A Study of Non-Gaussian Data Assimilation for Volumetric Network Anomaly Detection

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Background

What is a volumetric anomaly?

Distributed Denial of Service Attack (DDoS)

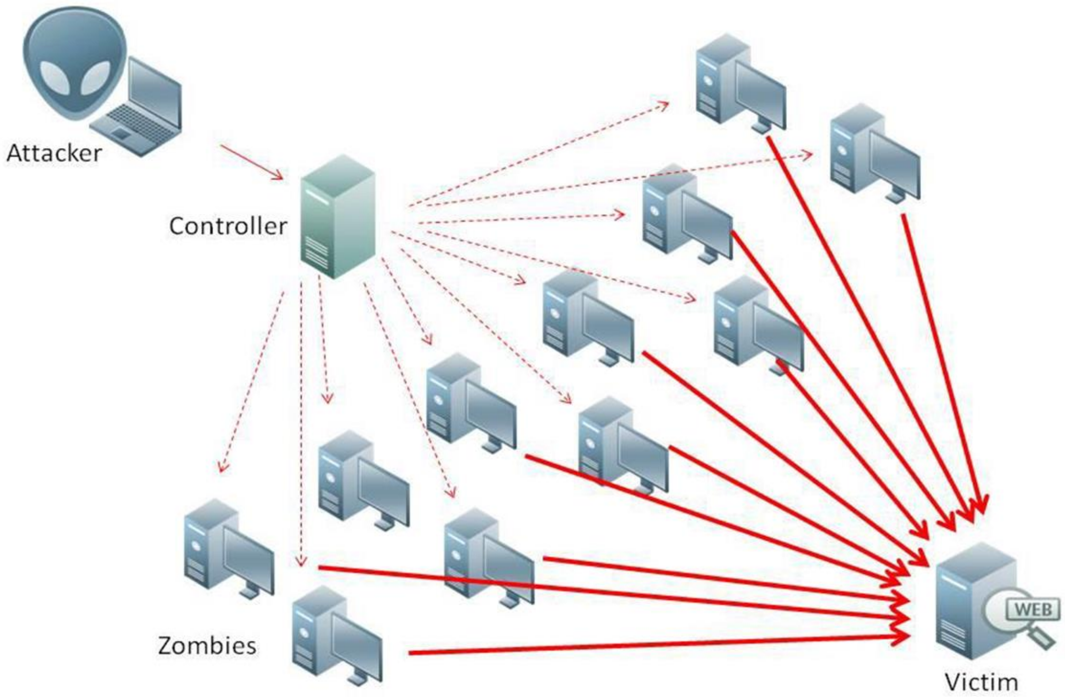
