Advanced Countermeasures: Integrating SSDs Into Cyber-Security Defense

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Cyber-security Landscape

- ## What's at risk
  - Data can have sentimental value (pictures)
  - Data can be very personal (medical records)
  - Data can be very expensive to acquire (DNA Sequencing)
  - Data can be critical for the operation of a business or even a city

- ## Problem
  - Data Theft and Data Ransoming are a growing problem
  - Bypassing standard antivirus tools is relatively easy if you understand how binaries are structured
  - The days of quick attacks are over
  - Attackers are taking their time to study the network, find the most valuable data or do the most possible damage by destroying backups

- ## Solution
  - AI/ML cyber-security suite that is tightly integrated with the storage align the protection system with the threat landscape

Weakest Link: People

- Lost/Stolen Device 18%
- Internal Theft 3%
- Human Error 32%
- Ransomware 23%
- Phishing 25%
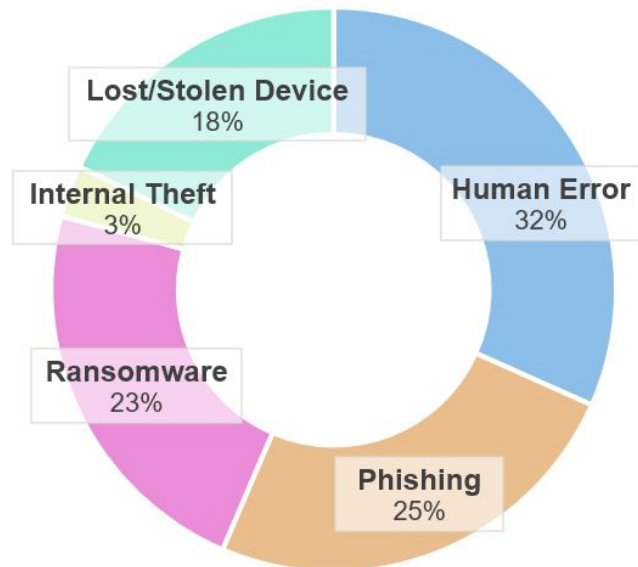
Cyber-security Landscape

- June/2019 – Florida Ransomware Headlines
  - Lake City: Pays $460,000 in Ransom to Cyber attackers
  - Key Biscayne: Someone clicks link, again, giving ransomware
  - Riviera Beach: Agrees to pay ransomware hackers $600,000 to unlock its data

- Current methods used to combat cyber security threads include: People, Process, Technology
  - Despite constant training, people remain the weakest link, accounting for 43% of all the security breaches

- How can AI/ML help detect and stop cyberattacks beyond what is being done today?
  - The Florida Ransomware attacks represent an advanced attack knows as a "triple threat"
 - What does this mean and how can we protect ourselves?

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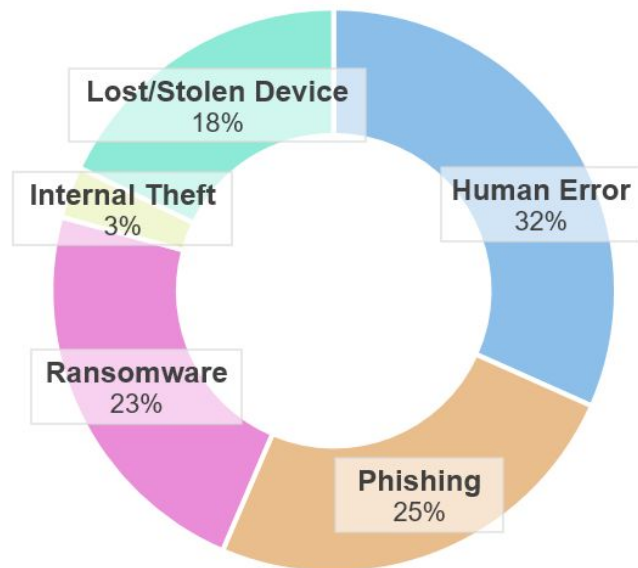
Getting into the network

