Cyber Security

Big Data Big Think II Working Group Meeting

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Agenda

• The Big Data Problem in cyber security
• The cyber security environment for a NASA supercomputer center and its associated big data (referred to as a Data Computation Center in this presentation)
• General cyber security objectives
• Focus on identification of actionable security events from the big mountain of data that flows into and out of a Data Computation Center
The Big Data Problem in Cyber Security

- Internet-accessible Data Computation Centers are under constant attack, which come from the Internet
- Attacks are intermixed with a large volume of legitimate Internet traffic flowing into and out of the Data Computation Center, which leads to a big mountain of data
- Cyber security tools are used to monitor for attacks, but these generate a big mountain of data that is added to the mountain of legitimate data traffic
- To keep from being overwhelmed, security analysts are interested in knowing about only those attacks for which manual or automated action is required to counter them
- The problem addressed by this presentation is how to extract actionable security data out of this big data mountain
The NASA Big Data Supercomputer Cyber Security Environment

• The Data Computation Center is accessible over the Internet
• Legitimate users must be identified and authenticated
• Users can download their own programs and any additional data that is needed
• Security should not be so onerous that it impedes the use of the system
• Actionable security events that could lead to a misuse of the system should be identified and acted upon
• Need to discover actionable events from the big mountain of data in which they are embedded
General Cyber Security Objectives

• Identify and authenticate legitimate users prior to granting them access to the Data Computation Center
• Ensure that users access only data to which they are authorized
• **Identify attacks** and block them while minimizing
  - False positives – so that legitimate users are not blocked
  - False negatives – so that dangerous attacks are not missed
• Ensure that malicious code and backdoors
  - Are not planted in system or
  - Are detected if they are
Two Broad Strategies for Detecting Attacks

• Direct detection approaches applied directly to the Data Computation Center data flowing to and from the network
• Detection approaches applied only after reducing the big mountain of Data Computation Center data flowing to and from the network to a more manageable level
Direct Detection Can Be Used To Detect Malicious Delivery Sites

• Phishing and malware delivery sites can hide behind constantly changing addresses
• Detection approaches are compute intensive for the big mountain of DNS data flowing to and from the network
• Changing IP addresses over a short time period is called Fast-Flux
  - Detection based on counting number of IP addresses associated with domain and time-to-live assessment
  - Important to add other parameters when making a decision as to whether this is malware, since content delivery networks use this for load balancing
• Randomly generated domain names at regular intervals in large numbers is called Domain Flux
  - Detection based on number of domain name failures returned by the host making DNS request
Direct Detection Can Be Used To Detect Malicious Delivery Sites

• Domain Generation Algorithms (DGAs) can automatically generate domain names
  - Generated names tend to be gibberish
  - Generation of names is deterministic so that Command and Control site and embedded malware can communicate after change

• Use Machine Learning to Detect Domain Generation Algorithm Attacks
Use Machine Learning to Detect Domain Generation Algorithm Attacks

- Use a combined 2-gram to 3-gram Markov chain to detect deviation from “normal” domain names.
- While this may not detect newer DGA-generated domains name such as those that pair real words in a noun-verb-noun-verb combination, it is still very useful.
- Combining with other techniques will reduce false-positives and false-negatives.
- Combining a 2-gram Markov chain (which is less strict on detecting gibberish) with an organization check and fast-flux domain flux detection may help detect the noun-verb-noun-verb DGA domains.
Detection After Reducing the Big Data Mountain to a More Manageable Volume

- Network flow data is the largest component of the big data mountain
- Want to categorize network flows into three risk categories:
  - Acceptable Risk: Flows that are unlikely to contain any security attacks – and thus can be discarded from further analysis
  - High Risk: Flows that are likely to contain security attacks – and thus must be extensively analyzed
  - Unknown Risk: Flows for which it is unknown whether or not they contain a security attack – which also must be analyzed
Categorization of Flows Based on the Source of the Flow

• **Acceptable Risk flows:**
  - Flows that come from IP addresses that fall under an organization from which an authorized user has logged on to a Data Computation Center system

• **High Risk risk flows:**
  - Flows that come from IP addresses and associated organizations that are on watch lists, have mounted an attack, or have scanned dark space

• **Unknown Risk flows:**
  - Flows that cannot initially be placed into the acceptable or high risk categories
Detection of Malicious Command & Control Channels Using High Risk & Unknown Risk Flows

• Detect Command and Control activity for any malicious code that may have been installed in a system
  - Network beaconing activity could indicate presence of
    - Botnet slave checking in for assignments
    - Advanced Persistent Threat (APT) checking in for assignments or delivering intellectual property
  - Detection by looking for a recurring flows that provides a pattern of communications
  - Need big data trending with flows remaining from data mountain reduction
Detect Attempted or Actual Intrusions by Looking at High Risk and Unknown Risk Reduced Flows

• Normally a large number of Intrusion Detection System (IDS) events for a large data center with heterogeneous systems
  - Big data mountain reduction eliminates all but High and Unknown risk flows, helping to focus on events of most concern
• Still need significant computation to de-clutter the IDS results to identify only actionable data
Correlation Provides a Useful Method to Eliminate False Positives

• Correlate IDS events with the flow that caused the IDS to trigger
  - The flows that correlate with an IDS event are the flows on which to focus attention
• Correlate IDS-flows with vulnerabilities from vulnerability scanner
  - The flows where the IDS correlates with a vulnerability are the events on which to focus
• Correlation reduces false positives, but is computationally intensive
• Use pattern discovery to detect distributed, targeted attacks that may involve recurring flows from multiple sources
Identify Indicators of Possible Data Exfiltration

- Aberrant user behavior may indicate insider threat or user-level compromise.
  - Unusual login time for a particular user
  - New source host or organization
  - Multiple logins for same user from different locations within a small time window
Identify Indicators of Possible Data Exfiltration

• Unusual outbound activity may indicate unauthorized data exfiltration
  - Unauthorized access or attempting to access unauthorized hosts
  - Unauthorized privilege escalation or attempting privilege escalation
  - Unusual file transfer protocol
  - File transfer to host or organization not seen before or to an IP address on a watch list
  - File transfer to unauthorized foreign country
  - Unusual emails such as emails with extremely large attachments and email bursts to free email providers
Visualization Is Important to Cyber Security Since a Picture is Worth 1000 Words

• Visualization allows the security analyst to see events and relationships that may be lost in rows of data as well as summarize security event activity
• Provide visualization of the various flows that are of most concern to help identify patterns not before seen
Questions?