyte on a keychain
    - Will all USB ports be disabled on desktop and laptop computers? Could they be?
  - CD, DVD -- could all CD, DVD write access be disabled?
  - Wireless transmission
    - A wireless card slipped into a laptop or desktop PC, transmitting to an external “base” computer (e.g., in a parked car)
    - Bluetooth local transmission to a cellphone, PDA, etc.
    - Infrared transmission to a local device (e.g., PDA)
    - Digital camera built into a cellphone or PDA
    - Audio recording within a PDA or cellphone

* “Hacking” into a supervisor’s computer (term undefined in report)
How could he?
Systemic problems in FBI InfoSec

- Bureau failed to develop an effective strategy to identify and protect critical information
- Classified information was moved into systems not properly accredited for it
- Until recently, FBI didn't certify and accredit most of its computer systems, including those handling classified information
- Inadequate physical protections
- Lack of adequate documented INFOSEC policies
- FBI failed to ascertain security requirements of "owners" of information, and identify threats and vulnerabilities that must be countered
- Users lack sufficient guidance about critical security features
- FBI failed to limit user access to systems and databases
- Many key InfoSec positions remained unfilled; when filled, staff have inadequate time, support, and authority
- Some FBI systems have insufficient resources to perform required audits; when audits are performed, audit logs are reviewed sporadically, if at all

FBI systems architecture (excerpts)

- The FBI operates between 30-60 classified systems (A7). In many cases, the boundaries and missions of these systems were difficult to ascertain (A6)
- Automated Case System (ACS) is the main investigative system of records
  - This was exploited "almost exclusively" by Hanssen during his last period of spying
  - Has access restrictions by office (O) or by list of persons authorized (P)
    - But HQ personnel could access all O cases opened by any field office (A20)
  - Highly sensitive information can be found in unrestricted admin files, a fact that Hanssen exploited (A30, 31)
  - After 9/11, HQ mandated that no ACS case may be restricted or deliberately not uploaded without approval of an Asst. Director; HQ later removed additional ACS case restrictions (A35)
  - No formal procedure for terminating accounts when a user's need for access ended

---

Note: Symbols such as (A7) provide appendix and page reference
FBI systems architecture (excerpts, cont.)

- **Trilogy** is a 3-part system and network upgrade underway
  - But it is being rushed to completion, with security features playing "catch up"
- **PBINet**
  - A Secret-high FBI network, but TS/SCI data has been processed on it (A42)
- **Diskettes**
  - Many unmarked, others marked unclassified -- were used on Internet terminals without screening information on the diskettes (A44)
- **HQ Data Center Facility**
  - Contains a trove of classified information; has backup tapes
  - In a SCIF, staffed 24 hrs/day. All staff polygraphed. All staff cleared for all SCI compartments
  - "If one of these persons were to smuggle these tapes out of the FBI ... the entire content of the FBI's Investigative Mainframe, including ACS and the ASSET database, could be restored outside the FBI and the tapes returned before anyone noticed them missing."
  
  ❧ (A40)

FBI systems architecture (excerpts, cont.)

- **Audit logs and trails**
  - Were used extensively to trace Hanssen's activity, *after the fact*
  - Investigators able to determine which ACS files Hanssen viewed, how he searched for them, how long he viewed them, and whether he downloaded them (A58)
    - But not whether he did screen dumps while viewing them
  - FBI audit trails were never reviewed in real time
  - Other than occasional and ill-defined reviews, no one at FBI reviewed and analyzed audit data proactively
Commission recommendations re. solution strategies

- Countermeasure objectives should be: (85)
  - Reduce the time between defection and detection
  - Reduce the number of defectors
  - Reduce the number of information compromises (attacks) by a defector, and
  - Reduce the amount of damage caused by each compromise (or attack)
- Distinguish three types of “moles”: (85-86)
  - Standard (has regular user privileges)
  - Privileged (more access and privileges (either mission-privileged, or over-privileged)
  - Cracker (bends or violates assigned permissions and privileges)

Commission recommendations re. solution strategies (cont.)

- Consider requirements of 18 baseline INFOSEC categories (from NSA’s INFOSEC Assessment Methodology) (85-86):
  - INFOSEC documentation
  - INFOSEC roles and responsibilities
  - Identification and authorization
  - Account management
  - Session controls
  - Networking/connectivity
  - Telecommunications
  - Auditing
  - Malicious code protection
  - Contingency planning
  - Maintenance
  - Configuration management
  - Labeling
  - Media controls
  - Physical environment
  - Personnel security
  - Education, training, awareness
  - System assurance
Some possible conclusions for this workshop

- It may be shortsighted to consider just one "test" system, such as Intelink
  - when the real world comprises a congeries of systems linked in various ways, with different authorities, owners, procedures, criteria -- even in one agency
- Many violations used "nontechnical means"
  - Can technical means aid in discovering these violations?
- If users are unaware/untrained/unappreciative of security markings, restrictions, controls -- data could be available to "normal" violators, not needing extraordinary means
- It is ever more trivial to record large amounts of data on tiny devices, for physical removal -- often with no trace or audit log record
- Audit logs are only as good as the uses to which they're put
  - Too many "false positives", too many resources required to operate and review, too many differing systems' logs not combined, too much data -- all weaken their effectiveness
Cyber Indications & Warnings
Insider Threat Workshop
Overview

Dr. Mark Maybury
MITRE

2 March 2004

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Meet Your New Employee

Robert Hanssen

FBI employee and spy

1979-2001

"If I thought the risk of detection was very great, I would never have done it."
Webster Report Findings

- **Goals**
  - Reduce time between defection and detection
  - Reduce the number of defectors
  - Reduce the number of information compromises (attacks) by defector
  - Reduce the amount of damage caused by each compromise (attack)

- **More sophisticated indications and warning**
  - "... classification [in contrast to profiling] has been used less often in the intrusion detection environment. This is because it is crucial for classification analysis that there be adequate collections of data representing both attacks and non-attacks. Because this type of analysis is new to the intrusion detection world, rarely is this information collected in the proper form."

