Analysis for problem 3: Entropy for Network Anomaly Detection

ATTACK DETAILS:
The first attack occurs at 08:12:16 am. It seems to be a DDoS attack where the attacker(s) are using several machines to bombard the same machine in the network with many communication requests so that it can't respond to other requests. In this case the destination IP is 172.016.114.050 . As a result communications seem to be down for the next 35s.

The second attack occurs around 11:55:15 am, targeting a mail server at 172.016.112.050. The 11:55 am attack could be either of two things. The source IP is spoofed to 1.2.3.4, a non-routable IP address. Either the attacker wants to probe that target server or its surrounding network as part of some sort of reconnaissance, or the attacker wants to DoS the server.

For the reconnaissance to work, the attacker needs to be able to sniff the response as it's being routed out of the target network. This is most likely not possible, since the attacker would realistically need to be on the same subnet as the spoofed IP address, which is unlikely given that the spoofed source is 1.2.3.4.

This then looks like an attempted DoS attack as well -- likely an attempt to create many half-open TCP connections and prevent that server from accepting anymore TCP connections from legitimate hosts. The attack traffic stopped in under a millisecond, so it would seem that a firewall on the network detected the behavior and started dropping all the packets from that source.

ENTROPY ANALYSIS:

We initially tried to analyze the entropy of the network at a point by maintaining a count of all events throughout the day. This however resulted in the counts being saturated so that the 2nd attack remained undetected in the entropy counts for all columns and pairs of columns.

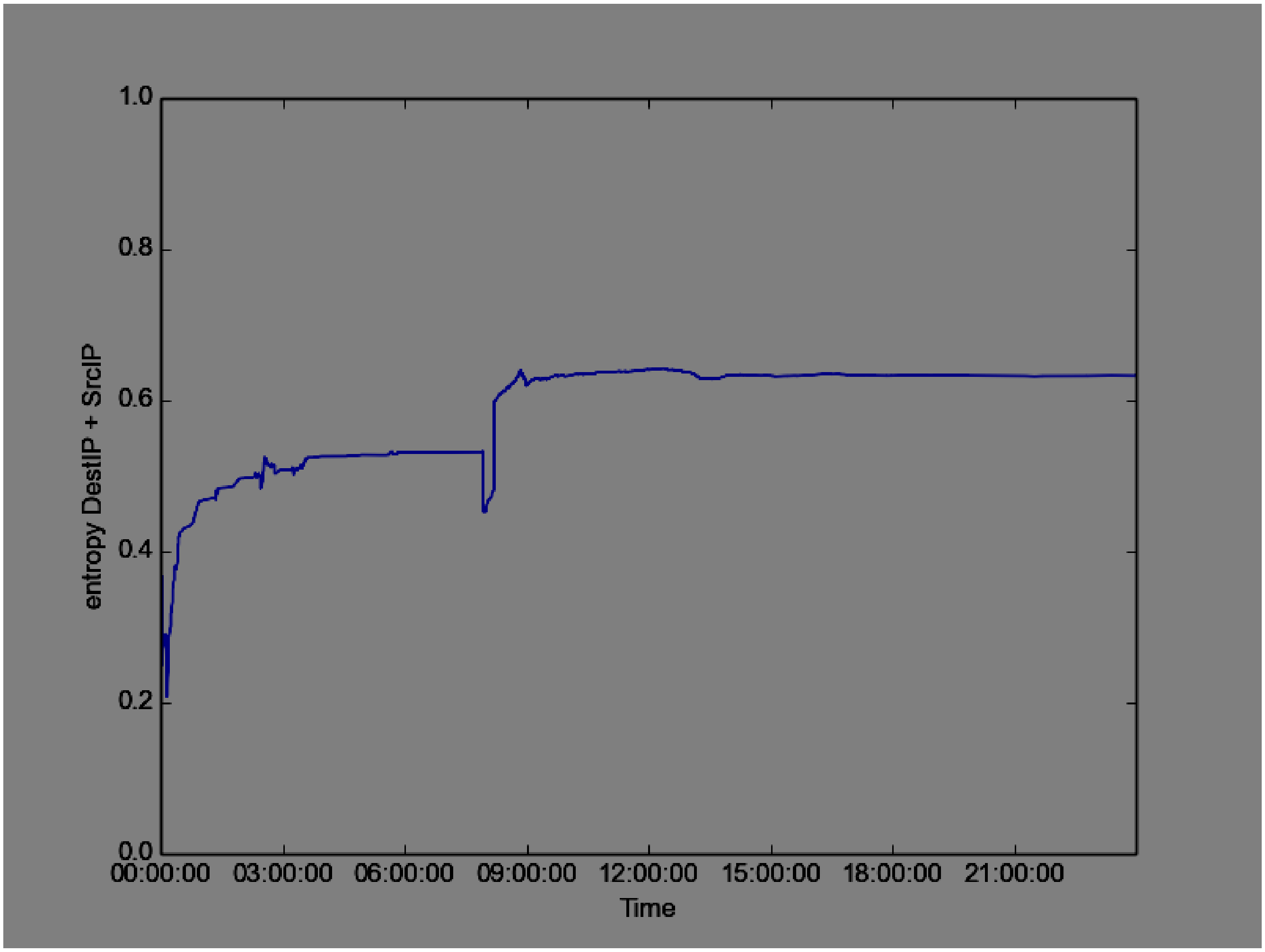
As a result we decided to use a sliding window entropy evaluation where we evaluated the entropy of the system over a window of the past 2000 requests after every 200 new requests. This resulted in more noisy entropy plots, but it was easy to spot both the attacks for certain pairs of columns.

