Security Incident Discovery and Correlation on .Gov Networks

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Homeland Security

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Agenda

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- Overview
- Data Collection
- Malware Activity Sets:
  - Beaconing
  - Redirection
  - Suspicious Activity
- Findings/Analysis
- Samples/Examples
- Recommendations
- Takeaways

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Who we are…

- ***US-CERT is the operational arm for cyber security under the Department of Homeland Security***
- ***Analysis Branch uses flow data from Einstein sensors deployed across .gov networks***

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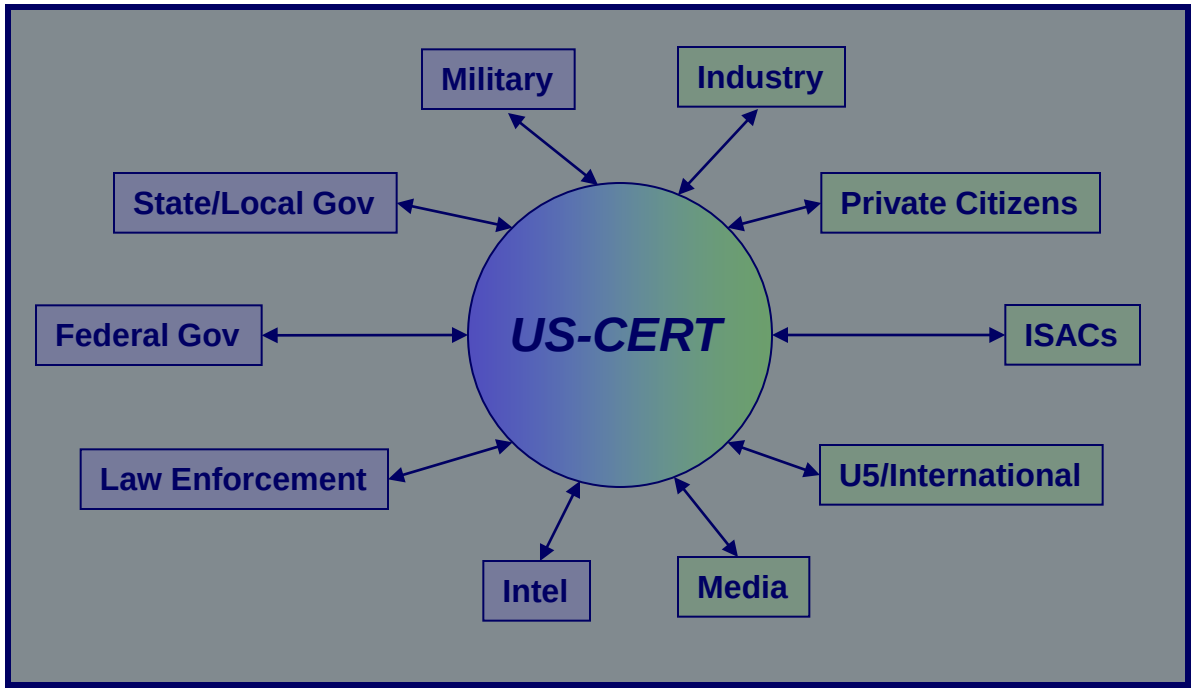
Information Correlation…



Facilitating collective analysis of cyber threats through partnerships.