- **Honeynets**
  - "Honeypots ... could be used to catch moles that fit within the standard or privileged model and operate "below the radar"
"A recent DoDIG report indicates that, for over 1,000 investigations, 87 percent of identified intruders into DoD information systems were either employees or others internal to the organization".

Cyber Indicators Exist: Nearly half of suspicious contact reports made to the Defense Security Service by defense contractors begin with an email request for information, especially by foreign organizations, per Gene Smith, a DSS counterintelligence analyst.

DoJ IG Hanssen Report
http://www.usdoj.gov/ig/special/03-88/index.htm

- Recommendation No. 14: Detecting Improper Computer Usage and Enforcing "Need to Know"
- The FBI should implement measures to improve computer security, including
  - (a) an audit program to detect and give notice of unauthorized access to sensitive cases on a real-time basis;
  - (b) an audit program designed to detect whether employees or contractors are using the FBI's computer systems to determine whether they are under investigation;
  - (c) procedures designed to enforce the "need to know" principle in the context of computer usage; and
  - (d) a program designed to ensure that restricted information cannot be improperly accessed through the use of security overrides or other means.
Workshop Goal

Design and develop a proof of concept system for early indication and warning of malicious insiders.

Definitions

- **Insider** – Anyone with access, privilege, or knowledge of information systems and services.
- **Malicious insider (MI)** – motivated to intentionally adversely impact an organization's mission (e.g., deny, damage, degrade, destroy).
- **Observable** – Anything that can be detected with current tech.
- **Sensor** – Measures an observable (e.g., login, print, delete)
  - **Sensor logs** – recording of observables
  - **Sensor stream** – series of observables from one sensor
- **Indicator** – Identifiable event based on sensor output logs
- **Detect** – Determines event based on processing indicators
- **Report** – Indications and warnings of malicious insider behavior
- **Incident** – Related set of events
- **Fusion** – Processing multiple sensor outputs to provide an enhanced result (e.g., more abstract/concrete, higher confidence)
### Workshop Participants

- Mr. Dick Brackney, ARDA
- Dr. Steve Chapin, Syracuse
- Dr. Brant Cheikes, MITRE
- Dr. John Copeland, Georgia Tech
- Mr. Mick Costa, MITRE
- Dr. Sandra Dykes, SwRI
- Mr. Thomas Eisenhut, SwRI
- Ms. Penny Lehtola, ARDA
- Mr. Jed Haile, Logan Group
- Mr. Tom Hetherington, ARL:UT
- Dr. Wenke Lee, Georgia Tech
- Mr. Scott Lewandowski, MIT LL
- Dr. Tom Longstaff, SEI of CMU
- Mrs. Paula MacDonald, MITRE
- Dr. Jack Marin, BBN
- Mrs. Sara Matzner, ARL:UT
- Dr. Mark Maybury, MITRE
- Mrs. Bev Nunan, MITRE
- Mr. Jeff Sebring, MITRE
- Mr. Conor Sibley, BBN
- Mr. Don Slife, consultant
- Mr. Lance Spitzner, Honeynet
- Mr. Jeffrey Picciotto, MITRE
- Mr. Richard Pietravalle, MITRE
- Mr. Brad Wood, BBN

And other graduate students and technical staff such as Christian Sarmoria and Cheol-min Hwang at Syracuse, undergraduate students George Chamales and Ryan Smith at ARL:UT; Bob Gaimari, Billy Garrison, and Laurie Damianos at MITRE.

### Definitions

- **Insider** – Anyone with access, privilege, or knowledge of information systems and services
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Hypotheses

- While some MIs can be detected using a single cyber observable, other MIs can be detected using a heterogeneous approach to indications and warning
  - Test using case analysis and experimentation
  - Increase the number of insiders detected
- Fusing information from heterogeneous information sources will allow us to formulate more accurate and timely indications and warning of insiders
  - Type of sensor (e.g., card reader, authentication, printer, telephone calls)
  - Level of IP stack (e.g., from network to application)
- Observables together with domain knowledge can help detect inappropriate behavior (e.g., need to know violations)
  - Domain model (e.g., user role, asset value to mission) helps distinguish need to know violations
  - Domain models need to be dynamic to distinguish the changing environment (user roles, asset value)

Group Hypotheses

- Structured Analysis
  - Real-time analysis of log data can classify some MI behavior as it occurs.
- Fusion
  - Accumulated cyber observables can be used to generate early indications of a MI.
- Honeynets
  - Instrumented targets can contribute to early MI identification.
Overview of the Results of a Recent ARDA Workshop on Cyber Indications and Warning

Methodology

- Insider Case Analysis
- Model Insiders and Observables
- Evaluation
- Novel Sensors Design and Development
- Live Network Experimentation

