detection_of_IoT_botnet_attacks_N_BaIoT Data Set exploration

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Data set description

According to UCI MAchine Learning Repository [1], this data set is the collection of real traffic data, gathered from 9 commercial IoT (*Internet of Things*) devices authentically infected by Mirai and BASHLITE (Gafgyt).

The data set has 115 attributes (parameters), below is the description of their headers:

1. It has 5 time-frames: L5 (1 min), L3 (10 sec), L1 (1.5 sec), L0.1 (500 ms) and L0.01 (100 ms).
2. The statistics extracted from each traffic stream for each time-frame:
   - *weight*: the weight of the stream (can be viewed as the number of items observed in recent history)
   - *mean*
   - *std (variance)*
   - *radius*: the root squared sum of the two streams' variances
   - *magnitude*: the root squared sum of the two streams' means
   - *covariance*: an approximated covariance between two streams
   - *pcc*: an approximated correlation coefficient between two streams
3. It has following stream aggregations:

[1] https://archive.ics.uci.edu/ml/datasets/detection_of_IoT_botnet_attacks_N_BaIoT

- *MI*: (“Source MAC-IP” in N-BaIoT paper) Stats summarizing the recent traffic from this packet’s host (IP + MAC)
- *H*: (“Source IP” in N-BaIoT paper) Stats summarizing the recent traffic from this packet’s host (IP)
- *HH*: (“Channel” in N-BaIoT paper) Stats summarizing the recent traffic going from this packet’s host (IP) to the packet’s destination host.
- *HH_jit*: (“Channel jitter” in N-BaIoT paper) Stats summarizing the jitter of the traffic going from this packet’s host (IP) to the packet’s destination host.
- *HpHp*: (“Socket” in N-BaIoT paper) Stats summarizing the recent traffic going from this packet’s host+port (IP) to the packet’s destination host+port. Example 192.168.4.2:1242 -> 192.168.4.12:80

Thus, the column *‘MI_dir_L5_weight’* in the data set shows the weight of the recent traffic from the packet’s host for L5 time-frame.

The data set consists of *.csv files, each representing a benign traffic or an attack. When I gathered *.csv files together in one data set, I added *‘botnet’* column, where I keep information about the attacks from the different botnets. The dataset contains of *combo*, *junk*, *scan*, *tcp* and *udp* Gafgyt attacks, and *ack*, *scan*, *syn*, *udp* and *udpplain* Mirai attacks. I used *‘ga’* prefix for Gafgyt attacks and *‘ma’* for Mirai attacks in the *‘botnet’* column.

List of attacks can be found in “N-BaIoT: Network-based Detectionof IoT Botnet Attacks Using Deep Autoencoders”[2] article.

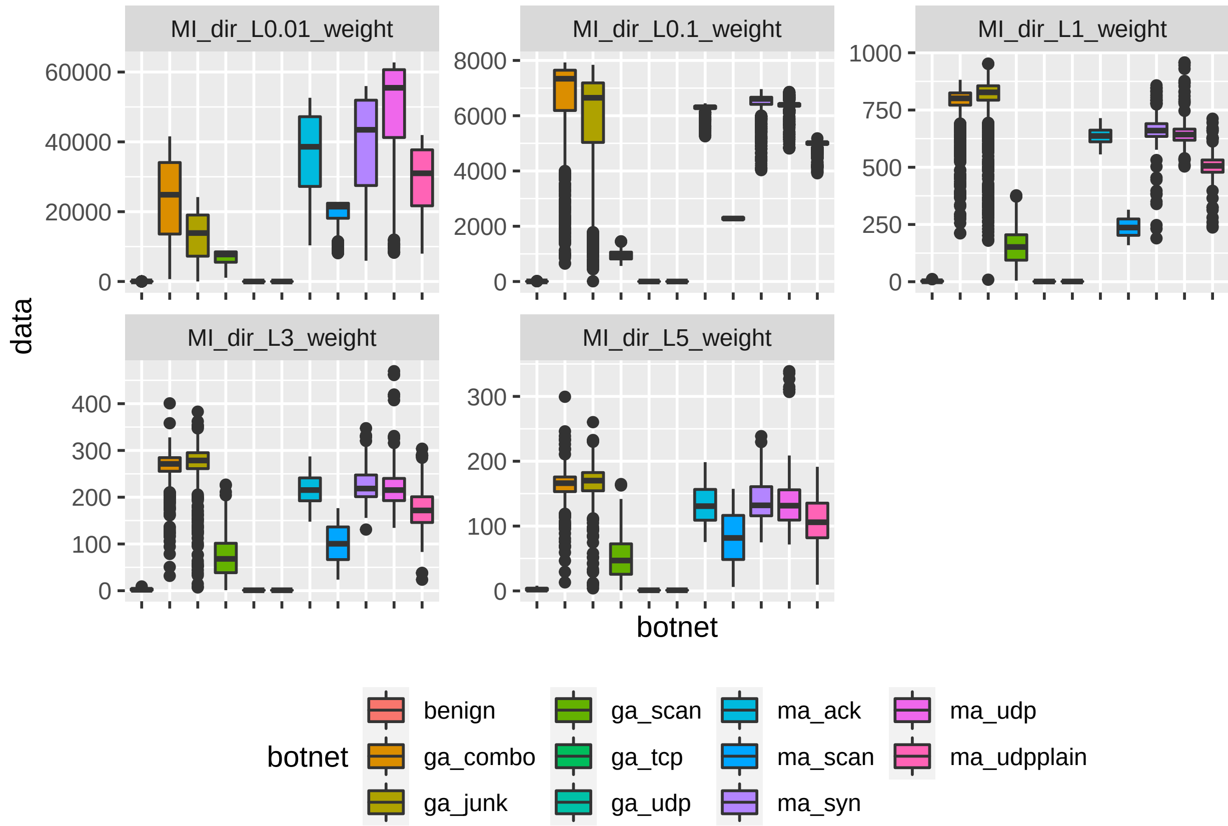
Data set exploration

Below I explore the data only from *Danmini doorbell* device. Because the whole dataset is huge, I’ll use a sample data set that contains about 1000 rows for each botnet just for an illustrative purpose. Otherwise, all plots will be too dense.

MI stream

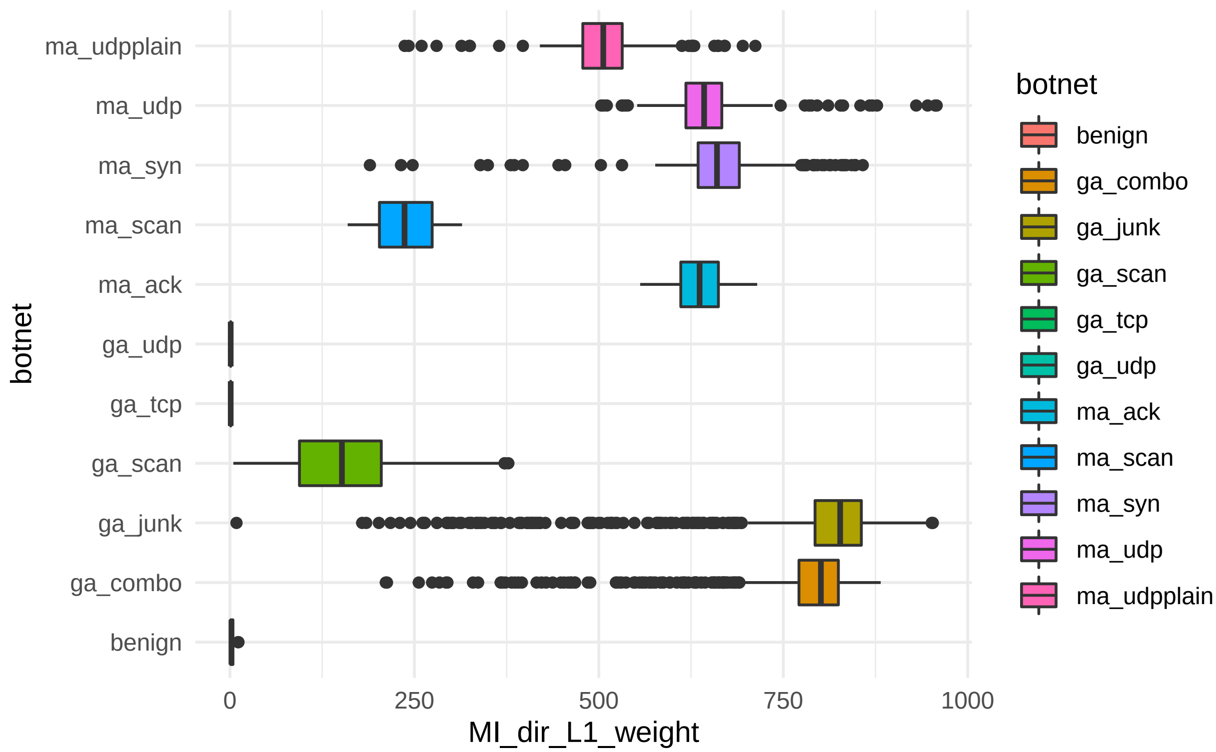
The few first columns contain the data for *MI* stream, and I start my research from *weight* data for L5 - L0.01 time-frames (MI_dir_L5_weight - MI_dir_L0.01_weight columns):

