Fundamentals of Information & Network Security ECE 471/571

Lecture #38: Intrusion Detection

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Why we need IDS?

- IDS: Intrusion Detection System
- Second line of defense: Prevention, Detection, Recovery
- Motivation:
  - Detect an attack: the sooner an attack is detected, the less the amount of damage and the more quickly that recovery can be achieved.
  - An effective IDS can serve as a deterrent, so acting to prevent intrusions.
  - IDS collects information about intrusion techniques that can be used to strengthen the intrusion prevention facility.

Who are the Intruders?

- significant issue for networked systems is hostile or unwanted access
- either via network or local
- can identify classes of intruders:
  - masquerader
  - misfeasor
  - clandestine user
- varying levels of competence

Examples of Intrusion

- remote root compromise
- web server defacement
- guessing / cracking passwords
- copying viewing sensitive data / databases
- running a packet sniffer
- distributing pirated software
- using an unsecured modem to access net
- impersonating a user to reset password
- using an unattended workstation

Intruder behavior patterns

- Hackers
  - motivated by thrill of access and status
  - benign intruders might be tolerable
  - IDS / IPS / VPNs can help counter
- Criminal Enterprise
  - organized groups of hackers now a threat
  - corporation / government / loosely affiliated gangs
  - criminal hackers usually have specific targets
  - IDS / IPS help but less effective
- Insider Attacks
  - among most difficult to detect and prevent
  - employees have access & systems knowledge
  - IDS / IPS may help but also need others

Hacker Behavior Example

1. select target using IP lookup tools
2. map network for accessible services
3. identify potentially vulnerable services
4. brute force (guess) passwords
5. install remote administration tool
6. wait for admin to log on and capture password
7. use password to access remainder of network

Criminal Enterprise

- organized groups of hackers now a threat
  - corporation / government / loosely affiliated gangs
  - typically young
  - often Eastern European or Russian hackers
  - often target credit cards on e-commerce server
- criminal hackers usually have specific targets
- once penetrated act quickly and get out
- IDS / IPS help but less effective
- sensitive data needs strong protection

Criminal Enterprise Behavior

1. act quickly and precisely to make their activities harder to detect
2. exploit perimeter via vulnerable ports
3. use trojan horses (hidden software) to leave back doors for re-entry
4. use sniffers to capture passwords
5. do not stick around until noticed
6. make few or no mistakes.

Insider Attacks

- among most difficult to detect and prevent
- employees have access & systems knowledge
- may be motivated by revenge / entitlement
  - when employment terminated
  - taking customer data when move to competitor
- IDS / IPS may help but also need:
  - least privilege, monitor logs, strong authentication, termination process to block access & mirror data

Insider Behavior Example

1. create network accounts for themselves and their friends
2. access accounts and applications they wouldn't normally use for their daily jobs
3. e-mail former and prospective employers
4. conduct furtive instant-messaging chats
5. visit web sites that cater to disgruntled employees, such as f'dcompany.com
6. perform large downloads and file copying
7. access the network during off hours.

Intrusion Techniques

- aim to gain access and/or increase privileges on a system
- often use system / software vulnerabilities
- key goal often is to acquire passwords
  - so then exercise access rights of owner
- basic attack methodology
  - target acquisition and information gathering
  - initial access
  - privilege escalation
  - covering tracks

- Password Guessing
- Password Capture

Password Guessing

- one of the most common attacks
- attacker knows a login (from email/web page etc)
- then attempts to guess password for it
  - defaults, short passwords, common word searches
  - user info (variations on names, birthday, phone, common words/interests)
  - exhaustively searching all possible passwords
- check by login or against stolen password file
- success depends on password chosen by user
- surveys show many users choose poorly