Observables Taxonomy

- Polygraph
- Violations
- Missing
- Reporting
- Physical Access
- Cyber Security
- Access Reconnaisance
- Entrenchment
- Exploitation
- Extraction
- Communication
- Manipulation
- Counter Intelligence
- Activities
- Web Browsing
- DB Searches
- Net Scan
- Orphan Account use
- Password Cracking
- Account misuse
- Privilege escalation
- Terminals left logged on unattended, no time out

- Communications
- Foreign Travel
- Financial, Materials
- Counter Social Intelligence Activity
- Internal
- External

- Encrypted Email
- Coded Messages
- Covert Channels
- File Permissions
- Encrypted Email
- Coded Messages
- Covert Channels
- File Permissions
- Encrypted Email
- Coded Messages
- Covert Channels
- File Permissions

- Exfiltration
- Printing
- Downloads
- Removable Media
- Copy machine

- DATA and SENSORS
- Honeypot data
- Calling patterns
- Email patterns
- Travel/vacation
- Maintenance Schedule
- Keyboard logs
- File systems logs
- Trouble Tickets
- Network IDS Logs
Overview of the Results of a Recent ARDA Workshop on Cyber Indications and Warning

Account Taxonomy

User Accounts

Locations: Bedford, Washington, Sites

Professional Support
- Financial / Purchasing / Admin
- Human Resources
- Technical Project Support
- Media / Communications
- System & Network Admin
- Facilities & Equipment
- Transportation
- Information Security
- Security & Safety
- Misc Expert Services

Technical
- Applications Engineering
- Electronics Engineering
- Analytical
- Physical Engineering
- Information Security
- Data & Information
- Multi-Disciplinary
- Information Systems

Secretarial
- Co-op Summer
- Clerks / Aldis (46)
- Secretary (328)

Executive
- Co-op Summer
- Liaisons
- Consultants
- Mail Forwarder
- Subcontract
- Non-MITRE Employees
- Non-human entities

Others
- Groups

Analysts
- Physical Engineering
- Information Security
- Data & Information
- Multi-Discipline
- Information Systems

Executive, Secretary
- Secretary (328)
- Co-op Summer

Groups
- Non-human entities

Information Security
- Security & Safety
- Misc Expert Services

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Integrated Framework

Strategy & Tactics
I&W Operator
Adversary Models
- Asset threat probability
- Network mapping (free structure - UML)
- Mission decomposition (UML)

Anomaly Detection
- StealthWatch+

Sensor

Data Fusion
- Watchlist
- Honeynet

COMMON DATA
- Nmap, Authentication, Mail, DMZ
- Servers, IDS, Honeynet
- Application Logs (e.g., web, DB, mail)
- Nessus Scans (vulnerability analysis)
- Switch logs, Stealth Watch logs

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Common Data

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Malicious Insider Data Set

• Real network - MITRE's DMZ
  - A separate network for experimentation and sponsor community support established outside of the MITRE internal network
  - 300 - 400 hosts
  - Various services: Web, news, email, database, ...
  - Data sources on network for use in scenarios
  - Deploy additional sensors

• Three of 75 users active during period acted as malicious insiders based on historical and project scenarios of insider behavior

Testbed Network

- nrc-plymouth Email server
- nrc-hartford Email sensor Snort
- nrc-boston CDR
- nrc-trenton Honeynet Snort
- Clients
- nrc-boston CDR
- nrc-trenton Honeynet Snort
- StealthWatch
- Corp IDS
- Snort
- tides2000 News server Web server

KEY
- Existing Host
- Sensors deployed
- Logged Service

Page 23
Our Insider Knowledge and Focus

<table>
<thead>
<tr>
<th>Occurred</th>
<th>Not yet Occurred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detectable</td>
<td>MI who attacks the network</td>
</tr>
<tr>
<td>Hard to Detect</td>
<td>Non-cyber component</td>
</tr>
<tr>
<td>Not yet Detectable</td>
<td>Ana Belen Montes</td>
</tr>
</tbody>
</table>

Focus: “Indications and warnings not conviction and sentencing”

Insider Scenarios

- Three scenarios:
  - Aggregate Historical Insider
    - “Pal”
  - Projected Insiders
    - TIDES Admin
    - “Jack”
  - Drew upon historical examples for “Pal”
  - Intelligence analyst
  - TIDES Admin and “Jack” developed their scenarios
    - Needed to be consistent with prior activity on systems
      - An application administrator
      - A system administrator
      - More realistic (“red teaming”)

Page 24

Page 25
“Pal” Scenario

Web Search

Honeytoken

Retrieves “interesting” data for which has no need to know

Changes news subscriptions

Email

Makes new (inappropriate) queries

Exfiltration and communication with handler

“Insider” Team

Penny Chase         Laurie Damianos         Billy Garrison

aka “Pal”           aka Tides Admin         aka Jack
Tides Admin

Account Manipulation

Web Search

Creates news account and uses this account to read news
Makes new (inappropriate) queries

Covert Access

Accesses news through hidden newsgroups

Jack Scenario

Create backdoor

Searches for data

Stealthy exfiltration

Maps network

Builds a reverse ssh tunnel between tides2000 and nrc-erie

Searches tides2000 data at file system level

Masquerades compressed data as image

Maps network using nmap

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Evaluation Activity

Insider Activity with Journal Available During Test
Insider Activity with Journal Revealed After Test