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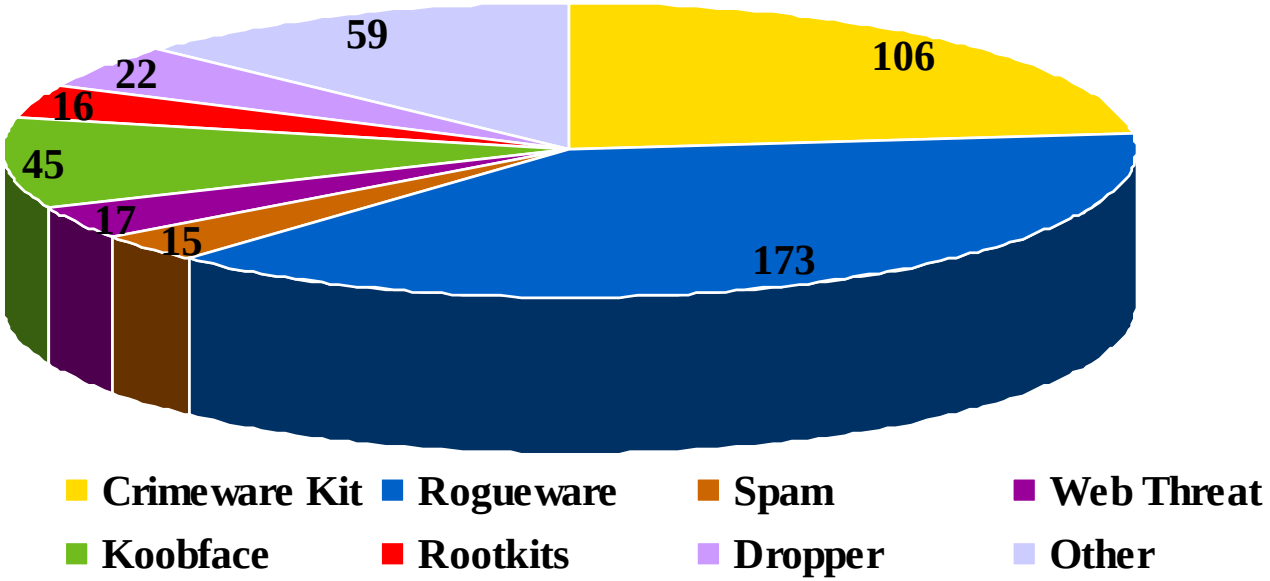
Threat Summary

- Security incidents reported to/by US-CERT since 1 January
  - *~108,000 total incidents reported YTD*
  - *13,000 Malicious Code Incidents YTD*
- Malicious Logic Incidents comprise primary focus area



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Context

- What we have:
  - Repository of federal/state/local govt, private/foreign sector security incidents
    - *~108K so far this year*
- What we needed:
  - Automated method to detect and identify security incidents/events using netflow
- What we devised:
  - Queries to mine database, correlate information and positively identify security incidents

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Prep: Data Collection
Initial Data Pull/RW Binary Creator

- Creates bin file to prep and execute queries:

```
#!/bin/sh

perl -pi -e "s/ \|\/\|/g" hosts.txt
perl -pi -e "s/\| /\|/g" hosts.txt
perl -pi -e "s/ //g" hosts.txt

BINFILE=`date "+%Y-%m-%d-%T.bin"`

day=`date +"%a"`

if [ "$day" = "Mon" ];
then
        STARTDATE=`date -d '-4 days' +'%Y/%m/%d'`
        ENDDATE=`date "+%Y/%m/%d"`
elif [ "$day" = "Sun" ];
then
        STARTDATE=`date -d '-7 days' +'%Y/%m/%d'`
        ENDDATE=`date "+%Y/%m/%d"`
elif [ "$day" = "Sat" ];
then
        STARTDATE=`date -d '-8 days' +'%Y/%m/%d'`
        ENDDATE=`date "+%Y/%m/%d"`
else
        STARTDATE=`date -d '-3 days' +'%Y/%m/%d'`
        ENDDATE=`date "+%Y/%m/%d"`
fi

if [ -f $BINFILE ];
then

echo "$BINFILE already exists !!!"
echo "Please insure rwprocessor.sh is not already running and then move or remove $BINFILE"
else
        if [ -f temphosts.txt ];
        then
                rm -f temphosts.txt
        fi

        if [ -f temphosts.set ];
        then
                rm -f temphosts.set
        fi
```

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Initial data pull: RW Binary Creator