Password Capture

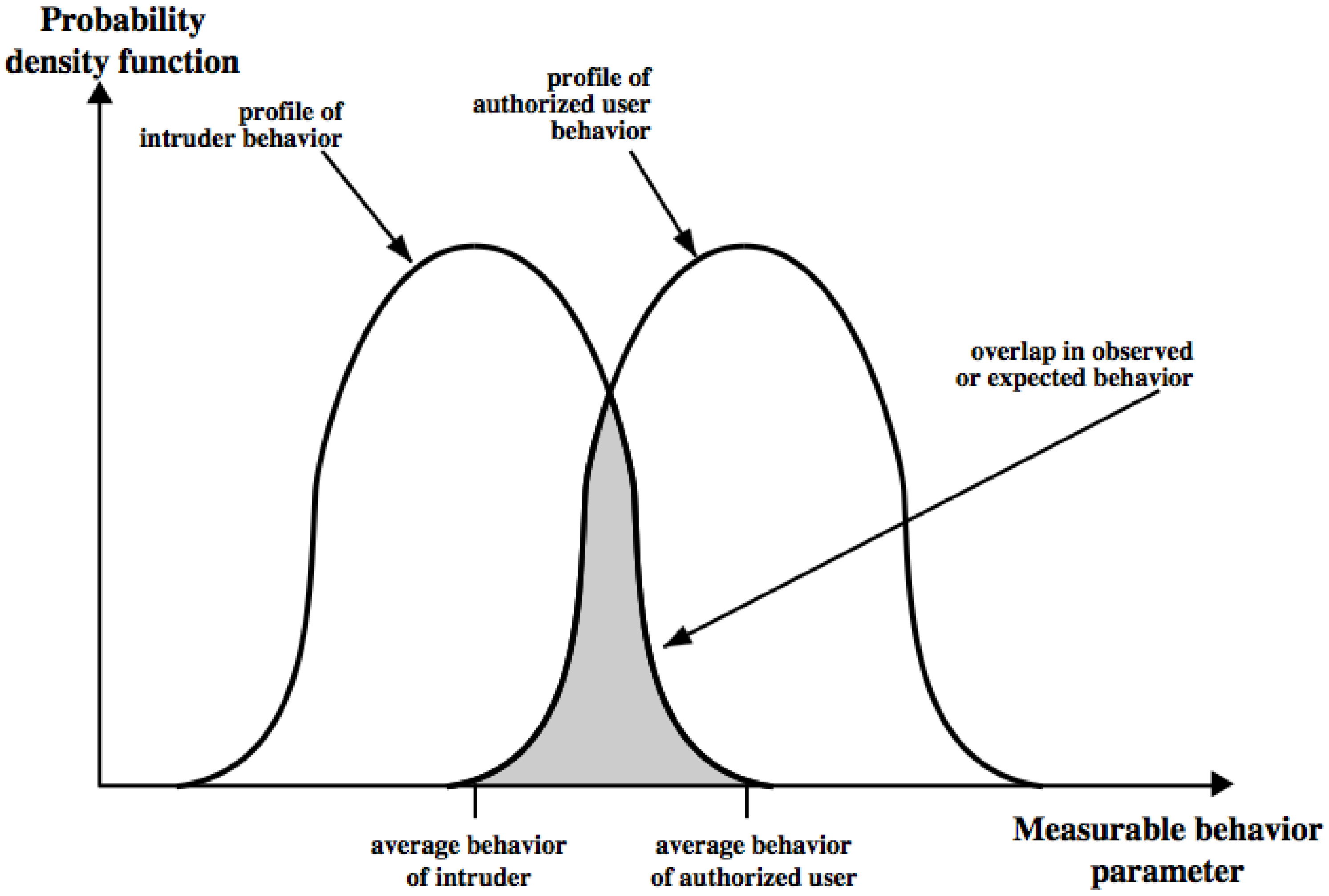
- another attack involves **password capture**
  - watching over shoulder as password is entered
  - using a trojan horse program to collect
  - monitoring an insecure network login
    - eg. telnet, FTP, web, email
  - extracting recorded info after successful login (web history/cache, last number dialed etc)
- using valid login/password can impersonate user
- users need to be educated to use suitable precautions/countermeasures

Intrusion Detection Approaches

- Rule-based detection
  - Attempt to define a set of rules that can be used to decide that a given behavior is that of an intruder
  - Define improper behavior, for known attacks.

- Statistical anomaly detection
  - Collect data relating to the behavior of legitimate users over a period of time, then apply statistical tests to observed behavior to determine with a high level of confidence whether that behavior is not legitimate user behavior.
  - Define normal, or expected, behavior, use threshold or profile to detect abnormal behavior, could be used for unknown attacks.