Pal

Tides

Admin

Jack

December  January  February

Data

- Distributed sensor log collection system
  - 18 DMZ hosts (of 400), 17 sources, 11+M records
- Users
  - 4059 distinct users in logs (7658 incl. badge records)
  - 75 active DMZ users, 3 of which simulate malicious insider behavior
- Sensor data anonymization system
  - ~6k SLOC (Java, Perl, shell, SQL)
- Integration Framework software
  - Publish/Subscribe data dissemination system
  - Reasoning management system
  - Java Expert System Shell
  - ~4K SLOC (Java)
  - Common Data Repository (CDR)
Overview of the Results of a Recent ARDA Workshop on Cyber Indications and Warning

Multiple Data Sources

<table>
<thead>
<tr>
<th>Application</th>
<th>User Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>sendmail sshd</td>
<td></td>
</tr>
<tr>
<td>web_log web_notice</td>
<td></td>
</tr>
<tr>
<td>web_warn web_error</td>
<td></td>
</tr>
<tr>
<td>nmrp d imad</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Host</th>
<th>Taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>su login yppasswd</td>
<td></td>
</tr>
<tr>
<td>last</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Network</th>
<th>Domain Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snort IDS</td>
<td>Honeynet</td>
</tr>
<tr>
<td>Stealthwatch</td>
<td>e-mail sensor</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical</th>
<th>Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>badge reader</td>
<td></td>
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</table>

Collection and Anonymization

<table>
<thead>
<tr>
<th>Logs</th>
<th>Protected Computing Space</th>
</tr>
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<tbody>
<tr>
<td>Small mail logs</td>
<td>Archive Database</td>
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<td>ARDA NRRC Space</td>
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<td></td>
</tr>
<tr>
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<td></td>
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<td>StealthWatch logs</td>
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Heterogeneous Data (1 of 3)

- Badge reader:
  - "0M151_Telephone_Room 12/06/2003 02:43:26 Admitted user2930 at 0M151 Telephone Room"
  - "0M422_Rear_Door_[In] 12/06/2003 05:20:24 Admitted user2930 at 0M422 Rear Door [In]"

- Login:
  - "nrrc-plymouth.mitre.org ROOT LOGIN /dev/console"

- Su:
  - "nrrc-plymouth.mitre.org 'su root' succeeded for user1 on /dev/pts/1"

Heterogeneous Data (2 of 3)

- Sshd:
  - "Accepted publickey for root from 129.83.10.17 port 52893"
  - "Accepted password for user1265 from 66.189.44.167 port 61007"
  - "Failed password for user1265 from 66.189.44.167 port 61011"

- Last-a:
  - "nrrc-boston.mitre.org user2643 pts/0 Fri Dec 12 16:54 - 17:25 (00:30) sgdykes.datasys.swri.edu"
Heterogeneous Data (3 of 3)

- **Web_log:**
  - "GET /cvw/licenses/source/license.html HTTP/1.0"
  - "GET /basilix.php3?request_id[DUMMY]=.../.../etc/passwd &RequestID=DUMMY&username=user2311&password=xxxxx HTTP/1.1"

- **Web_error:**
  - "Invalid method in request get /scripts/..."
  - "File does not exist: /tides_1/.../etc/passwd"

- **Sendmail:**
  - "cvw.mitre.org 14436 iOJ507Lb014436: from=<user1036E@digito.com>, size=2789, class=0, nrcpts=0, proto=ESMTP, daemon=MTA, relay=smtp-bedford-x.mitre.org [192.160.51.76]"
  - "cvw.mitre.org 14645 iOJ7ErLb014644: to=user8, ctladdr=<user9@cvw.mitre.org> (1/0), delay=00:00:00, xdelay=00:00:00, mailer="file", prl=41013, dsn=2.0.0, stat=Sent"
Who is Suspicious?

user1265
user8859
user2304
user2644
user252
user11838
user317
user301
user324
user2645
user322
user215
user268
user2649
user319
user2647
user287
user2306
user264

I&W Approaches

- **StealthWatch**
  - Multilevel Monitoring – packet level (John Copeland, Georgia Tech), system level, and application level.

- **Honeynets**
  - Distributed honeynets to acquire attacker properties, pre-attack intentions, and potential attack strategies (Lance Spitzner/Jed Hall, Honeynet)

- **Structured Analysis Group (SAG)**
  - Novel functional model related to attack graphs which will map pre-attack indicators to potential attacks (Brad Wood/Jack Marin, BBN; Steve Chapin, Syracuse)

- **Data Fusion**
  - Automatic fusion of traditional and novel indicators (Sara Matzner, U Texas; Sandy Dykes, SwRI)
overview of the results of a recent arda workshop on cyber indications and warning

structured analysis group hypothesis

Real-time analysis of log data allows an expert system to classify bounded MI behavior as it occurs

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Structured Analysis Group

Observables Taxonomy

Polygraph

Violations

Ministry Reporting

Physical Access

Cyber Actions

Foreign Travel

Finance

Materials Transfer to Vices Handlers

Counter Social Intelligence Activity

Internal External

Communications

Access Reconnaissance Entrenchment Exploitation Extraction Communication Manipulation

Cyber Intelligence Activities

Web Browsing

Web Browsing

Seniors

Installation

Software

Password Cracking

Encryption

Account Misure

Decryption

Privilege Escalation

Distributed File System

Terminals left logged on unattended, no time out

DATA and SENSORS

Honeypot data

Maintenance Schedule

Travels

Sensors

Calling patterns

Email patterns

Travel/Vacation

File systems

Encryption

Pornography

Gambling

Disk Erasure

Disk Wiping

Computers

Encryption

Disk Erasure

Disk Wiping

Adversary Models

Confidentiality

Integrity

Availability

Data

Network

Hosts

Services

Users

Attacks

Countermeasures

Adversary Model: The adversary is a friend who has access to the network and is suspected of stealing proprietary data.