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- Creates bin file to execute queries against (cont.)

```
for i in `cat hosts.txt | cut -d "|" -f1 | sort | uniq`

do

echo $i >> temphosts.txt
done

rwsetbuild temphosts.txt temphosts.set
echo "Einstein query from $STARTDATE to $ENDDATE"
echo "Created $BINFILE"

rwfilter --anyset=temphosts.set --type=all --start-date=$STARTDATE --end-date=$ENDDATE --pass=$BINFILE &


      if [ -f temphosts.txt ];
      then
            rm -f temphosts.txt
      fi

      if [ -f temphosts.set ];
      then
            rm -f temphosts.set
      fi
Fi
```

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Malware Activity Patterns

- ***Main Focus Areas:***
  - ***Beaconing***
  - ***Redirect***
  - ***Suspicious***

Image from procalme.com

Beaconing

- Goal is to detect and identify beaconing activity to/from constituent systems
  - Regular and irregular patterns
  - High and low volume connections
  - Known malicious IPs/domains
  - Investigate to identify data exfiltration / low-and-slow actions
- Triggers when victim IP address sends requests on the same dest port with a consistent packet size and at a specific time interval or pattern (i.e., 60 secs., 60 mins., etc.)
- Beaconing is a symptom

Image from Wellroundedsquare.com

Beaconing

- *Personal favorite*
- 'Quick and easy' to vet true positives
- Good indicator of compromise/infection

Sample Output (beaconing occurring at 1 hour / 10 minute intervals):

sTime	sIP	dIP	sPort	dPort	bytes	sensor	InitFlag
2010/10/04T13:06:38	199.9.9.9	195.161.112.6	1315	80	1623	USGA	S
2010/10/04T14:16:40	199.9.9.9	195.161.112.6	1366	80	1623	USGA	S
2010/10/04T15:26:42	199.9.9.9	195.161.112.6	1418	80	1623	USGA	S
2010/10/04T16:36:44	199.9.9.9	195.161.112.6	1515	80	1623	USGA	S
2010/10/04T17:46:45	199.9.9.9	195.161.112.6	1600	80	1623	USGA	S
2010/10/04T18:56:48	199.9.9.9	195.161.112.6	1721	80	1623	USGA	S

Automated Timestamps

Byte Sizes

Initial Flags

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Beaconing Script

- The beaconing script uses several commands, as sampled below, to filter by flows for indications of hourly/daily/weekly beaconing activity:

```
                    for bytes in `rwfilter --saddress=$victimip --daddress=$badip --type=all
bin/$i.bin --pass=stdout | rwuniq --fi=bytes --flows=5 --no-titles --no-final-delimiter --no-columns
| cut -d "|" -f1`
                do
                    daycount=`rwfilter bin/$i.bin --type=all --saddress=$victimip --
daddress=$badip --bytes=$bytes --pass=stdout | rwcut --fi=9 --no-titles | cut -d "/" -f3 | cut -d "T"
-f1 | sort -u | wc -l`
```

Findings Analysis: Beaconing

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- Using seconds/milliseconds to build timeline
  - Helps dispel irregularities
  - Common traffic obfuscation technique for FakeAV and Rootkits

Sample Output (note the second count):

sTime		sIP	dIP	sPort	dPort	bytes	sensor	initialF	Records
2010/08/17T11:25:	23	199.9.9.9	94.228.209.200	1529	80	549	USGA1	S	1
2010/08/17T14:21:	23	199.9.9.9	94.228.209.200	1989	80	549	USGA1	S	1
2010/08/17T21:26:	24	199.9.9.9	94.228.209.200	2346	80	549	USGA1	S	1
2010/08/17T22:32:	24	199.9.9.9	94.228.209.200	2602	80	549	USGA1	S	1
2010/08/18T02:09:	24	199.9.9.9	94.228.209.200	3103	80	549	USGA1	S	1
2010/08/18T05:43:	24	199.9.9.9	94.228.209.200	3607	80	549	USGA1	S	1
2010/08/18T14:10:	25	199.9.9.9	94.228.209.200	3996	80	549	USGA1	S	1
2010/08/18T16:18:	25	199.9.9.9	94.228.209.200	4295	80	549	USGA1	S	1
2010/08/18T18:51:	24	199.9.9.9	94.228.209.200	4640	80	549	USGA1	S	1
2010/08/19T05:22:	24	199.9.9.9	94.228.209.200	1229	80	549	USGA1	S	1
2010/08/19T09:56:	24	199.9.9.9	94.228.209.200	1341	80	549	USGA1	S	1
2010/08/19T15:42:	24	199.9.9.9	94.228.209.200	1806	80	549	USGA1	S	1
2010/08/20T06:24:	24	199.9.9.9	94.228.209.200	2186	80	549	USGA1	S	1
2010/08/20T09:37:	25	199.9.9.9	94.228.209.200	2321	80	549	USGA1	S	1
2010/08/20T12:04:	25	199.9.9.9	94.228.209.200	2871	80	549	USGA1	S	1
2010/08/21T15:22:	25	199.9.9.9	94.228.209.200	3439	80	549	USGA1	S	1
2010/08/21T17:34:	25	199.9.9.9	94.228.209.200	3532	80	549	USGA1	S	1