- An unwitting victim receives a phishing email that usually contains a macro-enable office document

  o When "Enable Content" is pressed, a macro runs that spawns a command shell and downloads the "Emotet" trojan

  o Emotet was identified in 2014; it attempts to steal sensitive information

  o It has advanced polymorphic functionality that helps evade signature-based anti-malware products

  o It detects if it is in a VM/Sandbox and will remain dormant

  o Designed to spread to other computers on the network

  o US Department of Homeland Security concluded that Emotet is one of the most costly and destructive malwares, costing upward of $1M per incident to clean up
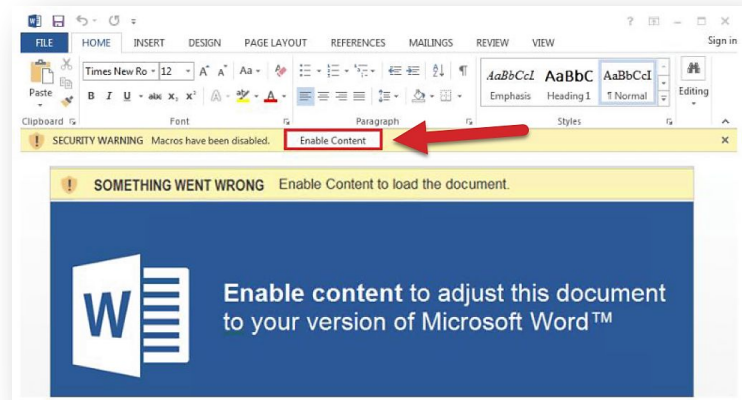
"It all starts with a single user – click"
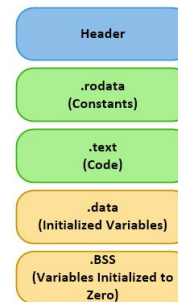
AI Detection & Prevention

- Reviewing attack vectors

  - Users are trained not to open attachments, but if the email appears to be internal, they assume it's safe

  - Office Macros are heavily used in corporate environments and while IT experts prefer to disable them, user backlash usually gets them re-enabled

  - Powershell is used in everything from auditing, account management, system hardening and configuration management

- These tools are entrenched, so why not use AI/ML to help detect unusual activity?

  - Attacks are typically structured as a chain, where one step allows the next step to continue

  - Breaking that chain will stop the attack

  - Machine Learning algorithms such as decision trees and nearest-neighbor type algorithms can detect deviations from baseline behavior

  - No need to search for specific file names or signatures

  - Enable maximum productivity by focusing on system activity that is outside the norm

Breaking Virus Scanner

- Polymorphic code or self-mutating sounds cool, but what does it mean?

  o The binary understands its own code structure

  o It can move sections around and self-edit, but still respects the rules of binary layout

  o Can be based on a valid executable that simply changes one of the branch calls to execute the attack function

  o Adds random symbols and instructions calls that are not actually accessed

  o SHA-256 hash will produce a substantially different signature even when only a few bytes are changed

  o Result is that the attacking exe passes the signature check

  o Though setting up this self-editing code is tedious, it is not that hard to do if you understand how compilers work

Basic Bin Layout

Header

.rodata
(Constants)

.text
(Code)

.data
(Initialized Variables)

.BSS
(Variables Initialized to Zero)

Defeating Virus Scanner

```
Contents of section .rodata:
 4005f8 01000200 57696E64 6F777300 00        ....Windows.
Contents of section .text:
 400410 31ed4989 d15e4889 e24883e4 f0505449   1.I..^H..H...PTI
 400420 c7c0a005 400048c7 c1100540 0048c7c7   ....@.H...@.H..
 400430 f4044000 e8c7ffff fff49090 4883ec08   ..@.........H...
```

This part isn't actually called by any branch in the bin. It's dead code.

```
Hash / Signature: a50087195cd390eececbcb7d4bbfef7b
```

Polymorphic == Self-edits to Bin

```
Contents of section .rodata:
 4005f8 01000200 57696E64 6F777300 00        ....Windows.
Contents of section .text:
 400410 31ed4989 d15e4889 e24883e4 f0505449   1.I..^H..H...PTI
 400420 c7c0a005 400048c7 c1100542 0049c7c7   ....@.H...B.I..
 400430 f4044000 e8c7ffff fff49090 4883ec08   ..@.........H...
```