Adversary Model: The adversary is an employee who has access to the network and is suspected of stealing proprietary data.

Adversary Model: The adversary is an attacker who has access to the network and is suspected of stealing proprietary data.

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Technical Approach

- Decomposed two insider scenarios (PAL and Jack)
- Focused on "Intelligent discovery averse techniques" for scoring methodology
- "Insider Chaining"
  - User attribution
    - SU, SSH, News, Web
  - Host attribution
  - Temporal characteristics
    - Event proximity
      - Immediate vs. days vs. years
    - Observables ordering

1: SSH => News => Mail
2: Mail => News => SSH

PAL and Jack Ranking
Data Fusion Hypotheses

Multiple cyber observables can be fused in order to provide earlier indications of a malicious insider.

Indications from multiple sources further support and strengthen the conclusion.

Data Fusion Observables Taxonomy

- Polygraph Violations
- Missing Reporting
- Physical Access
- Foreign Travel
- Finances
- Materials Transfer
- Counter Intelligence Activity
- Social Internal
- External

Access Reconnaissance
- Network: Web browsing needs
- Built new/new search
- Net Scan in IDS logs
- Authentication logs
- root access for non-admin
- ssh from one normal user to another
- IDS logs
- http, tcp from non-standard ports

Exploitation
- Sensor: Unusual recipient & encrypted
- Hidden or unapproved content type
- Lack of required digital watermark on images

Sensors
- Implemented for Workshop
- Not Implemented Yet

DATA SOURCES
- Authentication logs (login, ssh, su, passwd)
- Network IDS Logs (Snort, StealthWatch)
- Application server logs (web, news, email)

ArDA

DATA SOURCES
- Authentication logs (login, ssh, su, passwd)
- Network IDS Logs (Snort, StealthWatch)
- Application server logs (web, news, email)

ArDA
Execution Sample

Indicator Cyber-Access, user324, weight 1, at 2003-12-10 11:14:38, from tides2000.mitre.org
su to user9676 failed for non-admin user user324 on /dev/pts/0

Indicator Physical-Access, user295, weight 5, at 2003-12-15 19:19:37,
After hours badge access for user295

Indicator Cyber-Extraction-Exfiltration, user2649, weight 5, at 2004-01-06 15:37:28, from nrrc-springfield.mitre.org,
Data was uploaded to an external server via FTP protocol

Indicator Cyber-Reconnaissance, user295, weight 10, at 2004-01-09 20:57:18, from nrrc-springfield.mitre.org,
User user295 searching in non-need-to-know country korea

Execution Sample (continued)

Indicator Cyber-Communication, user9, weight 15, at 2004-02-10 22:14:48, from cvw.mitre.org,
User user9 received email with masqueraded content from user11649@yahoo.com

Indicator Cyber-Reconnaissance, user1, weight 5, at 2004-02-10 13:54:15, from nrrc-plymouth.mitre.org,
Ongoing CI violation – 066.170.227.074 currently has 49613 alerts of this type

Indicator Cyber-Extraction-Exfiltration, user295, weight 8, at 2004-02-12 23:54:58, from dmzsrv1.mitre.org,
User user295 sent encrypted email to user9983@comcast.net

Indicator Cyber-Extraction-Exfiltration, user1, weight 15, at 2004-02-20 12:25:03, from nrrc-erie.mitre.org,
User user1 sent email with masqueraded content to user1@mitre.org
### Experimental Results

#### User Weights and Indicators

<table>
<thead>
<tr>
<th>User</th>
<th>Weight</th>
<th>Breadth</th>
<th>Watch</th>
<th>Alert Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>user295</td>
<td>304</td>
<td>5</td>
<td>Y</td>
<td>Reconnaissance (75.6%), Cyber Access (13.2%), Communication (5.2%), Physical Access (3.2%), Extraction-Exfiltration (2.6%)</td>
</tr>
<tr>
<td>user8599</td>
<td>252</td>
<td>1</td>
<td>N</td>
<td>Reconnaissance</td>
</tr>
<tr>
<td>user1</td>
<td>75</td>
<td>3</td>
<td>Y</td>
<td>Cyber Access (66.6%), Reconnaissance (20%), Communication (20%)</td>
</tr>
<tr>
<td>user301</td>
<td>70</td>
<td>2</td>
<td>Y</td>
<td>Extraction-Exfiltration (71.4%), Cyber Access (28.6%)</td>
</tr>
<tr>
<td>user2649</td>
<td>70</td>
<td>2</td>
<td>Y</td>
<td>Cyber Access (71.4%), Extraction-Exfiltration (28.6%)</td>
</tr>
<tr>
<td>user322</td>
<td>60</td>
<td>1</td>
<td>N</td>
<td>Cyber Access</td>
</tr>
<tr>
<td>user2644</td>
<td>40</td>
<td>1</td>
<td>N</td>
<td>Cyber Access</td>
</tr>
<tr>
<td>user2304</td>
<td>30</td>
<td>1</td>
<td>N</td>
<td>Cyber Access</td>
</tr>
<tr>
<td>user2645</td>
<td>25</td>
<td>1</td>
<td>N</td>
<td>Cyber Access</td>
</tr>
<tr>
<td>user2647</td>
<td>25</td>
<td>1</td>
<td>N</td>
<td>Cyber Access</td>
</tr>
<tr>
<td>user9</td>
<td>15</td>
<td>1</td>
<td>N</td>
<td>Communication</td>
</tr>
<tr>
<td>user265</td>
<td>10</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>user7448</td>
<td>5</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>user215</td>
<td>5</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>user324</td>
<td>5</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>user269</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### DATA REDUCTION
- 7.4 M records examined for 75 users
- 259 indicators for 24 users