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Findings Analysis: Beaconing

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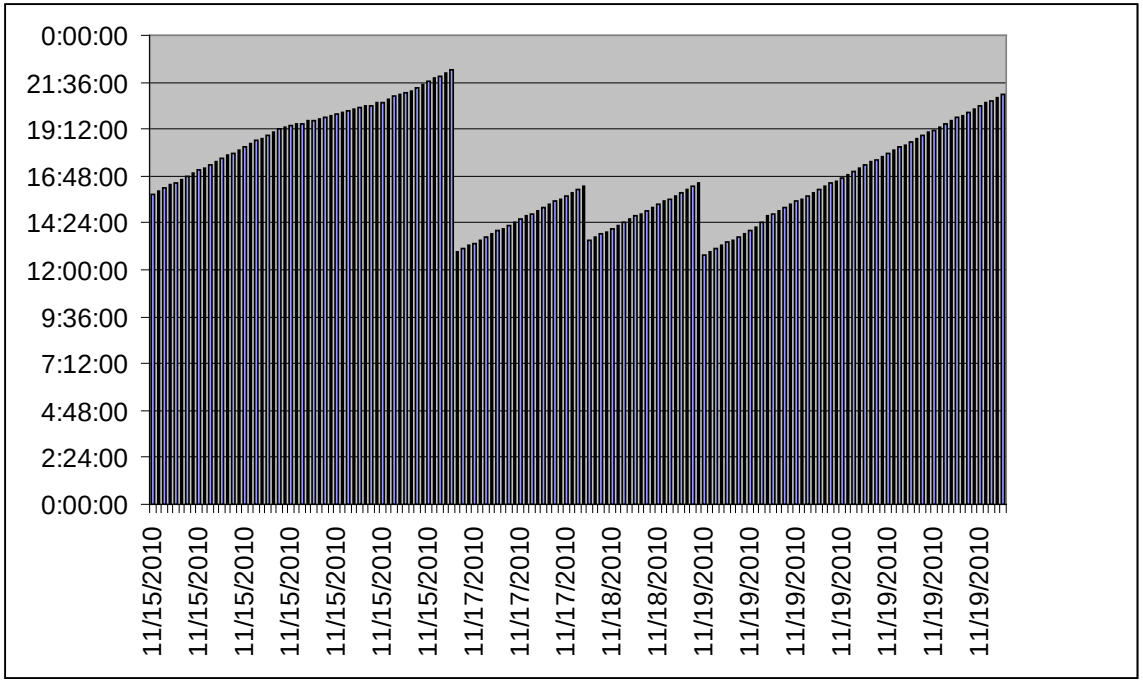
- Graphical Representation
  - Easy-to-read synopsis of activity
  - Helpful handout/reference for constituency



- Victim IP observed beaconing every 8 minutes and 55 seconds

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Beaconing Script: Excel Charting