We have included plots for some of the column pairs where the attacks can be inferred. The rest of the plots are included in the entropy_plot folder. Files starting with w_ are the windowed entropies while the other files are streaming entropies.

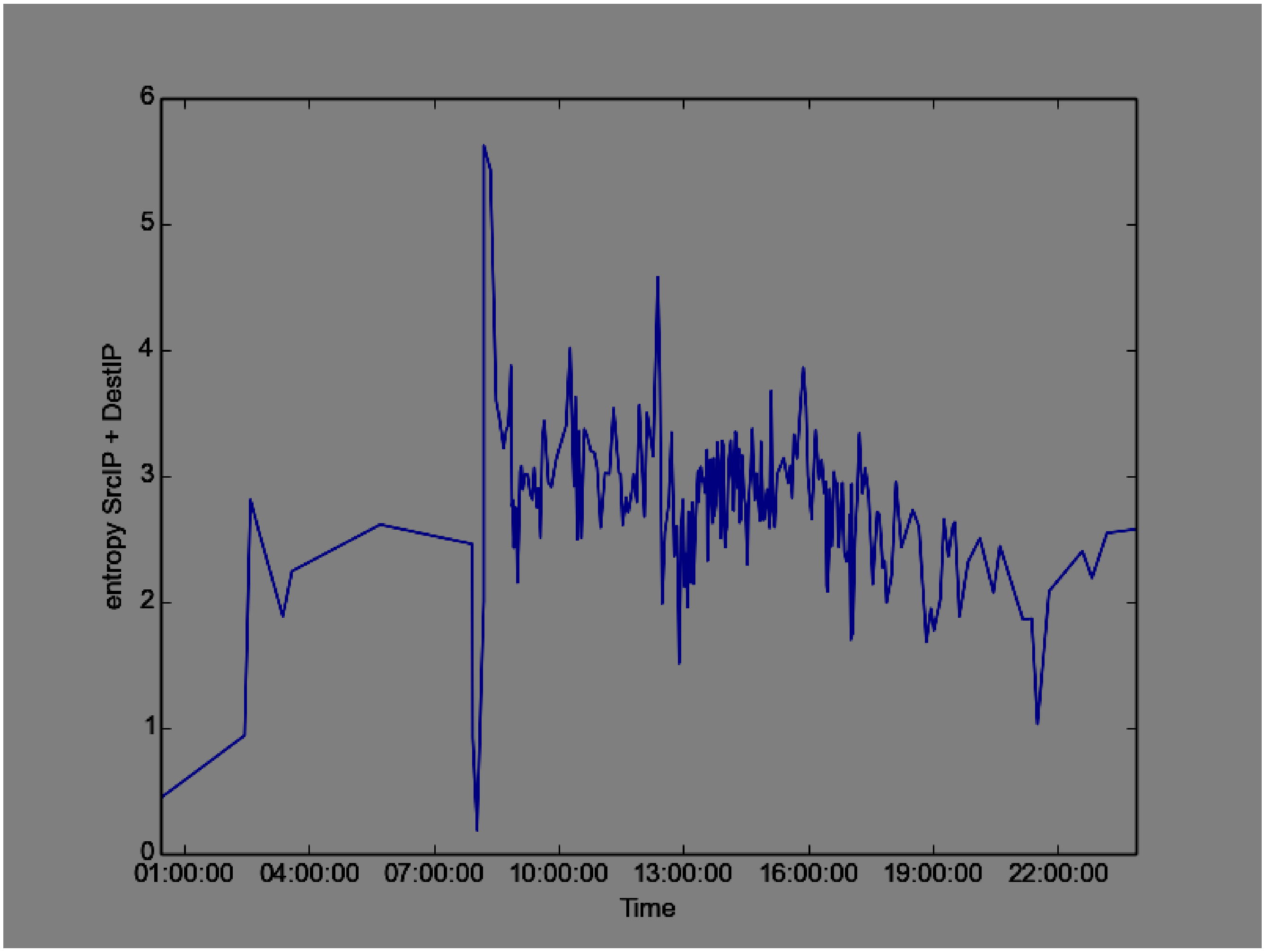
**In the windowed entropy plots, events appear sometime after they have occurred since they are accounted for after the window they appear in.

DST IP and SRC IP:

Streaming entropy



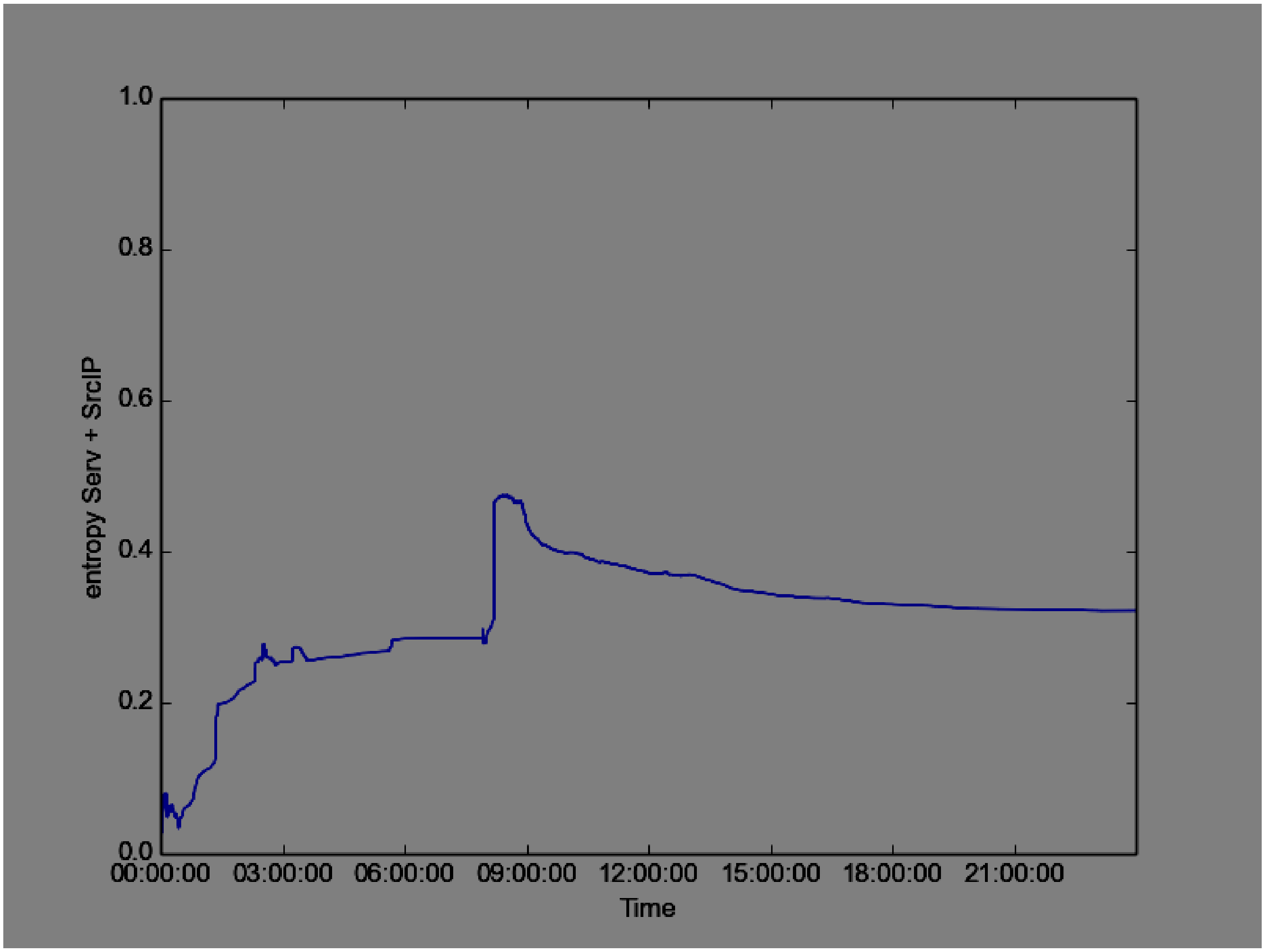
Windowed entropy



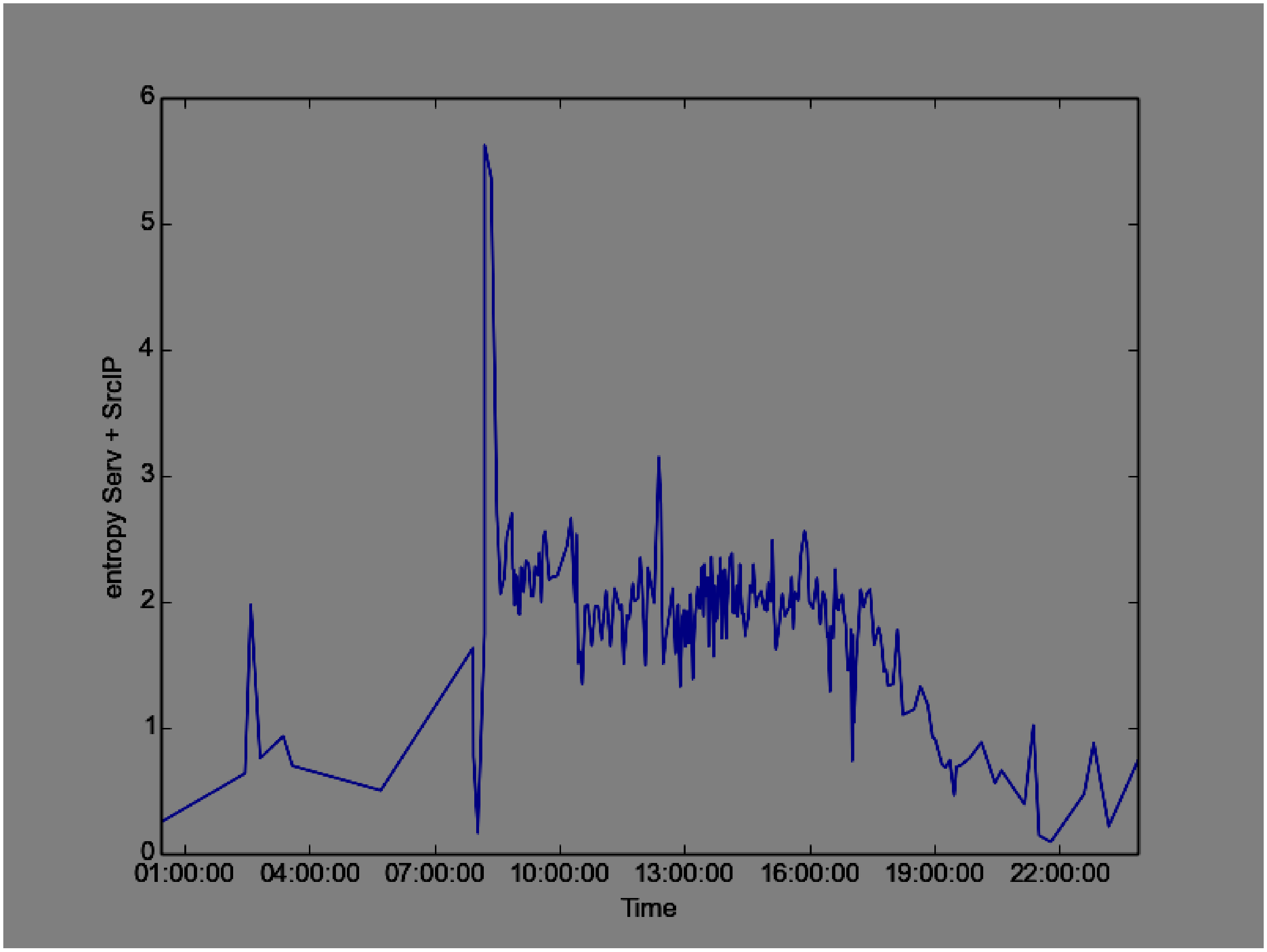
As we can see, in the streaming entropy plot, the 1st attack manifests in the form of a drop and then a steep increase in entropy. However, the second attack fails to manifest due to count saturation and the attack being smaller in duration. In the second plot, the 2 attacks clearly appear as the 2 largest maxima. However, since the entropy is calculated over a smaller period of time, it results in a noisy plot where a few other network anomalies are also seen, even though they might not be actual attacks.

SERV and SRC IP:

Streaming entropy



Windowed entropy



Similar patterns are observed in the plot of serv + src IP entropy vs time. For streaming entropy the 1st attack is clearly visible, but the second attack remains unnoticed. For windowed entropy we can see both the attacks as the 2 highest maxima but the plot is noisy and using automated methods for anomaly detection might result in false positives.

Most of the single column entropies (DestIP, Duration, Serv, Src Port, SrcIP) can be used to detect attack1 but don't detect attack 2. However, a few pairs of windowed entropies (Duration - SrcIP, Serv - SrcIP, SrcIP - DestIP) can be used to detect the second attack, although they are slightly noisy and might result in false detections. This could probably be removed by increasing the sliding window size to smoothen the estimates, but that might also result in the attacks being less visible from the entropies (the false positive - false negative trade-off).

SUMMARY:

From the results it seems like entropy could be useful in identifying network traffic anomalies. Using pairwise entropy seems like a better approach since it is more successful in identifying the attacks since the attacks leave signals over combinations of variables. However, pairwise entropy plots are pretty jagged even for normal network traffic and might result in misdetections.