---

![Data Fusion Graph](image)

**Data Fusion**
- User Weights and Indicators

- Cyber Extract-Exfiltrate
- Physical Access
- Cyber Communication
- Cyber Access
- Cyber Recon
Summary

Insider Case Matrix

Performance Evaluation Metrics

- Developed evaluation methods/metrics
- Timeliness, e.g., time from defection to detection
  - years, months, weeks, minutes
- Accuracy
  - Precision = # correctly detected insiders / # reported
  - Recall = # reported insiders / total # actual insiders
  - False positives = 1-precision
  - False negatives = total # actual insiders - # correctly detected
Caveat on Experiment results

- Limited users (75)
- Limited # of algorithms attempted
- Insider models motivated by actual insider behavior but require community vetting (e.g., Jack would already know network topology so would not scan)
- Differences from IC networks (e.g., no guards, open network)
- Relatively few hosts (18/400) instrumented
- Data set collected over several months, insiders known to operate over years

Example Calculation of Fusion Performance

<table>
<thead>
<tr>
<th>Identified On Watchlist</th>
<th>MI</th>
<th>Not MI</th>
</tr>
</thead>
<tbody>
<tr>
<td>MI</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>PAL, Jack</td>
<td></td>
<td>User301, User8889</td>
</tr>
<tr>
<td>Not MI</td>
<td>1</td>
<td>70</td>
</tr>
<tr>
<td>Tides-Admin</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

False Positives: 2  False Positive Rate = 1/72 = 0.03
False Negatives: 1  False Negative Rate = 1/3 = 0.33
**Performance: Accuracy**

<table>
<thead>
<tr>
<th></th>
<th>StealthWatch *</th>
<th>SAG</th>
<th>Data Fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Scan</td>
<td>Data</td>
<td>Connect</td>
</tr>
<tr>
<td><strong>Precision</strong></td>
<td>1/6=17%</td>
<td>1/4=25%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>1/3=33%</td>
<td>1/3=33%</td>
<td>0%</td>
</tr>
<tr>
<td><strong>False Positive</strong></td>
<td>5 (0.28)</td>
<td>3 (0.18)</td>
<td>0</td>
</tr>
<tr>
<td><strong>False Negative</strong></td>
<td>2 (0.67)</td>
<td>2 (0.67)</td>
<td>3 (1.0)</td>
</tr>
</tbody>
</table>

*StealthWatch error rates computed on host IPs in network; SAG and Data Fusion computed on users.

Across approaches, correctly identified 3 out of 3 insiders

**Performance: Timeliness**

<table>
<thead>
<tr>
<th></th>
<th>StealthWatch</th>
<th>SAG</th>
<th>Data Fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Watch list</td>
<td>Alert</td>
<td></td>
</tr>
<tr>
<td><strong>PAL</strong></td>
<td>12/9/04</td>
<td>2/15/04</td>
<td></td>
</tr>
<tr>
<td><strong>TIDES Admin</strong></td>
<td>2/6/04</td>
<td>1/24/04</td>
<td>2/15/04</td>
</tr>
<tr>
<td><strong>Jack</strong></td>
<td>2/11/04</td>
<td>2/20/04</td>
<td>2/20/04</td>
</tr>
</tbody>
</table>
Findings

- MI effectively represented by historical case and real experts (analyst (Penny), app admin (Laurie), system admin (Billy))
- Multisource, multilevel logging supports MI behavioral trace
  - Careful sensor deployment important (e.g., network monitoring and application monitoring)
  - Not all logs provide user or host attribution
- Cumulative non-temporal (data fusion) and temporally dependent structural analysis model both worked well
  - Both approaches insensitive to weights
  - Require expertise on alert sources and systems
- Automated broad classification of users feasible (e.g., end user versus system administrator)

Limitations

- Unclassified, non IC network
  - Open network, no guards, no machine lock down
  - IC has swipe in/out, common networking timing
- Relatively few hosts (18/400) instrumented
- Data set collected over several months, insiders known to operate over years
- Representative insider threats addressed ... many additional models required (e.g., slow Jack attack, Ana Belen Montes)
- Common applications addressed (e.g., mail, news, web), but additional services would have enabled richer scenarios (e.g., instant messaging, database access) and analyses (e.g., social network analysis).
Lessons Learned

- Methodology
  - Do scenarios up front.
- Modify classical sensors
- Clear where to place sensors for outsider, not obvious where you place sensors for insider
- Important not only to detect MI but also provide evidence for investigation
- Underestimated complexity of sensor selection and log analysis leaving insufficient time for experimentation
- Workshop format efficient and enjoyable: few but key physical meetings, work in between meetings, weekly telecon, common shared data