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Beaconing excel macro is used to give pattern charts:

```
Sub Patterns()
'
' Patterns Macro
' Macro recorded 12/3/2010 by ttragess
'
' Keyboard Shortcut: Ctrl+Shift+T
'
    Columns("B:B").Select
    Selection.Insert Shift:=xlToRight
    Columns("B:B").Select
    Selection.Insert Shift:=xlToRight

    Columns("A:A").Select
    'Range("A549").Activate
    Selection.TextToColumns Destination:=Range("A1"), DataType:=xlDelimited, _
        TextQualifier:=xlDoubleQuote, ConsecutiveDelimiter:=False, Tab:=False, _
        Semicolon:=False, Comma:=False, Space:=False, Other:=True, OtherChar _
        :="|", FieldInfo:=Array(1, 1), TrailingMinusNumbers:=True
    Columns("A:A").EntireColumn.AutoFit

    Columns("A:A").Select
    Selection.TextToColumns Destination:=Range("A1"), DataType:=xlFixedWidth, _
        OtherChar:="|", FieldInfo:=Array(Array(0, 1), Array(10, 1), Array(11, 1)), _
        TrailingMinusNumbers:=True

totalrows = ActiveSheet.UsedRange.Rows.Count totalrows = Int(totalrows) beginRange = 1 loopcount = 1

For i = 1 To totalrows
Range("A" & i).End(xlDown).Select
'
' patterns Macro
' Macro recorded 11/26/2010 by ttragess
'
'
     ' Test contents of active cell; if active cell is empty, exit loop.
      Do Until IsEmpty(ActiveCell)
```

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Beaconing: Excel Charting (cont.)

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```
ActiveCell.Offset(1, 0).Select
        endRange = ActiveCell.Address(False, False)
        ' myCell = ActiveCell.AddressLocal

          endRange = Right(endRange, Len(endRange) - 1)

          If loopcount = 1 Then
             beginRange = 1
                    Else
             beginRange = i - 1
          End If
          loopcount = loopcount + 1
          i = endRange + 1
          endRange = endRange - 1
          goodguy = Range("D" & beginRange).Value
          badguy = Range("E" & beginRange).Value
          bytecount = Range("F" & beginRange).Value
       Loop

    Range("E" & beginRange).Select

    Charts.Add
    ActiveChart.ChartType = xlColumnClustered
    ActiveChart.SetSourceData Source:=Sheets("Sheet2").Range("G" & beginRange)
    ActiveChart.SeriesCollection.NewSeries

    ActiveChart.SeriesCollection(1).XValues = "=Sheet2!R" & beginRange & "C1:R" & endRange & "C1"
    ActiveChart.SeriesCollection(1).Values = "=Sheet2!R" & beginRange & "C3:R" & endRange & "C3"

    ActiveChart.Location Where:=xlLocationAsObject, Name:="Sheet2"
    With ActiveChart
       .HasAxis(xlCategory, xlPrimary) = True
       .HasAxis(xlValue, xlPrimary) = True
       .HasTitle = True
       .ChartTitle.Characters.Text = goodguy & " beaconing to " & badguy & "with a byte count of " & bytecount
    End With
    ActiveChart.Axes(xlCategory, xlPrimary).CategoryType = xlCategoryScale
    ActiveChart.HasLegend = False