Intrusion Detection


Probability density function
profile of intruder behavior
profile of authorized user behavior
overlap in observed or expected behavior
average behavior of intruder
average behavior of authorized user
Measurable behavior parameter

Statistical Anomaly Detection

- threshold detection
  - count occurrences of specific event over time
  - if exceed reasonable value assume intrusion
  - alone is a crude & ineffective detector
- profile based
  - characterize past behavior of users
  - detect significant deviations from this
  - profile usually multi-parameter

Audit Record Analysis

- foundation of statistical approaches
- analyze records to get metrics over time
  - counter, gauge, interval timer, resource use
- use various tests on these to determine if current behavior is acceptable
  - mean & standard deviation, multivariate, Markov process, time series, operational
- key advantage is no prior knowledge used

Rule/Signature-Based Intrusion Detection

- observe events on system & apply rules to decide if activity is suspicious or not
- Rule-based anomaly detection
  - analyze historical audit records to identify usage patterns & auto-generate rules for them
  - then observe current behavior & match against rules to see if conforms
  - like statistical anomaly detection does not require prior knowledge of security flaws
- Rule-based penetration identification

How good can an IDS be?

- practically an intrusion detection system needs to detect a substantial percentage of intrusions with few false alarms
  - if too few intrusions detected -> false security
  - if too many false alarms -> ignore / waste time
- this is very hard to do
- existing systems seem not to have a good record

Base-Rate Fallacy

- Consider the following: A patient has a test for some disease that comes back positive (indicating he has the disease).You are told that
  - The accuracy of the test is 87% (i.e., if a patient has the disease, 87% of the time, the test yields the correct result, and if the patient does not have the disease, 87% of the time, the test yields the correct result).
  - The incidence of the disease in the population is 1%.

- Q: Given that the test is positive, how probable is it that the patient does not have the disease? That is, what is the probability that this is a false alarm?

Base-Rate Fallacy

- We need Bayes' Theorem:

$$\begin{aligned}\Pr[\text{well/positive}] &= \frac{\Pr[\text{positive/well}]\Pr[\text{well}]}{\Pr[\text{positive/disease}]\Pr[\text{disease}] + \Pr[\text{positive/well}]\Pr[\text{well}]} \\ &= \frac{(0.13)(0.99)}{(0.87)(0.01) + (0.13)(0.99)} = 0.937\end{aligned}$$

How to fix this problem?

Honeypots

- decoy systems to lure attackers
  - away from accessing critical systems
  - to collect information of their activities
  - to encourage attacker to stay on system so administrator can respond
- are filled with fabricated information
- instrumented to collect detailed information on attackers activities
- single or multiple networked systems
- cf IETF Intrusion Detection WG standards