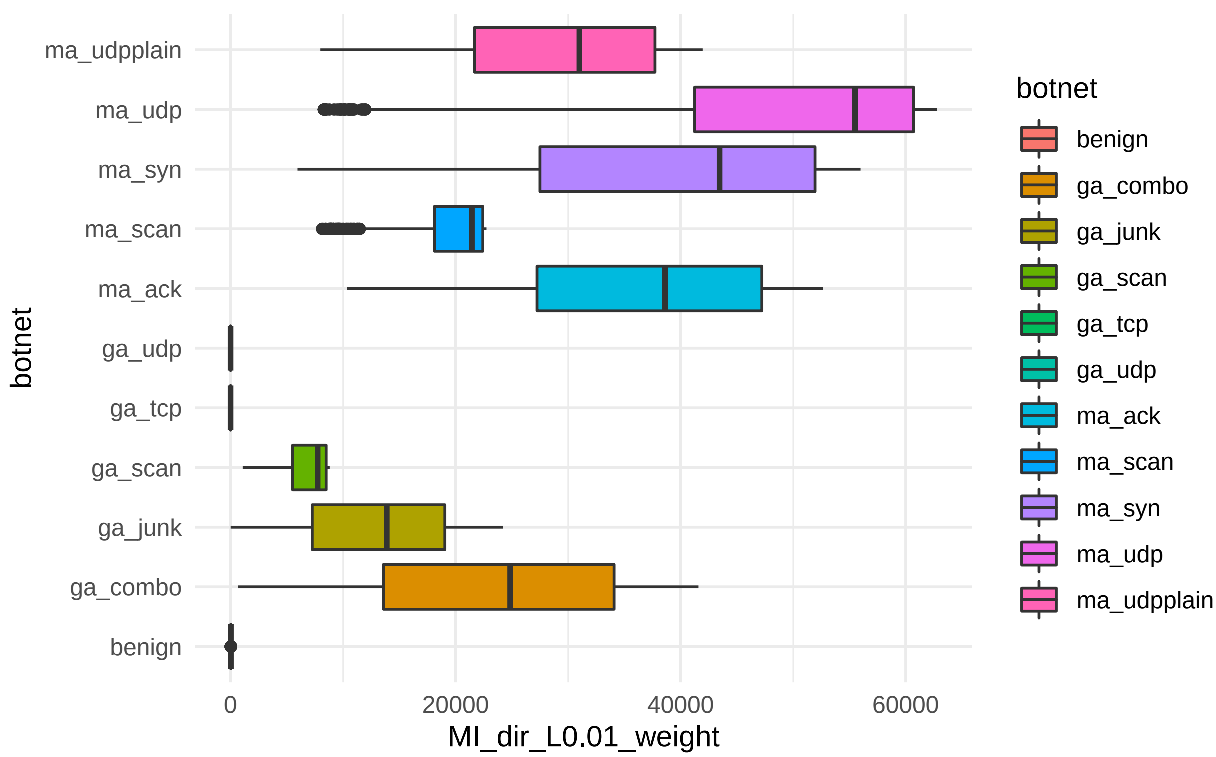
[2] https://arxiv.org/pdf/1805.03409.pdf, p.5



The plot shows that using only the *weight* attribute, I can easily separate **benign traffic**, **ga_tcp** and **ga_udp** attacks from the other attacks. Boxplots for **benign traffic**, **ga_tcp** and **ga_udp** shows that their medians are close to 0, they do not have large IQR, they do not have outliers.

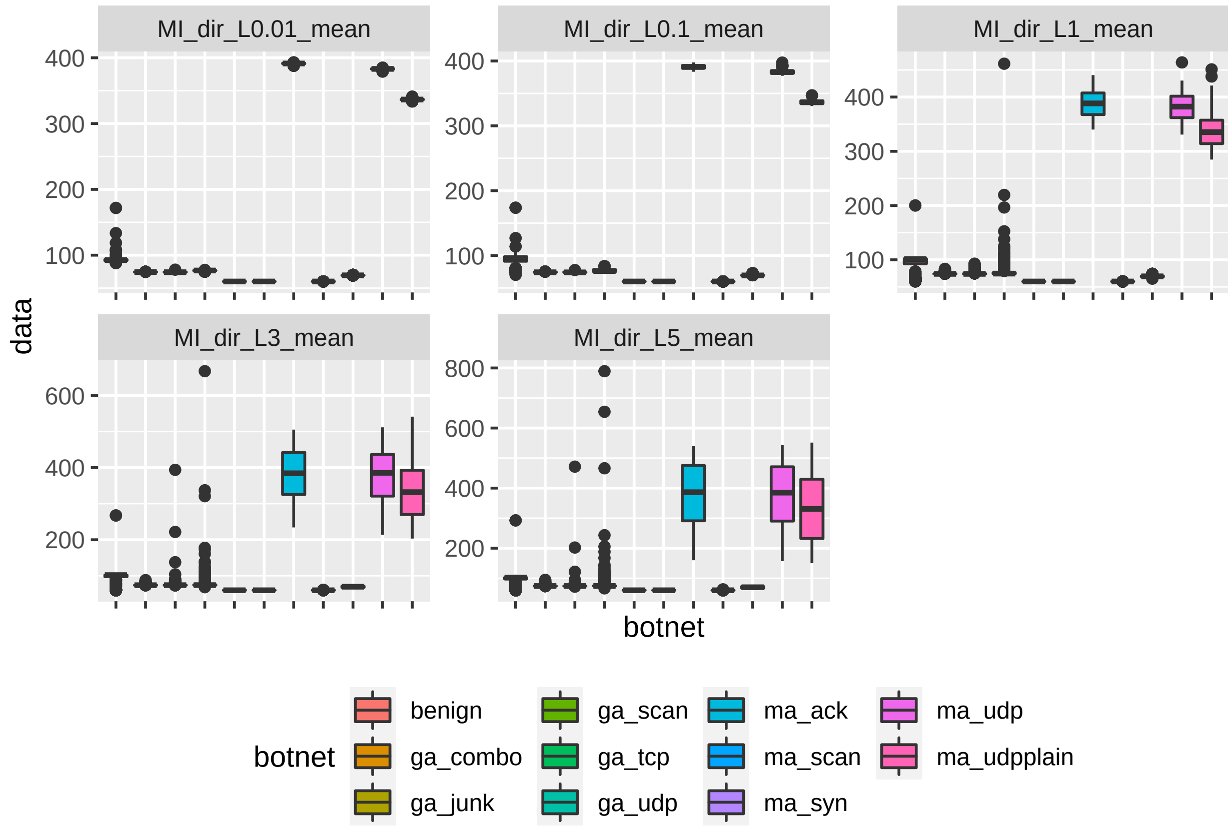
This is more clearly seen at the small time-frames, let's view close up the *weight* attribute for L1 and L0.01 time-frames:



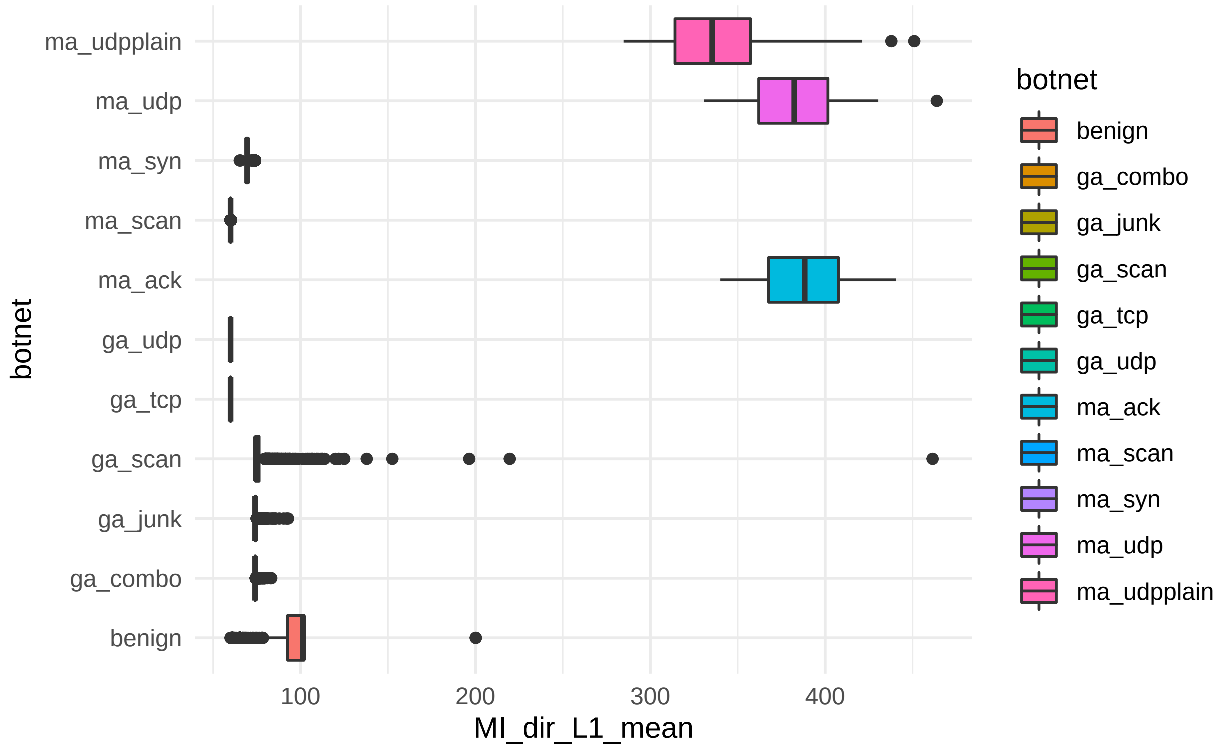


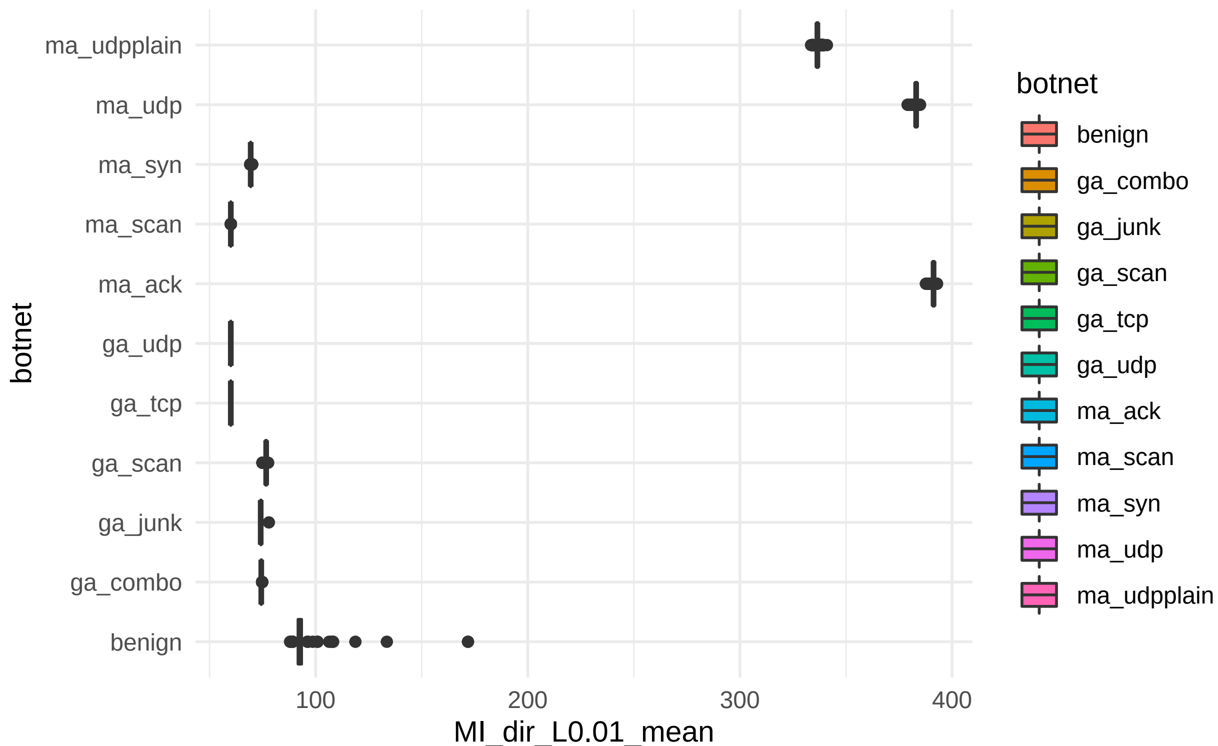
The **ga_tcp** an **ga_udp** disguise themselves well as **benign traffic**. So, I have to find at least one another attribute, that can help me separate **benign traffic** from **ga_tcp** and **ga_udp** attacks.

Next, I would like to explore *mean* attribute for the same stream (MI_dir_L5_mean - MI_dir_L0.01_mean):



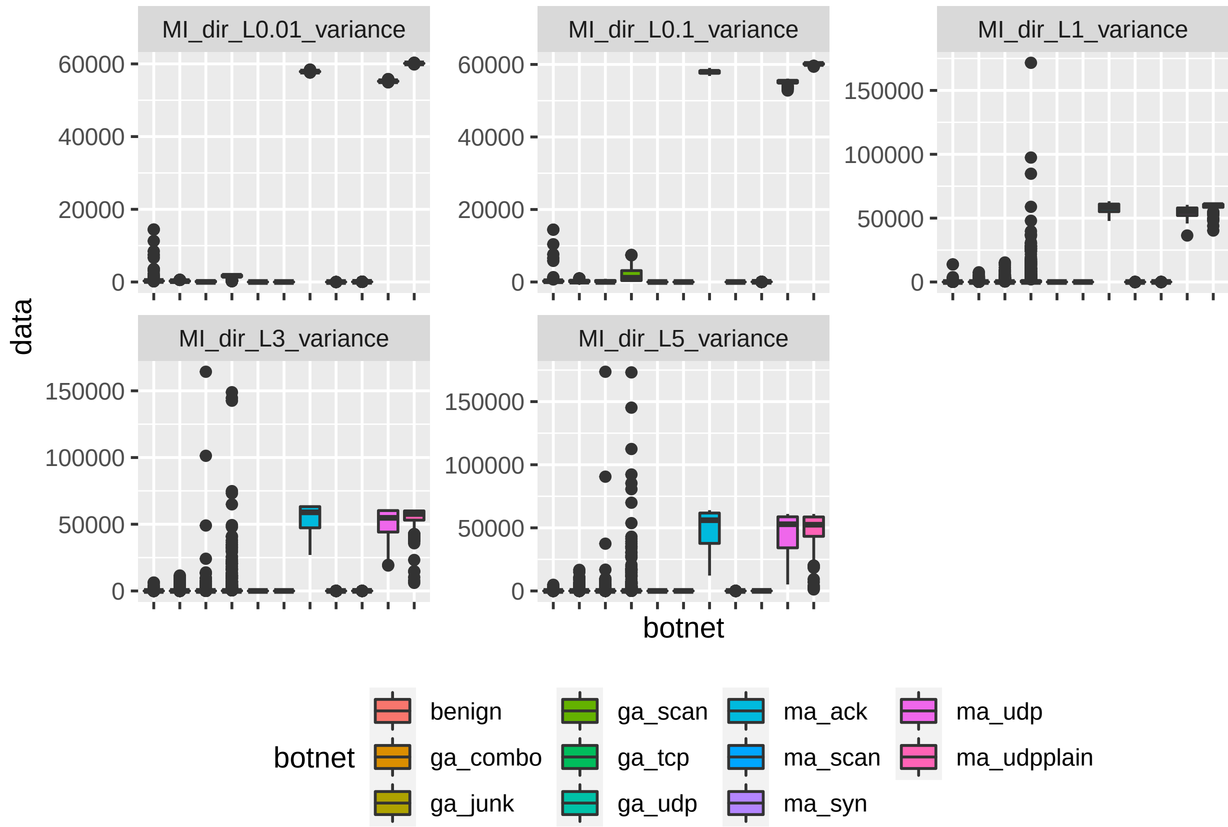
This plot shows that *mean* attribute can help me separate **benign traffic** from **ga_tcp** and **ga_udp**, as median for **benign traffic** is higher that for these attacks. Let's check this on the small time-frames (L1 and L0.01):





Some outlies for *benign traffic* have values close to those that **ga_tcp** and **ga_udp** have, and these values may confuse in separation from attacks. Thus, using only the *weight* and *mean* attributes will not help clearly separate **benign traffic** from the attacks. Therefore, I still need one more attribute that help separate *benign traffic* from the **ga_tcp** and **ga_udp** attacks.