Next
End Sub
```

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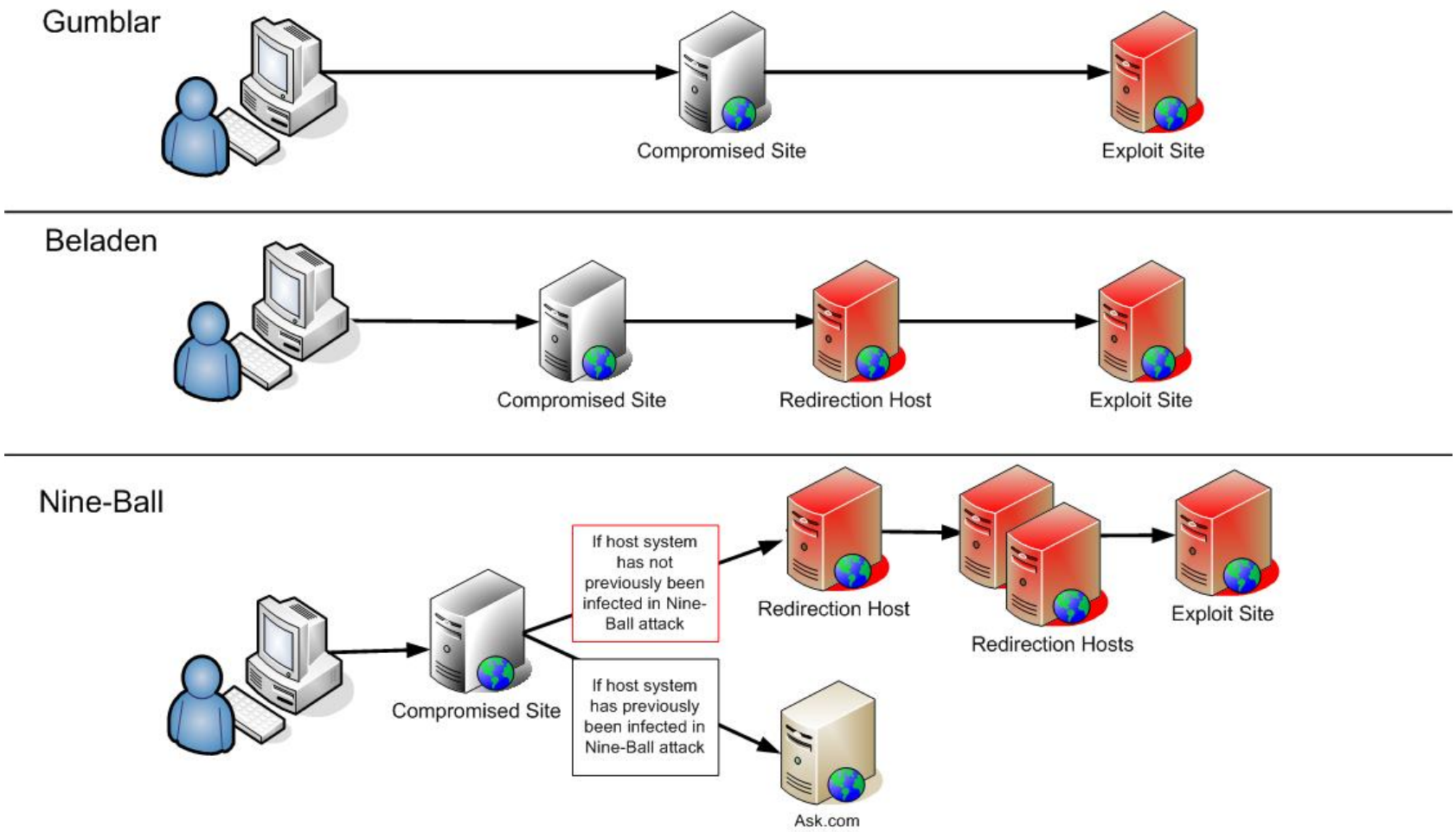
Redirect Activity

- *Victim IP Address communicates with first mal IP/domain and is immediately redirected to a secondary mal IP/domain*
- Identifies malicious and anomalous activity
  - Tracks connections/patterns to IPs/domains of interest
  - Correlates activity with incident database information
  - Can help to:
    - Identify post infection beaconing such as pattern is seen every half hour before victim tries again.
    - Identify new types of malicious activity or malware based off of pattern recognition from the victim IP
      - First and last/size of bytes downloaded from each
    - Provide more than two attacker sessions and identify malicious traffic such as Gumblar

Redirect Campaigns



Redirect Criteria

- Victim initiates connection to first malicious IP address and then within milliseconds initiates connection to second malicious IP address. The victim then does the same activity 30 minutes later in a dual initiate connection to the malware IP address set.
  - *VICTIM ----------->> MAL1*
  - *MAL1 ----------->> VICTIM*
  - *VICTIM ----------->> MAL2*
  - *MAL2 ----------->> VICTIM*

  - *VICTIM WAITS 30 MINUTES TO INITIATE NEXT SESSION*
  - *VICTIM ----------->> MAL1*
  - *MAL1 ----------->> VICTIM*
  - *VICTIM ----------->> MAL2*
  - *MAL2 ----------->> VICTIM*
- Alternate criteria:
  - Victim IP contacts several IP addresses/domains in sequence (and repeats activity). Examples include Gumblar or other fast flux activity.

Redirect Code

- The snippet below creates the coupling between the victim and attacker IPs. Many more lines are used to accurately focus on back and forth communications, however this is the basis for pairing the attacker/victim:

```
 # Check to make sure there was a ip.set for the pair of malicious IP addresses if so pull victim IP addresses and add then to one set.

if [ -f $i.outweb.set ] || [ -f ${ip[$p]}.outweb.set ]; then
        rwsetintersect --add-set=$i.outweb.set --add-set=${ip[$p]}.outweb.set --set=bothout.set if [ -f bothout.set ]; then

# Create the the flow data for the pair of malicious IP addresses.
# from from the small binary files and place the results in a base.bin # Using the ip.set query of base.bin and place results in intersected.bin

        rwappend --create base.bin bin/$i.bin bin/${ip[$p]}.bin
        rwfilter --anyset=bothout.set base.bin --pass=Intersected.bin
        count=`rwfilter Intersected.bin --type=outweb --pass=stdout | rwsort --fi=22 | rwcut --fi=1-12,26 | grep -A 1 $i | grep -B 1 ${ip[$p]} | wc -l`
```

Findings Analysis: Redirect

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- *Sample Output*
  - *Quick second/millisecond session redirects*
  - *Detected recent gbot activity w/ 2k+ infections*

sIP	dIP	sPort	dPort	packets	bytes	flags	sTime
attacker IP1	victim	80	1514	5	629	FS PA	2010/10/27T14:58:03.219
attacker IP1	victim	80	1519	5	629	FS PA	2010/10/27T14:58:05.072
attacker IP2	victim	80	1515	4	589	FS PA	2010/10/27T14:58:07.243
attacker IP2	victim	80	1515	1	40	A	2010/10/27T14:58:07.418
victim	attacker IP	1514	80	5	470	FS PA	2010/10/27T14:58:08.174
victim	attacker IP	1519	80	6	517	FS PA	2010/10/27T14:58:08.026
victim	attacker IP	1515	80	8	602	FSRPA	2010/10/27T14:58:11.159
victim	attacker IP	1515	80	1	40	R A	2010/10/27T14:58:14.418

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Suspicious

- Seeking to detect and identify ‘suspicious activity’ and outliers
  - Communicating with known mal IPs
  - Pattern matching/identification
  - Conjecture
- The query covers activity that may not be caught elsewhere
  - Low and Slow beaconing that may not be caught
  - High port to high port activity
  - Rootkit type activity with unique instructional patterns

Photo courtesy of CurrentTV

Data Exfil Criteria

- *Beaconing can potentially become data exfiltration when:*
  - *The victim IP address downloads a percentage of total packets exchanged (at least with web traffic).*

Image from huffingtonpost.com

Noted false positives when the victim is a web server and normal web traffic exceeds downloaded data of 70-90% and uploads of 10-30%

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Suspicious Script/Code

- The suspicious script gets all possible victim IP addresses and then prints out traffic based on time (what the communication looked like back and forth) to help determine suspicious patterns. Simply put it is a straight rwcut filtered on time.