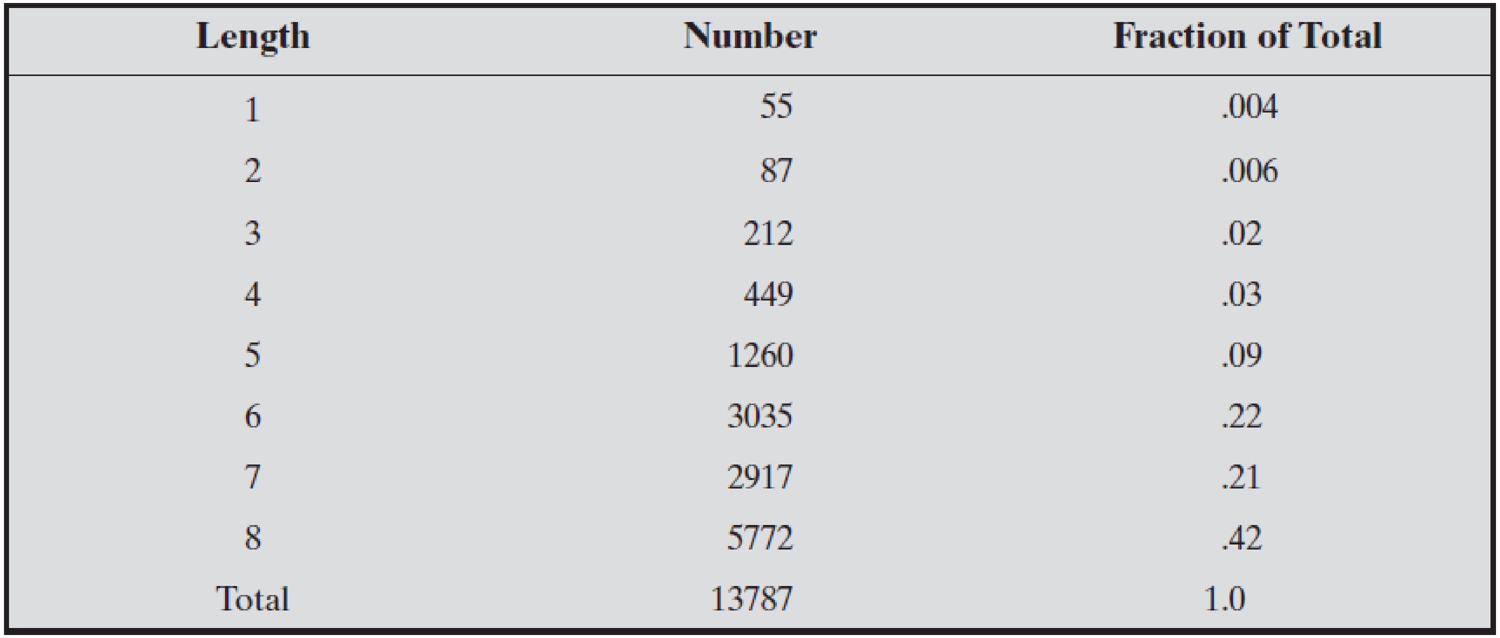
Password Management

- front-line defense against intruders
- users supply both:
  - login – determines privileges of that user
  - password – to identify them
- passwords often stored encrypted
  - Unix uses multiple DES (variant with salt)
  - more recent systems use crypto hash function
- should protect password file on system

Password Studies

- Purdue 1992 - many short passwords
- Klein 1990 - many guessable passwords
- conclusion is that users choose poor passwords too often
- need some approach to counter this

Table 20.4 Observed Password Lengths [SPAF92a]



Length	Number	Fraction of Total
1	55	.004
2	87	.006
3	212	.02
4	449	.03
5	1260	.09
6	3035	.22
7	2917	.21
8	5772	.42
Total	13787	1.0

Table 20.5 Passwords Cracked from a Sample Set of 13,797 Accounts [KLEI90]

Type of Password	Search Size	Number of Matches	Percentage of Passwords Matched	Cost/Benefit Ratio[a]
User/account name	130	368	2.7%	2.830
Character sequences	866	22	0.2%	0.025
Numbers	427	9	0.1%	0.021
Chinese	392	56	0.4%	0.143
Place names	628	82	0.6%	0.131
Common names	2239	548	4.0%	0.245
Female names	4280	161	1.2%	0.038
Male names	2866	140	1.0%	0.049
Uncommon names	4955	130	0.9%	0.026
Myths & legends	1246	66	0.5%	0.053
Shakespearean	473	11	0.1%	0.023
Sports terms	238	32	0.2%	0.134
Science fiction	691	59	0.4%	0.085
Movies and actors	99	12	0.1%	0.121
Cartoons	92	9	0.1%	0.098
Famous people	290	55	0.4%	0.190
Phrases and patterns	933	253	1.8%	0.271
Surnames	33	9	0.1%	0.273
Biology	58	1	0.0%	0.017
System dictionary	19683	1027	7.4%	0.052
Machine names	9018	132	1.0%	0.015
Mnemonics	14	2	0.0%	0.143
King James bible	7525	83	0.6%	0.011
Miscellaneous words	3212	54	0.4%	0.017
Yiddish words	56	0	0.0%	0.000
Asteroids	2407	19	0.1%	0.007
TOTAL	62727	3340	24.2%	0.053

Managing Passwords - Reactive Checking

- reactively run password guessing tools
  - note that good dictionaries exist for almost any language/interest group
- cracked passwords are disabled
- but is resource intensive
- bad passwords are vulnerable till found

Managing Passwords - Proactive Checking

- most promising approach to improving password security
- allow users to select own password
- but have system verify it is acceptable
  - simple rule enforcement (see earlier slide)
  - compare against dictionary of bad passwords
  - use algorithmic (markov model or bloom filter) to detect poor choices

Reading Assignment

- [Stallings] Chapter 23