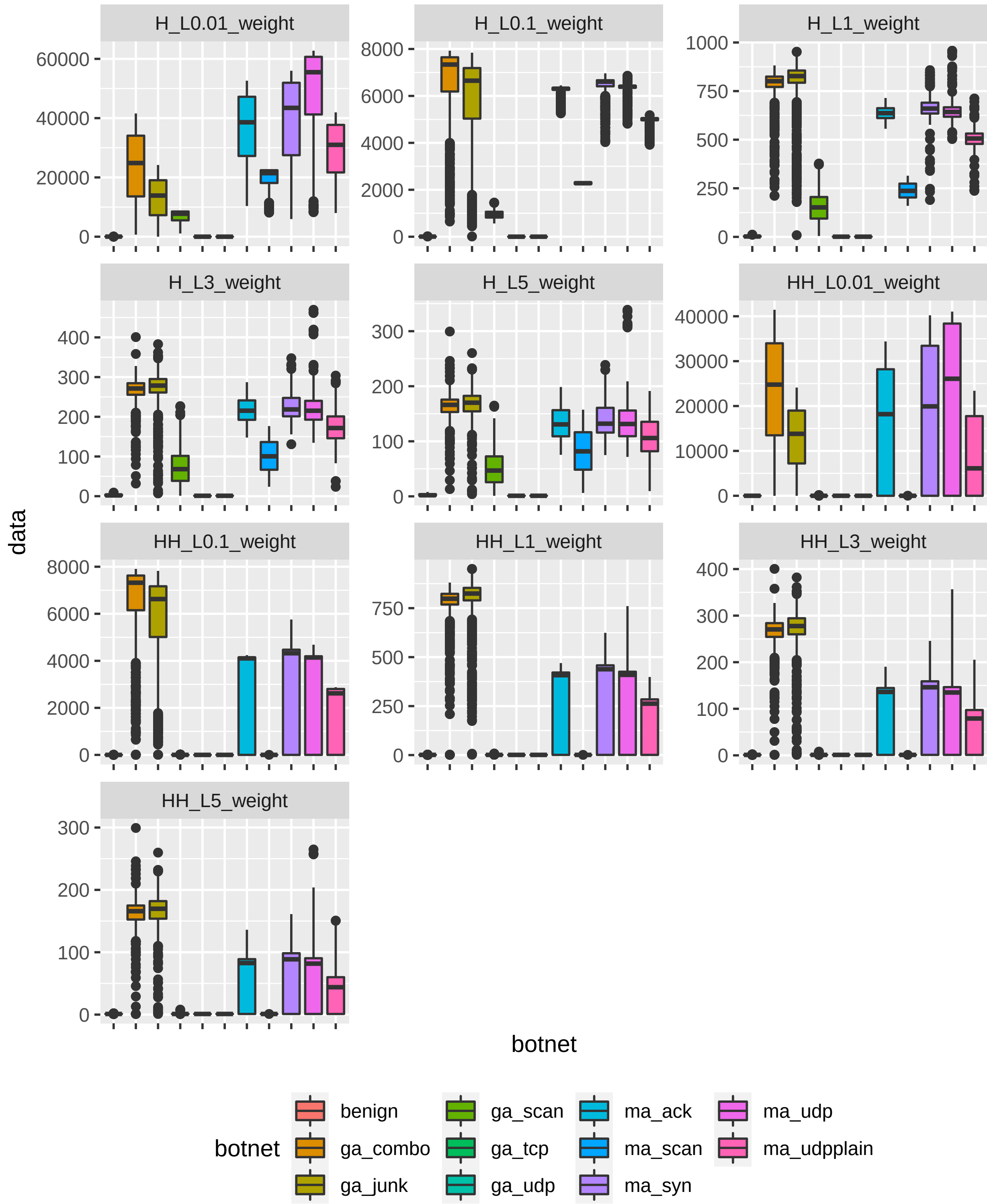
Next, let's explore *variance* attribute (MI_dir_L5_variance - MI_dir_L0.01_variance) - does it provide any information for separating *benign traffic* from the attacks:

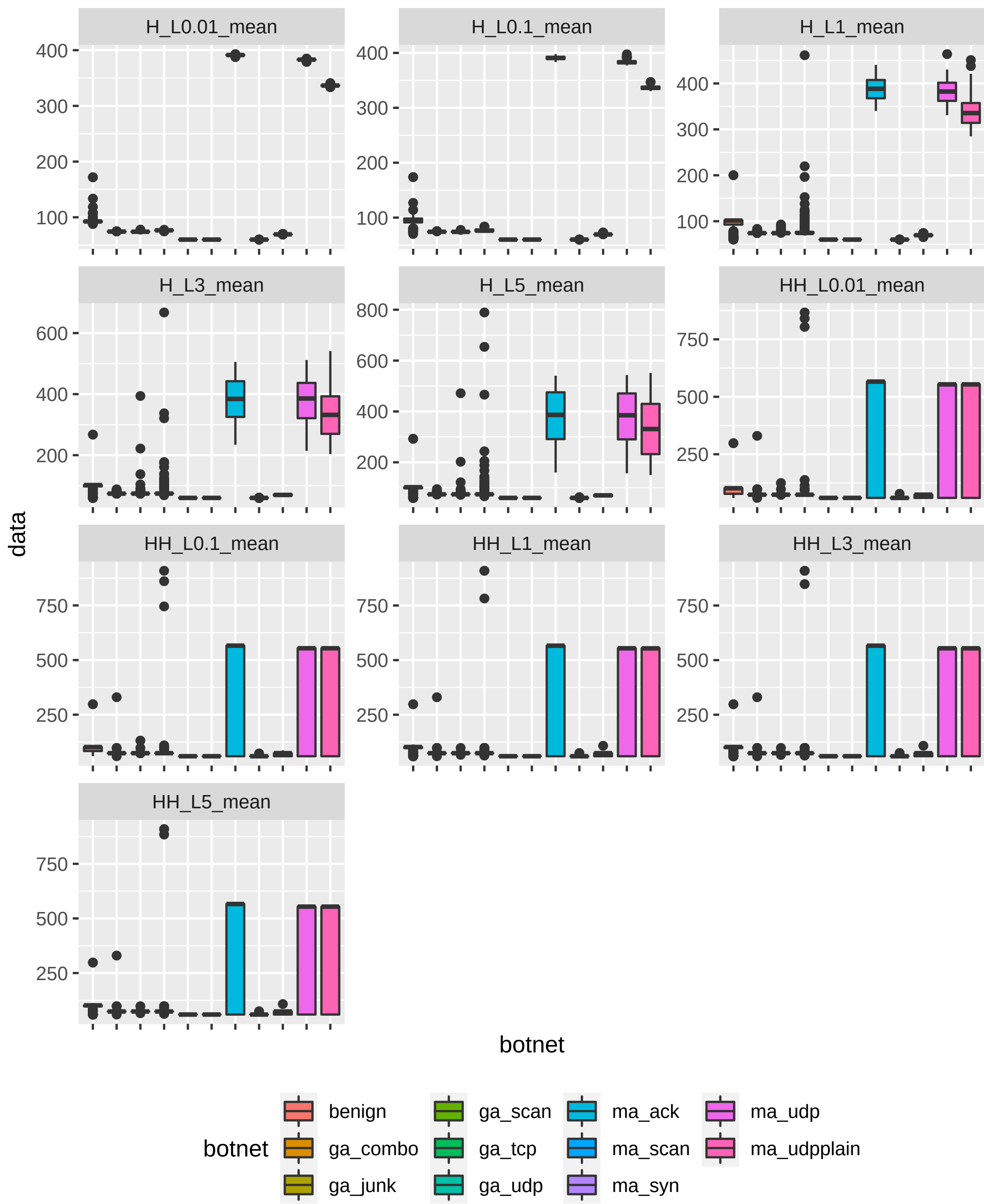


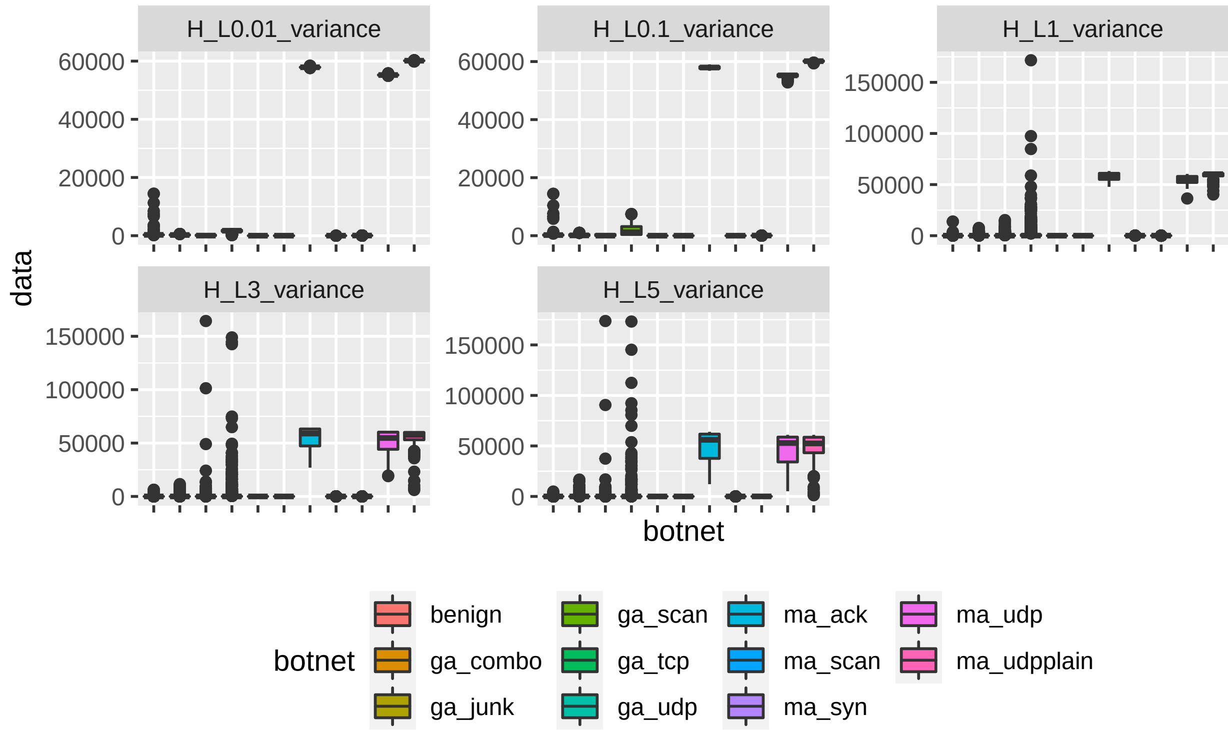
This plot shows that *variance* attribute doesn't give a new information on how to separate **benign traffic** from attacks, so I can easily remove this attribute if I need to reduce the data set dimension.