We can put any hex value we want here

```
Hash / Signature: 0c2f38b0e02b36d29888d7638e6fdc40
```
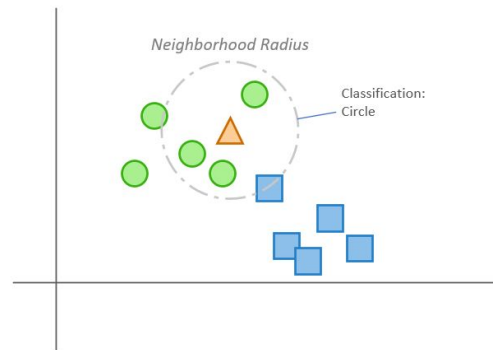
AI Detection & Prevention

- The AI/ML is trained to look for abnormal execution patterns

  o Normal usage of system binaries

  o Normal use (or non-use) of system commands such as "net", "taskkil", "psexe", "vssadmin", etc…

  o Normal lateral network communications

  o Normal access patterns as the encryption and removal of many files at once from storage

- Layered approach

  o Attackers use many different tools together to attack a system

  o The solution must take a similar approach

  o Sensors come with a pre-trained baseline and adapt based on the environment and specific user

  o Here are a few examples of Input Sensors:

Sensor Keyboard Usage	Sensor Peripheral Connections	Sensor Kernel Calls	Sensor Storage Access Patterns	Sensor Network Topology

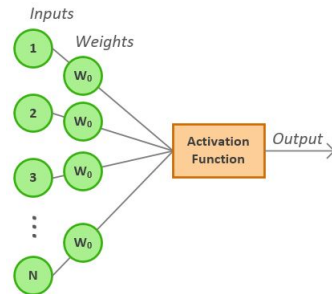1d   Training Time   1w
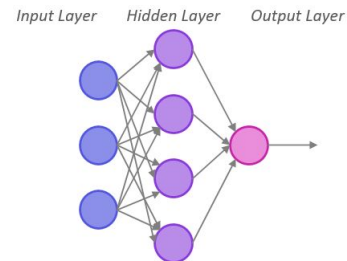
Training AI/ML Examples

- The K-Nearest Neighbor (KNN) algorithm executes very quickly and has good predictive power

  - In this example we have a set of circles and squares representing known items.

  - The axis represent sensor inputs, though there is no reason to limit to only two inputs (it's just easier to draw)

  - The objective is to classify the triangle based on how many (K) neighbors it has

- A Neural Network (NN) can be trained dynamically

  - In this example we look at keyboard typing cadence and character usage

  - Input Network-1 is trained on character frequency

  - Input Network-2 is trained on delay from last keystroke

  - Hidden Layers add more complexity to the categorization

  - Output Node balances the input to make a determination

Neighborhood Radius

Classification: Circle

Single Neuron Node

Inputs

Weights

1

W_0

2

W_0

3

W_0

W_0

N

Activation Function

Output

Deep Network

Input Layer   Hidden Layer   Output Layer

Training AI/ML Examples

- A decision tree looks a lot like a flow chart

  - The training is a lot simpler as the data it works with does not need to be process or normalized

  - The Decision Tree works together with the KNN and NN based categorization engines to classify activity and then make a decision

  - The categories and issues are automatically identified by the learning algorithm based on the data collected

  - The objective with each split is to obtain many items of a specific class in that category

  - Apply regression function with a simple square of the error to prune out bad branches

  - Stop when minimum number of training issues assigned to each class is below a set target