Future Insider Knowledge and Focus

<table>
<thead>
<tr>
<th>Detectable</th>
<th>Not yet Detectable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurred</td>
<td>Not yet Occurred</td>
</tr>
<tr>
<td>MI who attacks the network</td>
<td>Non-cyber component</td>
</tr>
<tr>
<td>Ana Belen Montes</td>
<td>Robert Philip Hanssen</td>
</tr>
</tbody>
</table>
Access to Insider Threat Data Set

- Corpus created including policy, scenario creation, instrumenting/capturing, archiving, anonymization, and database indexing network, application, and physical access logs,
- 11+M records
- Based on Infosec/legal/HR review, availability beyond workshop requires addressing:
  - Security Vulnerabilities
    - IP and possibly machine anonymization
    - We believe no vulnerability data (e.g., no nessus scans)
    - Recovery of network topology
  - Privacy
    - User IDs from URLs
    - Machine names from URLs
    - Approval from host owners and users for new use

SpyCatcher Motivation

- Community-wide, corpus and metrics-based evaluation has resulted in rapid advances in areas including
  - Speech, e.g., ATIS
  - Machine translation
  - Information retrieval, e.g., TREC
  - Information Extraction, e.g., MUC
- With the development of MITRE’s DMZ corpus, we have an opportunity to inject simulated (historical or projected) insider behavior and test
- Systems can then be run against this data, results compared, and error analysis performed.
SpyCatcher Challenge Process

Select Insider Case

Simulate on DMZ (or OSIS)

Participants Sign Data NDA

Data Sent to Participants

Participants Submit Runs

Detailed Plan

- Each year select an increasingly challenging insider threat (e.g., start with FBI's Robert Hanssen then move on to DIA's Ana Belen Montes)
- Annually publish the kinds of logs and indicators that will be present in the data set (e.g., no financial records but system, network, and application logs). Do this during summer workshops.
- Simulate newly modeled threat in context of real network (e.g., DMZ)
- Groups sign non-disclosure of data agreement
- Research groups are given logs and asked to produce indicators and warnings (e.g., list of suspected accounts, likely targets) in short time period (e.g., days).
- Separate categories for manual/semi-automated and automated approaches (help discover new indications and warning methods).
- Award cash prizes for the best (fastest and most accurate) and most innovative systems (e.g., $5 or $10K, plus bragging rights) as judged by panel of experts
- Share results at open workshop so community learns
**Overview of the Results of a Recent ARDA Workshop on Cyber Indications and Warning**

**Goal**

Design and develop a proof of concept system for early indication and warning of malicious insiders (Mis).

**Novel Ideas**

- Novel functional model related to attack graphs which will map pre-attack indicators to potential attacks (Brad Wood/Jack Marin, BBN; Steve Chapin, Syracuse)
- Automatic fusion of traditional and novel indicators (Sara Mattner, U Texas; Sandy Oyekes, SwRI)
- Distributed honeypots to acquire attacker properties, pre-attack intentions, and potential attack strategies (Lance Spitzner/Jed Hall, Honeynet)
- Multilevel Monitoring – packet level (John Copeland, Georgia Tech), system level, and application level.
- Knowledge Based Infrastructure for I&W Integration (Brant Cheikes, Rick Pietravalle, MITRE)

**Accomplishments**

- Developed taxonomies of Mi observables and assets.
- Developed scenarios: analyst PAL (historical need to know violator) and sys admin Jack (projected attacker)
- Developed Common Data Repository (CDR): 11+ million records of cyber events: physical access (e.g., badge logs), network (e.g., StealthWatch, Snort, Honeynet), host/admin access (e.g., password, su, login), and user/application level (e.g., web, mail, news).
- Real-time detection of PAL and Jack Mis, exploiting data fusion, StealthWatch, and novel sensors

Accomplishments

• Digital Library for Research in Insider Threat
  - Affidavits, case studies, case analysis, observable/asset taxonomy
  - Briefed Insider Modeling at ARDA's Advanced Countermeasures for Insider Threat (ACIT) Kickoff
• Experimentation Data Set and data integration environment
  - Developed Common Data Repository (CDR): 11+ million records of cyber events: physical access (e.g., badge logs), network (e.g., StealthWatch, Snort, Honeynet), host/admin access (e.g., password, su, login), and user/application level (e.g., web, mail, news).
  - Toolset to support anonymization and filtering
• Developed scenarios: analyst PAL (historical need to know violator – EO 12968) and sys admin Jack (projected attacker)
• Proof of Concept Tech Approaches for Detections
• Test Cases for Evaluation

Publications

• Lance Spitzner. Dec 2003 "Honeypots: Catching the Insider Threat” ACSAC, Las Vegas, NV.
Intelink Factoids

Pete Jobusch, CTO
Information Assurance Directorate
Intelink Management Office
peterj@intelink.gov
Topics

- What is Intelink?
- History
- Statutory and Policy Environment
- Information Space Issues

What is Intelink?