```
for j in `rwfilter bin/$IP.bin --type=all --pass=stdout | rwuniq --fi=1 --no-titles --no-columns | grep -v $IP | cut -d "|" --fi=1 | sort -u`
do
sensor=`rwfilter bin/$IP.bin --any-address=$j --pass=stdout | rwcut --fi=12 --no-titles --no-columns --no-final-delimiter | head -1`
sensor=`grep -w $sensor ../sensor.txt | head -1 | cut -d "|" -f2`
```

Findings Analysis: Suspicious

- Heuristic detection techniques
- Rarely detects FakeAV

Example Output: Victim IP uploaded 21360 bytes and downloaded 8142 bytes to malicious IP Address:

sIP	dIP	sPort	dPort	pro	packets	bytes	flags	sTime	dur	eTime	sensor	initialF
victim	attacker	37688	80	6	6	288	S	2010/12/06T15:58:26.288	92.985	2010/12/06T15:59:59.273		
victim	attacker	41745	80	6	6	288	S	2010/12/06T15:58:35.282	92.985	2010/12/06T16:00:08.267		
victim	attacker	38283	80	6	6	288	S	2010/12/06T15:58:47.025	92.985	2010/12/06T16:00:20.010		
victim	attacker	23620	80	6	6	288	S	2010/12/06T15:59:02.375	92.982	2010/12/06T16:00:35.357		
victim	attacker	22906	80	6	6	288	S	2010/12/06T15:59:26.089	92.984	2010/12/06T16:00:59.073		
victim	attacker	48356	80	6	6	288	S	2010/12/06T16:00:05.258	92.984	2010/12/06T16:01:38.242		
victim	attacker	24169	80	6	6	288	S	2010/12/06T16:24:20.051	92.984	2010/12/06T16:25:53.035		

Requirements

- **Commodity hardware and available storage capacity**
- **In-house development capability to create/tune/maintain scripts**
  - **Update scripts based on new patterns and emerging threats**
- **Process to coordinate actions/activities**
  - **Standardization/certification of analytical process and background**
- **Manpower to verify and/or vet findings for accuracy and action**

Recommendations

- **Provide user-friendly portal/system to process findings**
  - **Hierarchical view for different users**
    - **Incident summary or overview for management**
      - **Paraphrase activity and provide easy-to-understand format**
      - **HTML and Executive Summary reports**
      - **The report script is approximately 2500 lines of shell script and analyzez different parts of the above logs to give initial findings.**
    - **Detailed view explaining specific query findings (e.g., beaconing, suspicious, etc.)**
    - **Detailed technical specifics for findings and incidents**
      - **Incident findings**
      - **Department impacted**
      - **Associated activity**
- **Provide automated methods and templates for processing**
  - **Vehicle and report template to disseminate validated findings**
    - **i.e.- “Notify Accounting of virus identified on IP 1.1.1.1”**

Recommendations (cont.)

- **Standardize incident criteria, taxonomy, templates**
- **Normalize incident handling/analysis processes**
- **Standardize product and include incident information**
  - **Network Flow data**
    - **Usual Stuff: Src/Dest IPs/Ports/Proto/Bytes/Time/etc.**
  - **IP correlation / analyst notes / database entries**
  - **Include references (proprietary, open source, etc.)**
- **Trust but Verify**
  - **Ensure automated findings are checked for accuracy and properly vetted prior to dissemination, formal reporting and/or follow-up action**

Considerations

- **Integrate into operations**
  - **Ensure capability is properly integrated into operations commensurate with organizations priority and operational necessity**
- **Maintenance and Functionality**
  - **Be able to allocate support levels to add/modify as necessary**
- **Eyes-on analysis/vetting**
  - **What person/department and what level of granularity**

Benefits

- **Discover and detect security events and malicious activity**
  - **Predicated on flow data**
  - **Expand incident discovery/detection capabilities**
  - **Timely and effective reporting of security incidents**
  - **Enables mitigation and remediation of findings**
  - **Scalable and especially useful for large/compartmented enterprises**

- **Automated query process**
  - **2-click vetting and approval process optimal (depending)**

Takeaways

- **Harness flow data to identify security events and incidents of interest across the enterprise**
- **Develop automated queries to do work for you and vet results for accuracy**
  - **Tune appropriately**
- **Layered view to provide a user friendly view of information and data pertinent to different levels of org.**
  - **Customize different views across organization:**
    - **Leadership / Security Operations**
    - **Technicians / Responders**
    - **Constituents (if desired)**

Contact

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- Information available at http://www.us-cert.gov

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Questions?

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