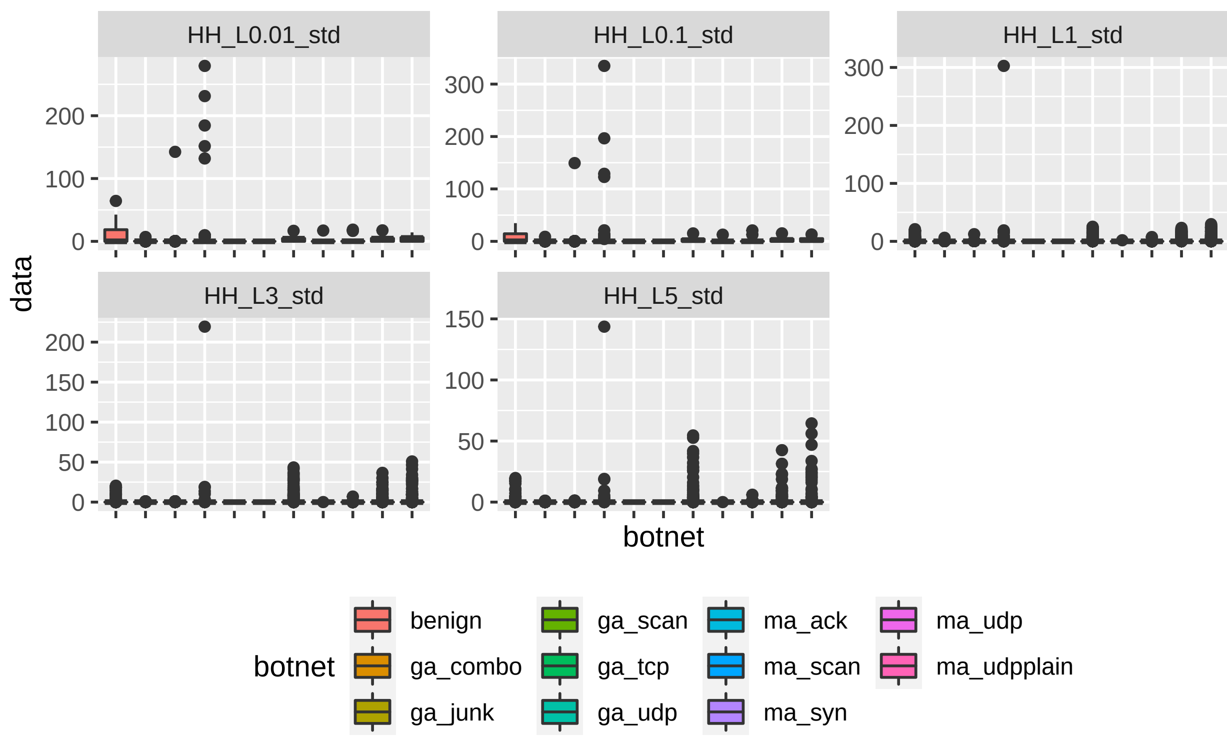
H and HH streams

Let's explore statistics for H and HH streams. In the same way as for the previous stream, I will consider *weight*, *mean* and *variance* (or *std*) attributes:


H_L0.01_weight
H_L0.1_weight
H_L1_weight
H_L3_weight
H_L5_weight
HH_L0.01_weight
HH_L0.1_weight
HH_L1_weight
HH_L3_weight
HH_L5_weight
data
botnet
botnet
benign
ga_combo
ga_junk
ga_scan
ga_tcp
ga_udp
ma_ack
ma_scan
ma_syn
ma_udp
ma_udpplain


H_L0.01_mean
H_L0.1_mean
H_L1_mean
H_L3_mean
H_L5_mean
HH_L0.01_mean
HH_L0.1_mean
HH_L1_mean
HH_L3_mean
HH_L5_mean
data
botnet
botnet
benign
ga_combo
ga_junk
ga_scan
ga_tcp
ga_udp
ma_ack
ma_scan
ma_syn
ma_udp
ma_udpplain

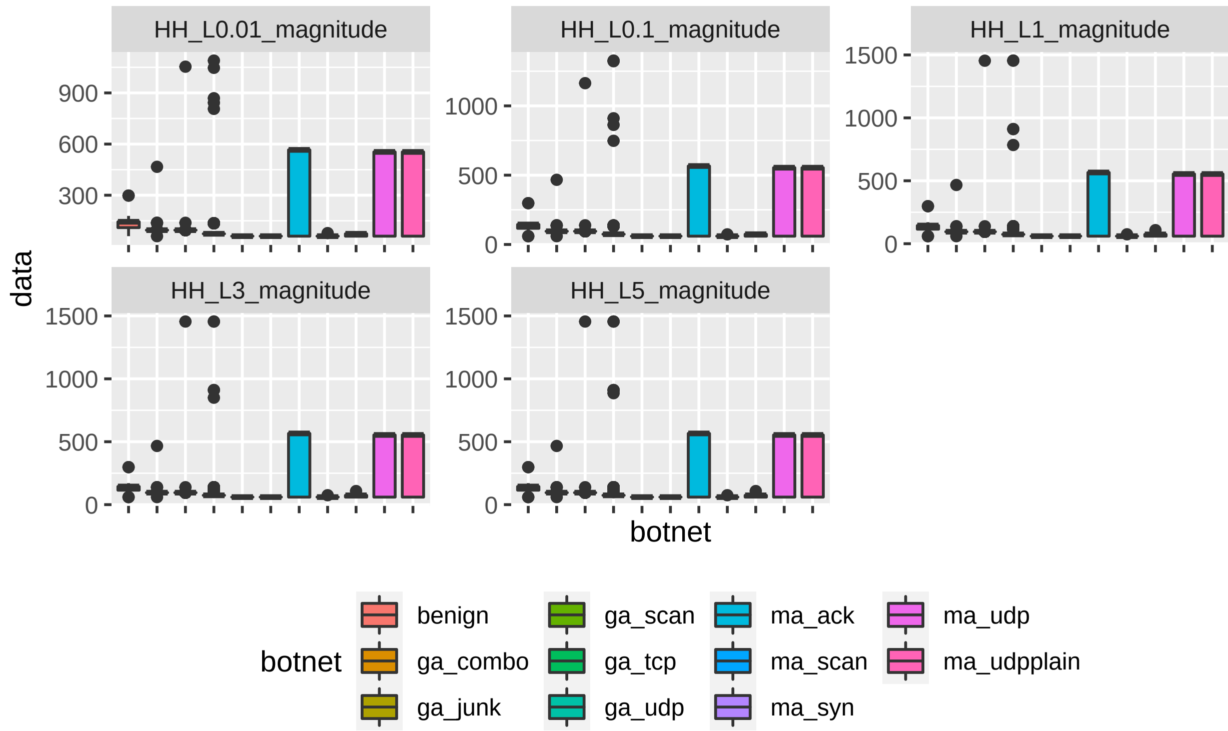




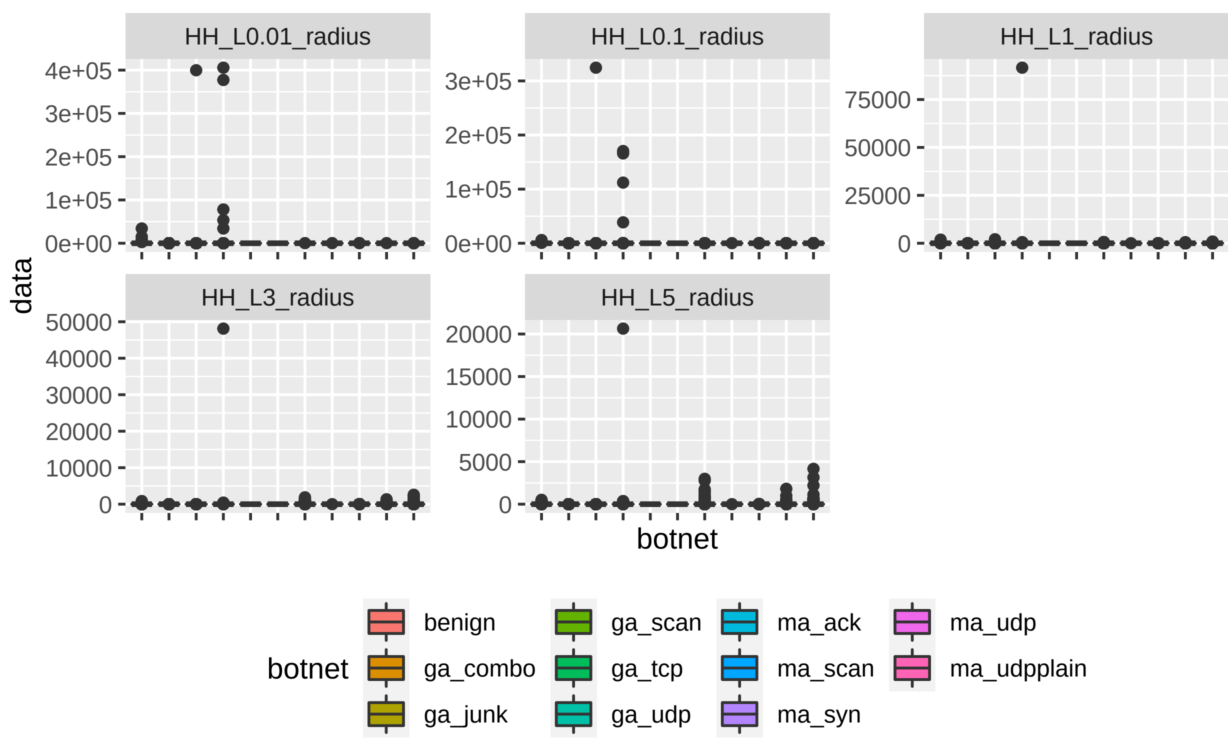
Just like plots for MI stream, all plots for H and HH streams show that I can use *weight* and *mean* attributes to separate **benign traffic** from the attacks, and remove *variance* or *std* attributes if I need to reduce the data set dimension.