- Intelink is NOT a Network
- Intelink is NOT a Service
- Intelink is a Corroboration
History

- Mosaic
- Intelink Services Management Center
- Intelink Management Office

Statutory and Policy Environment

- Title 50
- DCI Directives
- Community Policies
Information Space Issues

- Utility not derived from "dancing pigs"
- Not all Information equally Sensitive
- Secure COI
- Community PKI
- Other Protections

Questions?
Glass Box Analysis Project: Overview for Insider Threat Workshop

Dr. Frank L. Greitzer
Battelle, Pacific Northwest Division (PNWD)

PNWD Glass Box Project Manager: Paula Cowley

Glass Box
March 4, 2004
Glass Box as a NIMD Hub

Glass Box Objectives:
- Meaningful data for NIMD research community
- Utility software for examining data
- Facilitate new tool development by NIMD researchers

Goal: Capture the Analytic Process

- Collect data from signed-up analysts
  - Perform analytic taskings provided by analysts
  - Collect "ground truth" data of what analysts actually did
  - Capture cognitive thought processes
  - Capture queries and documents read
  - Capture reports generated
  - Capture "Over The Shoulder" view of activities
- Distribute Database, Filestore, and Access Tools to NIMD Researchers
- Enable reconstruction and visualization of analytic process.
Glass Box Instrumentation Software Automatically Captures Workstation Events

- Web Browser activity
  - URLs and contents of all pages visited
  - Images displayed on Web pages
  - Queries submitted by analyst to search engine
  - Results of query
- Application records (e.g., MS Word, PowerPoint, Excel)
  - Periodic snapshots of documents
  - Various actions such as “Find…”
- Window events (active window, location on screen, how long open, …)
- File/Save events
- Copy/Paste events
- Keyboard and mouse data
- Analyst-initiated annotations are also captured.

Glass Box Software Also Provides Review Functions for NIMD Researchers

- Tabular Review shows time-stamped activities
- “Replay” Events in ‘Deja View’ mode
- “Over-the-Shoulder” View mode (Camtasia)

Data enable visualization of analysis process.
Glass Box Instrumentation Can Be Used To Support Insider Threat R&D

Possible Applications
- Capture sample data to support event characterization and vulnerabilities R&D
- Create/capture sample data using insider threat "simulations"
- Use Glass Box API to integrate/test proposed sensors
- ...
APPENDIX I

Presentation: Interacting with Information: Novel Intelligence from Massive Data (NIMD)

UNCLASSIFIED

Interacting with Information: Novel Intelligence from Massive Data (NIMD)

Dr. Lucy Nowell
NIMD Program Manager
ARDA
Advanced Research and Development Activity

3/9/04  UNCLASSIFIED
Today

- NIMD and Insider Threat
- Motivation for NIMD
- NIMD Research Agenda
- NIMD Events
- Communicating with NIMD

NIMD & Insider Threat

- Glass Box team and I are here to support you
- NIMD Program will facilitate Insider Threat program access to Glass Box software and data
  - Input on new capabilities to add to GB?
- Relevant NIMD research results will be available
  - Models of analytic process
  - Cognitive task/work analysis
  - Etc.
Why NIMD?

- Heavily motivated by Heuer’s *Psychology of Intelligence Analysis*
- Focus is on “Novel Intelligence” more than on Massive Data
- Goals:
  - Build a suite of mixed-initiative analytic tools that support analyst interaction with information
  - Sustain consideration of multiple hypotheses and viewpoints
  - Deliver better analytic product

NIMD Research Areas

- Human Information Interaction
  - Modeling Analysts & Analytical Strategies
  - Prior & Tacit Knowledge
  - Hypothesis Generation & Tracking

Glass Box Analysis Environment
Keys to NIMD – Driving Ideas

- Recognize analyst's assumptions and biases;
  - Make different assumptions and evaluate how the outcome changes.
  - Evaluate implications of analytic bias; counter as needed.
- Recognize analyst's strategy;
  - Employ different strategies and evaluate how the outcome changes.
- Examine prior and tacit knowledge embedded in reports and queries;
  - Validate and capture for use by others;
  - Ensure that organizational prior knowledge is reflected in the analysis.
- Find and call out relevant data not used in the analysis;
- Provide a mixed-initiative analytic environment that supports simultaneous tracking of multiple hypotheses and exploration of massive data.
Data Provided to Researchers

- Glass Box Data
- Center for Non-Proliferation Studies data on biological and chemical WMD and terrorism, adding nuclear WMD this year
- NIMD does not provide access to Government databases

NIMD Knowledge Base(s)

- Cognitive models of analysts
- Models of analytic strategies
- Captured prior and tacit knowledge
  - Driven by analytic taskings and analysts' activities
- Ontologies and other domain mappings of data
- Other types to be determined during research

- NOT aimed at capturing data about individuals other than analysts
NIMD Events

- PI Meeting - May 25-28 in Crystal City
- Fall PI Meeting in Orlando, dates TBD

- ARDA Knowledge Representation Symposia (sponsored by NIMD)
  - Three 3-day sessions
  - August, October, January -- dates TBD
  - Goal is to facilitate interoperability

Communicating with NIMD

- Dr. Lucy Nowell, PM - ltnowel@nsa.gov, 443-479-8010 or 301-688-7092 (ARDA ofc)

- Dan Doney, NIMD SETA - gddoney@nsa.gov

- Thomas Fortney, NIMD SETA - tafortn@nsa.gov

- NIMD web site maintained by NIST - access can be provided on request from Dick Brackney
Thank You!

Dr. Lucy Nowell
NIMD Program Manager
ltnowell@nsa.gov
lucy.nowell@pnl.gov