  - The final classification is submitted to the security policy set up by the end-user or security officer
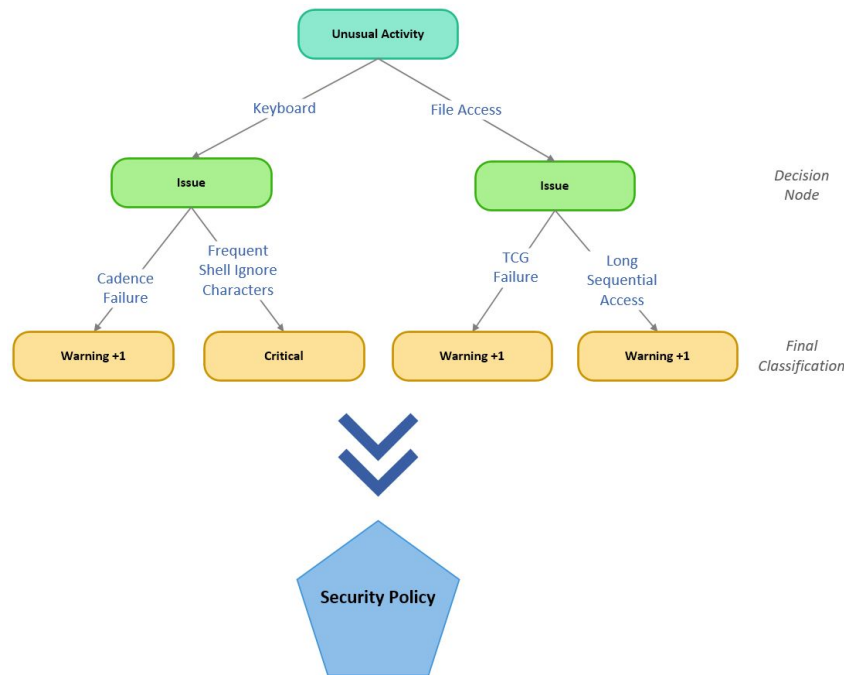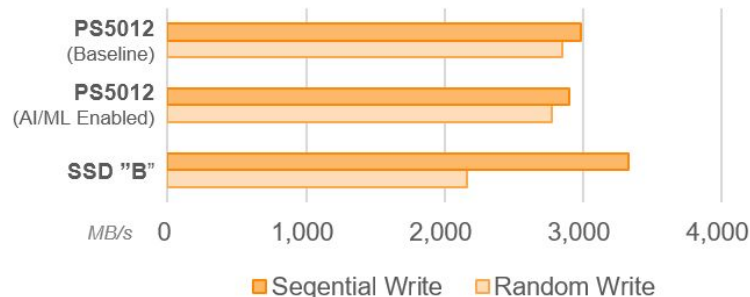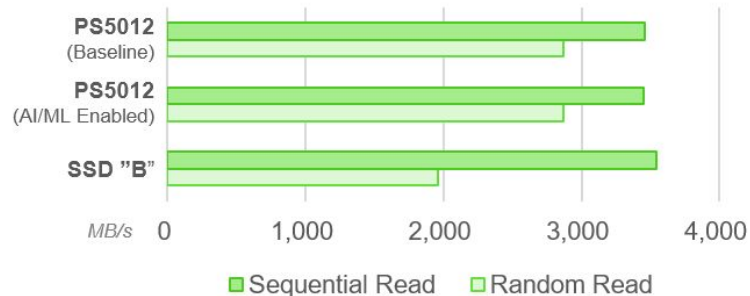
Sensor: SSD Storage

- ## The SSD can become another sensor input into the AI/ML engine

  - Based TCG Opal Self-Encrypting Drive (SED)

  - The SSD is divided into TCG Opal Ranges

  - The SSD maintains logs for each TCG Opal Ranges that can be analyzed by the AI/ML engine

- ## Secure SSD Sensor

  - Careful Hardware and Firmware design ensures no degradation in performance

  - Projected impact of logging on TBW is ~24B / 4K (0.1%)

  - No meaningful impact on drive lifespan

  - No significant degradation in performance

Crystal Disk Mark 6.0

PS5012 (Baseline)
PS5012 (AI/ML Enabled)
SSD "B"

MB/s   0   1,000   2,000   3,000   4,000

■ Sequential Read   ■ Random Read

PS5012 (Baseline)
PS5012 (AI/ML Enabled)
SSD "B"

MB/s   0   1,000   2,000   3,000   4,000

■ Seqential Write   ■ Random Write

Key Takeaway

1. Data Theft and Data Ransoming are a growing problem

2. Attackers take their time to learn the network: Maximize Theft & Damage

3. Attackers can read white papers too, they will adopt AI as well

4. The only thing that beats AI is a better AI, simple rule-based logic is obsolete

5. Applying adaptive AI/ML gives a realistic chance of breaking the attack chain

6. Pushing the detection and response further down the data stack (all the way to the storage device) is a force multiplier for AI/ML defense

7. AI/ML cyber-security + tightly integrated storage = solid protection

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