HH stream

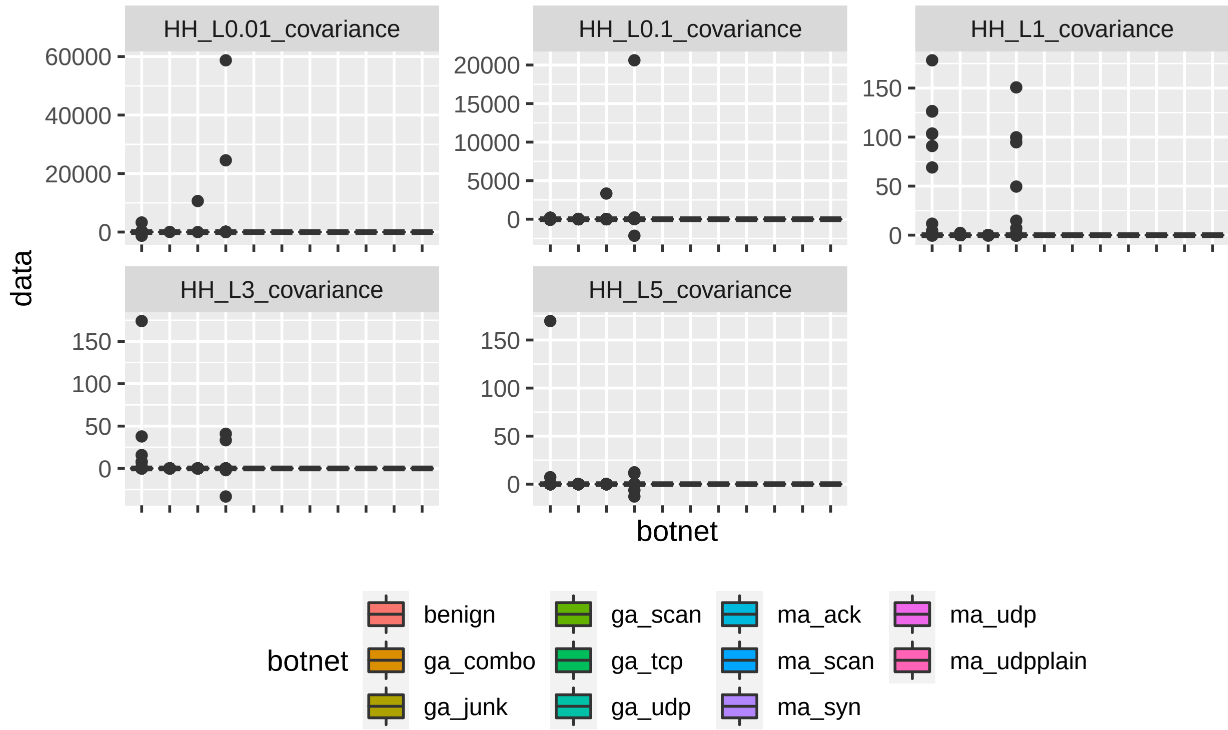
HH stream also has *magnitude*, *radius*, *covariace* and *pcc* attributes, let's explore them:



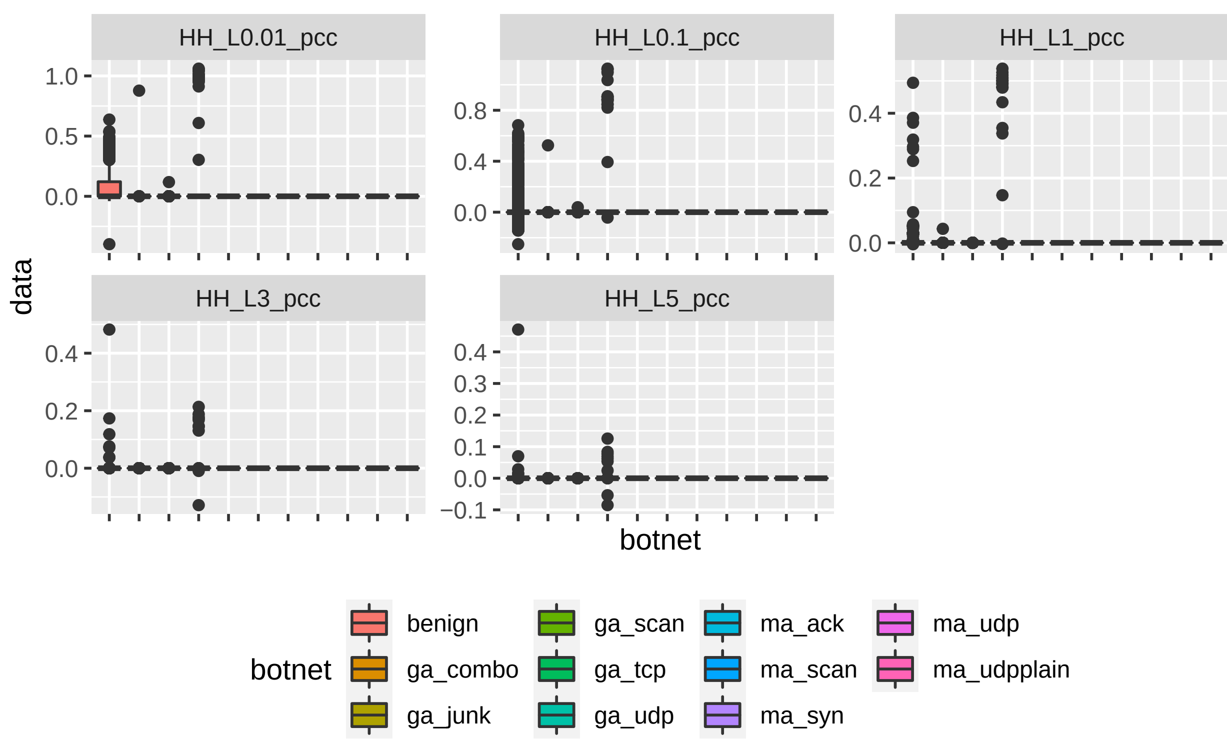
The plot shows that *magnitude* attribute can be used for separation **benign traffic** from the attacks.



The plot shows that *radius* attribute doesn't give any information on how to separate **benign traffic** from the attacks and can be removed if I need to reduce data set dimension.



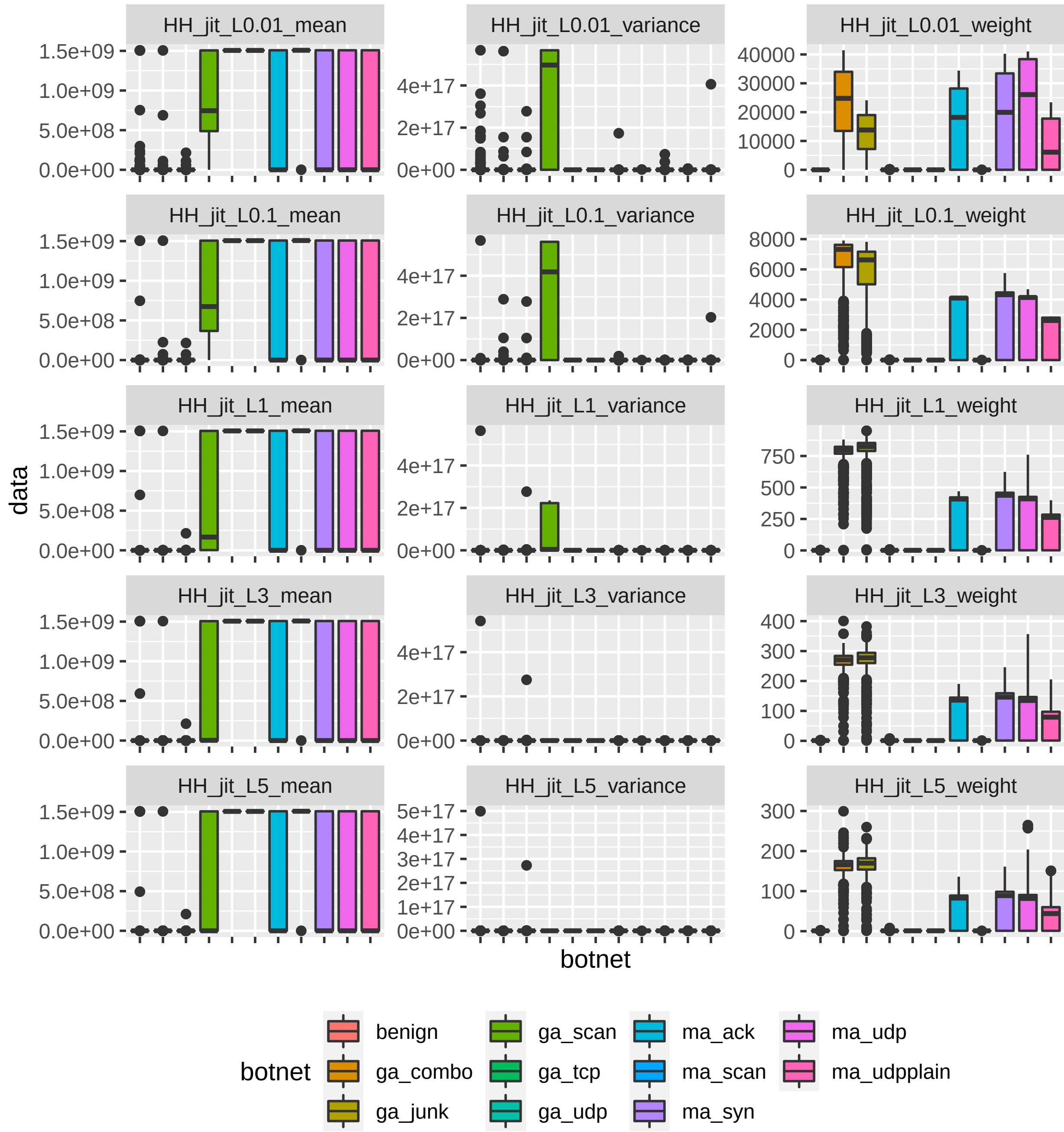
Covariance attribute can be used for separation attacks from **benign traffic**, and, probably, it's the one I've looked for.



