Anomaly-based Botnet Server Detection

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Abstract

We present simple statistical techniques for anomaly-based detection of on campus botnet servers. The techniques are derived from two experimental flow tuples that collect statistics based on four types of Layer 7 IRC messages including PRIVMSG, JOIN, PING, and PONG. These messages are used to extract a set of IRC channel names, the IP hosts in the channels, and message count statistics related to channel and host IRC usage. In the last year we have captured three instances of bot servers. In each case when compared to normal campus IRC servers, the bot server had certain highly anomalous statistics when compared to normal campus IRC servers.

1 Introduction

Botnets [1][4] are a modern scourge of the Internet and a cause of spam, denial of service attacks, and infected wormy hosts. Ourmon [2] is an near real-time network monitoring and anomaly detection tool. Originally our tool was intended as an open-source network monitoring system. Over time we discovered that it was also an anomaly-based detection system. We noticed that normal graphics or statistics were sometimes replaced by highly anomalous activity often associated with scanners, botnets, or DOS attacks. In the last year we have modified ourmon to detect botnets as well.

In this paper we look at two experimental IRC flow tuples that were created to primarily track IRC (and botnet client) networks. We then look at one example taken from Thanksgiving 2005 of how simple statistics associated with those IRC tuples proved to also catch a botnet server on our campus. In the last year we have captured multiple instances of botnet clients and three examples of botnet servers. For botnet client meshes, we have enough samples to be confident that our system works. (Please see our paper [3] for more information on botnet client mesh capture). For the botnet servers it is fair to say that this is not a large statistical sample, but on the other hand the statistics for capturing the botnet servers were very simple and may prove useful elsewhere. We therefore point out a number of anomaly-based simple statistical measures that have proven to be good botnet server indicators so far.

2 IRC tuple architecture

In our network-based collection system we collect two IRC tuples in thirty second scanshots and then correlate the lists every hour over the day. This is because even in a large campus network such as ours with approximately 60000 packets per second peak traffic to the Internet, IRC data emerges in general very slowly. We assume we can capture up to 256 bytes worth of every packet including Layer-7 information such as IRC messages. IRC messages are parsed by
a hand-coded C parser to form two tuples called the
node list and channel list. The first list captures per
host IRC information and the second organizes the
hosts by IRC channel names (chatrooms). We are
only interested in four kinds of IRC messages includ-
ing PING, and PONG which are used to establish
client server connectivity, and JOIN and PRIVMSG,
both of which contain channel names. We do not
store PRIVMSG IRC data.

Roughly the node list has the following structure
and includes an IP address, as well as a number of
statistical counters, and a list of channel names asso-
ciated with the host.

\{IPSRC, TOTALMSG, JOINS, PINGS, PONGS, PRIVMSG,
CHANNELS, SERVERHITS\}

TOTALMSG, JOINS, PINGS, PONGS, PRIVMSGs
are counters. CHANNELS is the channel name list,
and SERVERHITS tells us if the host is in anyway
an IRC server.

The channel list has the following structure and
includes the channel name, various statistics, and a
list of IP hosts associated with the channel during
the sample period.

\{CHANNAME, HITS, JOINS, PRIVMSGs,
NOIPS, IP_LIST\}

HITS, JOINS, PRIVMSGs are counters. NOIPS is
the count of hosts in the channel, and the IP_LIST
is the list of host IP addresses associated with the
channel.

One additional IRC statistic gathered consists of
total network counts of the four kinds of IRC mes-
ages seen by the collection system during a sample
period.

3 Botserver Mesh Detection

Next we turn to botserver mesh detection using these
statistics. We can distinguish at least four kinds of
anomalies and there are probably more simply due
to the large amounts of IRC traffic when compared
to normal campus IRC traffic. Over Thanksgiving
2005, our campus experienced the largest botserver
we have ever seen. We believe that the botserver in
question at its peak had around 60000 off campus
hosts reporting to it. We should point out that as is
generally the case with anomaly detection, the ana-
yst should have some notion of normal in terms of
local domain statistics. In this case one has to have
observed local IRC activity to know what is unusual.
Even so, a bot server is easy to spot.

Outstanding anomalies included:

1. IP hosts per channel is a strong indicator of a
   botserver.

2. the number of messages for any given IRC server
   is a strong indicator.

3. lastly it can sometimes be the case that the over-
   all number of scanning hosts counted in our en-
   tire network (and within the bot server’s IRC
   channel) becomes very high.

4. PING and PONG message counts for our net-
   work domain as a whole are a strong indicator.

In terms of data presented by our system we note
anomalies one, two, and three in our list above by
looking at our ”channels sorted by max messages”
report subsection as seen in Table 1.

From experience we know that channel ”bark” is
benign (although somewhat automated in terms of
both JOINS and PRIVMSGs), and in any case has
a historically normal count of messages and hosts.
On the other hand, channels f, x, and f-exp are new.
The message count for f alone is historically unprece-
dented and an order of magnitude higher when com-
pared to ”bark”. The above statistics are for the
entire day, and busy chat channels on our campus
driven by human text messages usually have no more
than 2000 messages in one day. Therefore channel x
and its 40965 PRIVMSGs are significant. Another
significant anomaly appears with the ipcount (hosts
per channel) for the three channels in question. On
our campus we have never seen a normal chat IRC
channel with more than 100 hosts in it. 20 is normal.
Of course, further analysis shows that these numbers
are even more significant because the three channels
in question are shown elsewhere to share the same
off campus botnet server. For reasons of space we cannot discuss the scanner count measure at length. Roughly it is a small statistical measure that shows how many hosts are ”scanning”. The scanners column in the table shows the count of alleged scanning IPs in the channel. In addition Figure 2 shows an anomalous amount of external hosts ”scanning” our network. We discovered that these hosts were actually new bot clients attempting to connect over and over again to the bot server. Apparently the server had run out of TCP resources, thus new clients were not accepted.

Finally regarding anomaly number four – in a previous section we mentioned that we keep global count statistics for all IRC messages on our network and graph them using the RRDTOOL graph mechanism. Please refer to Figure 1. This graph shows a weekly view of counts of the four basic IRC message types. Normal daily counts for our message types are typically in the hundreds. Here we see that on Friday and Saturday PING and PONG messages suddenly are in the thousands. In all three bot servers we have seen on campus, PING and PONG messages were always elevated. PRIVMSG may or may not be elevated. All bot servers so far have significantly perturbed this simple graph.

4 Conclusion

Known techniques for botnet detection include honeynets and IDS systems such as snort[6] with signature detection. Honeynets [5] or darknets can certainly prove beneficial in terms of providing information about botnet technology.

We have recently published related work [3] on botnet-client detection using anomalies and present our botnet-server anomaly detection work here. We believe our anomaly-based work is an advance in the art, but ideally in the future we would like to be able to detect botnets via only layer 3 or layer 4 statistics as it is possible that layer 7 data may at some point be encrypted.

References


Figure 1: Thanksgiving Botserver IRC Message Counts

Figure 2: TCP Scanners During Bot Attack