The plot shows that, probably, *pcc* attribute can also be used for separation.

HH_jit stream

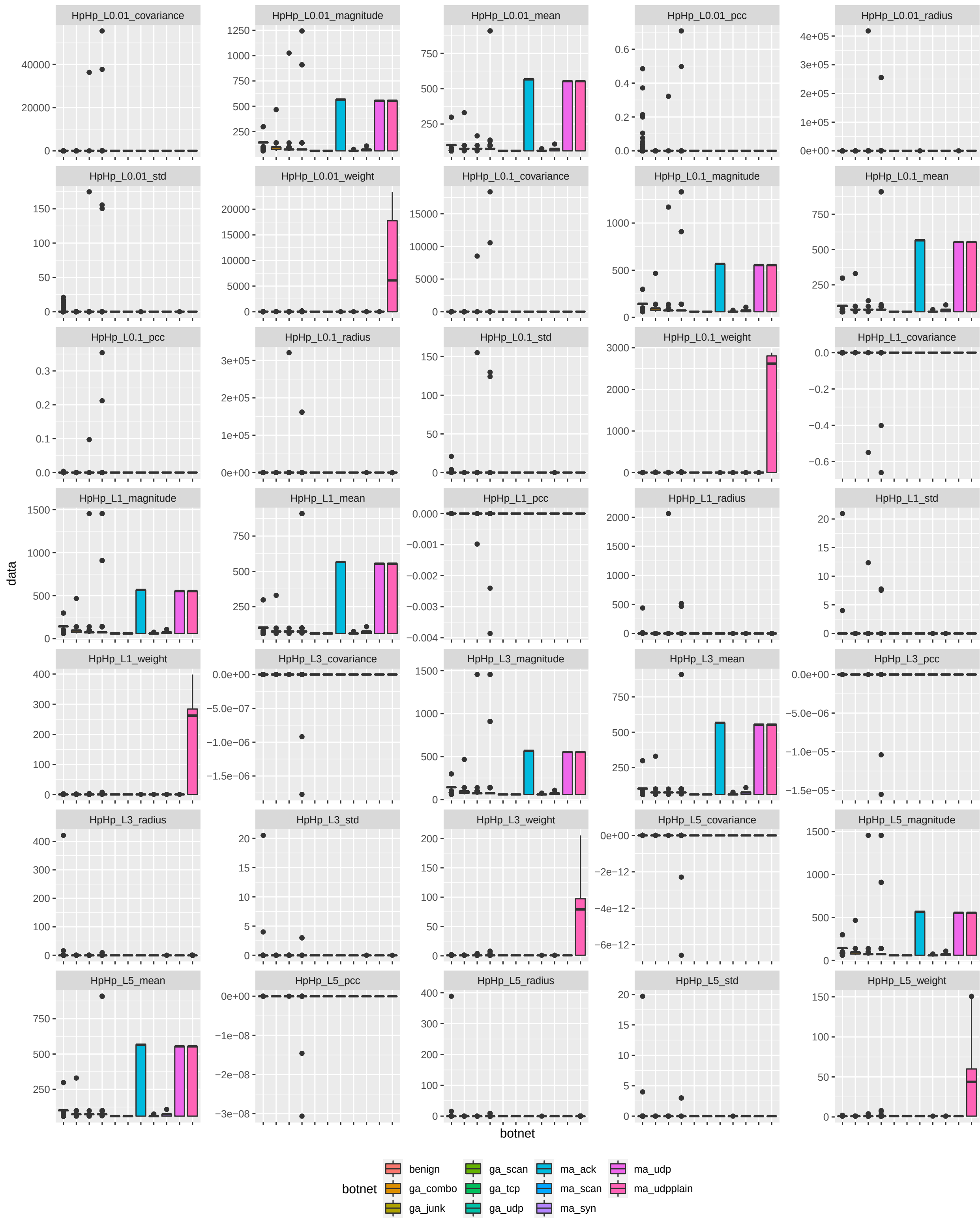
I will follow the same pattern in exploring attributes for this stream as for the previous ones:



These plots have no new information on how to separate **benign traffic** from attacks.

HpHp stream

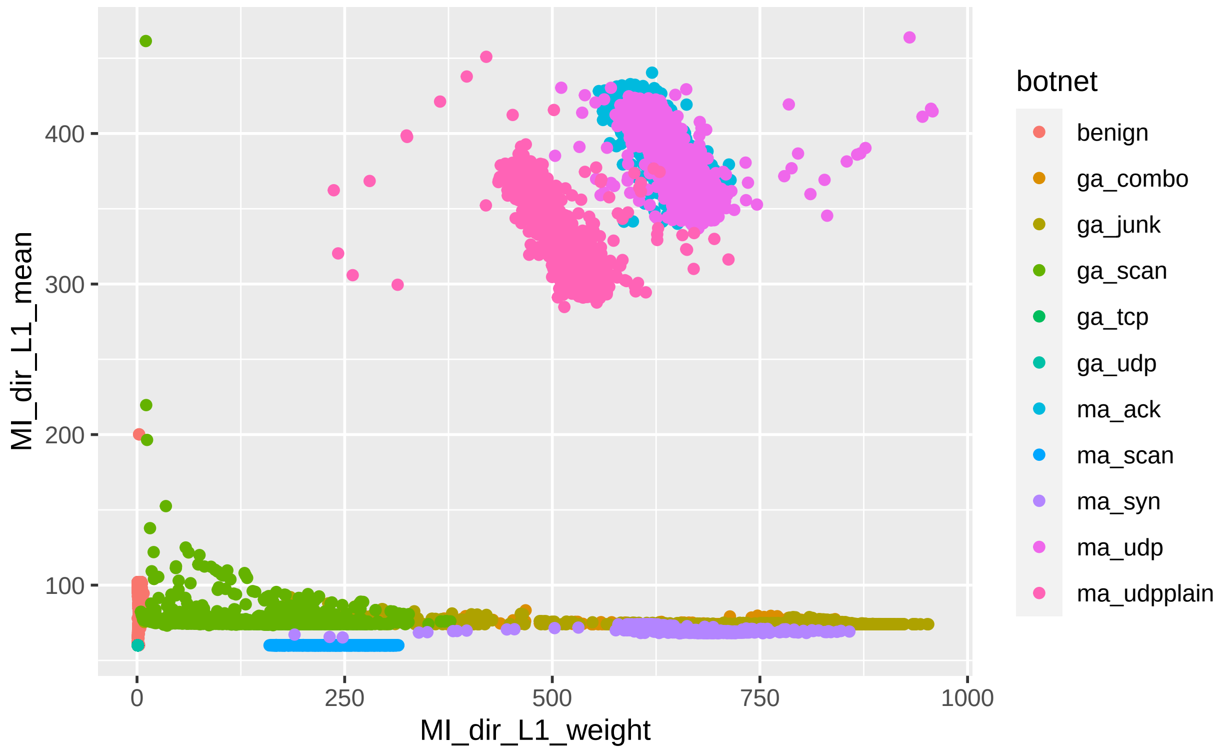
Let's have a quick look on plots for this stream:

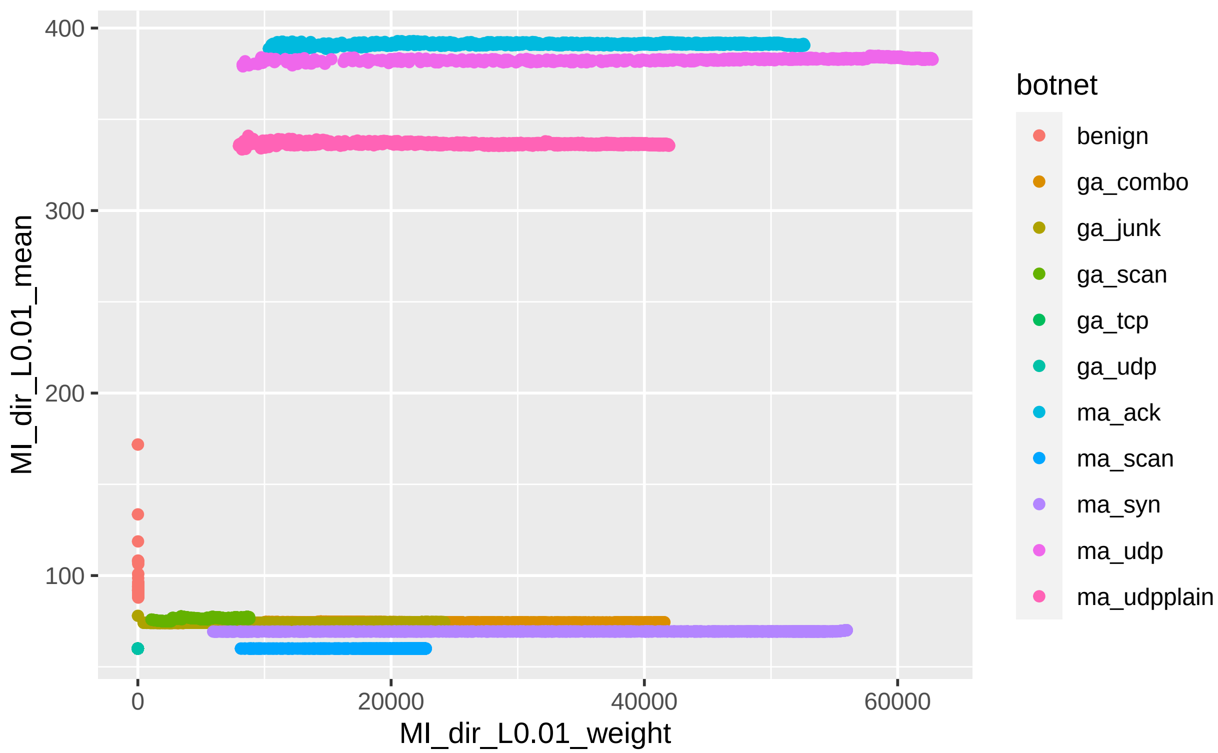


This stream also doesn't give me the new information on how to separate **benign traffic** from the attacks.

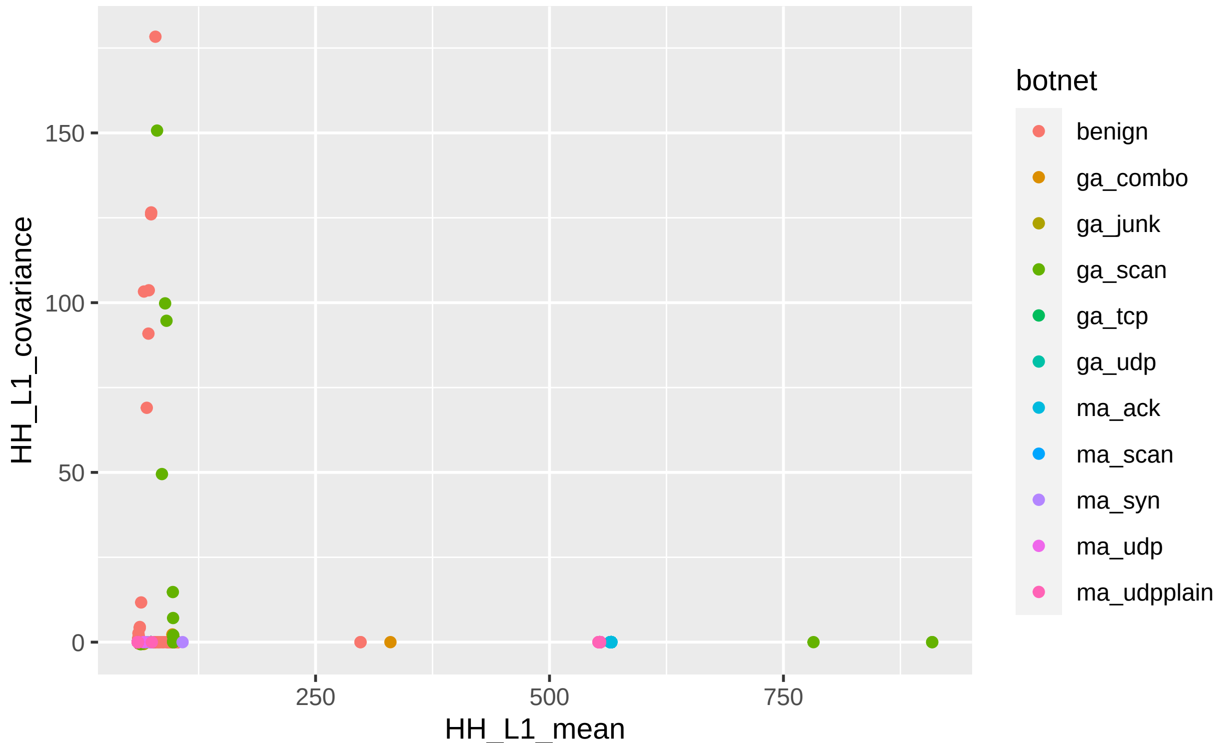
Data set exploration at small time frames

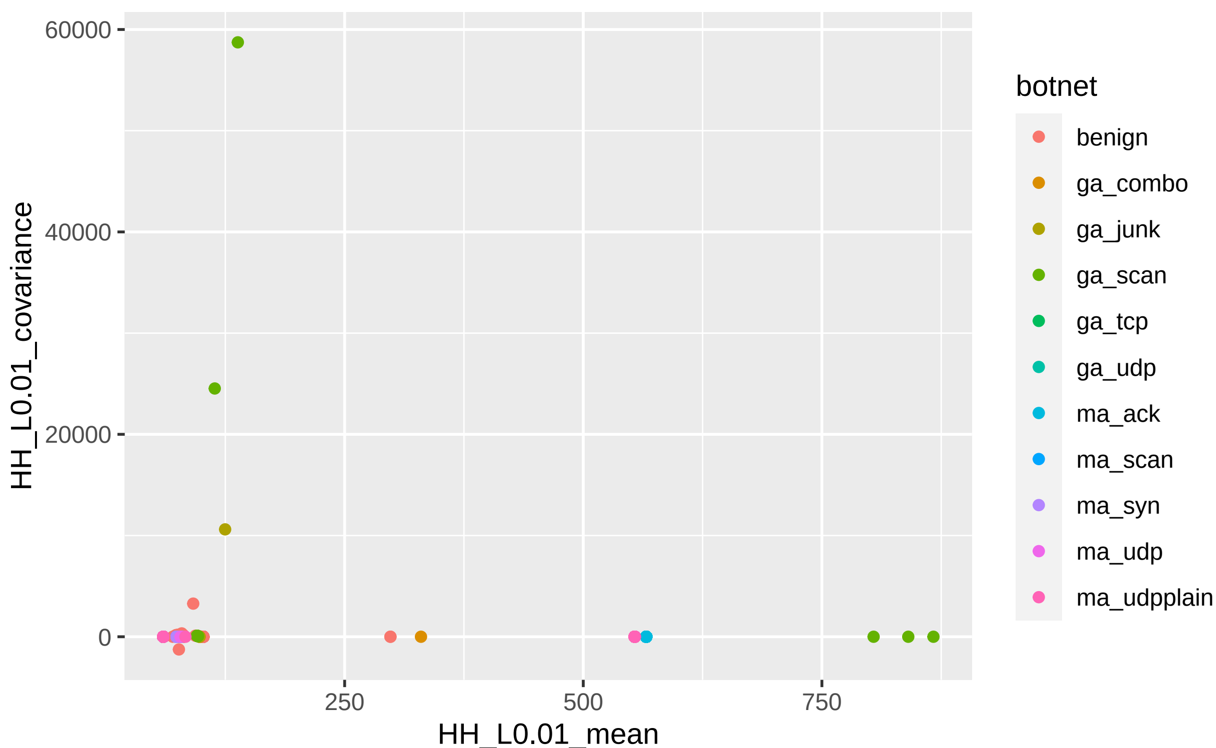
I've noticed that all the plots have more pronounced data at the small time-frames. I would like to explore what data will give me with some attribute combinations, like *weight* vs. *mean* exactly on these small time-frames.





Pair *weight-mean* for L0.01 time-frame shows how easily some attacks can be separated from **benign traffic**, compared with L1 time-frame.





Pair *mean-covariance* better shows how **ga_tcp** and **ga_udp** can be separated from **benign traffic**.

Conclusion

In a result, all explorations show that I can use *weight*, *mean* and *covariance* attributes to make a decision how to separate **benign traffic** from attacks, and remove other statistic attributes if I need to reduce the data set dimension.