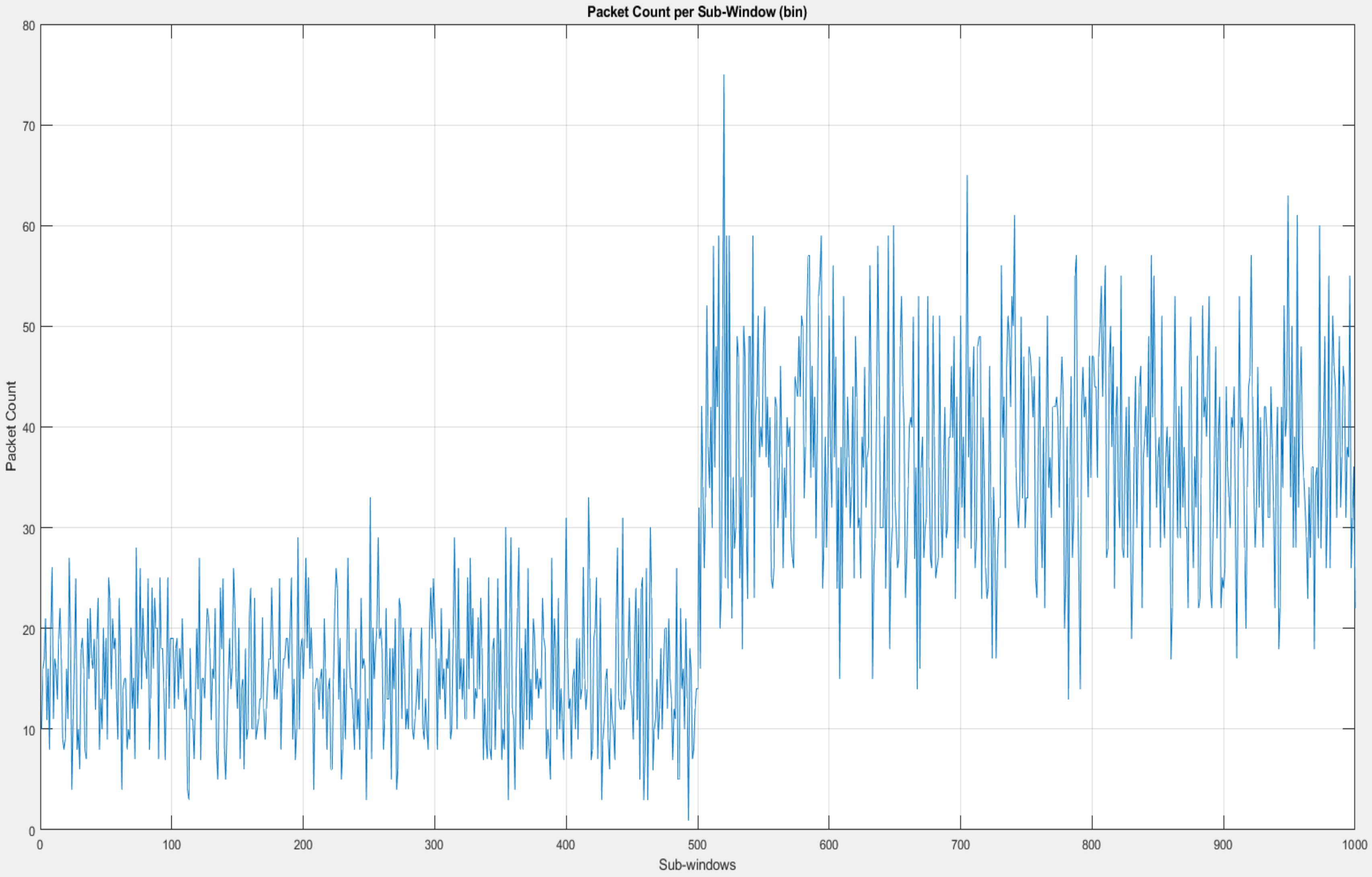


Image source: https://www.networkworld.com/

A Simulated Signal Mimicking a DDoS Attack

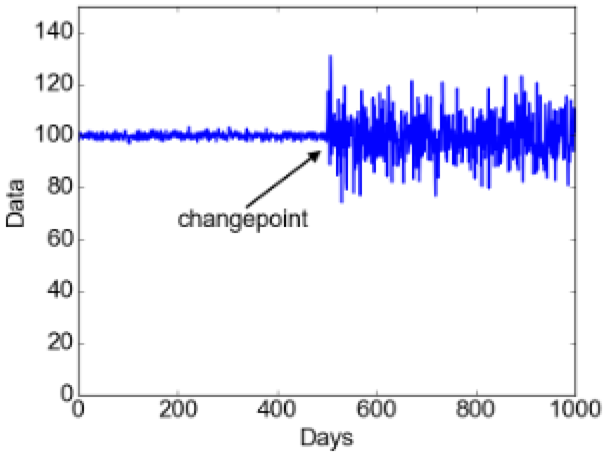


The Problem

Can the attacks be detected before they fully materialize?

Can we detect the volume change-point early?

Challenges?



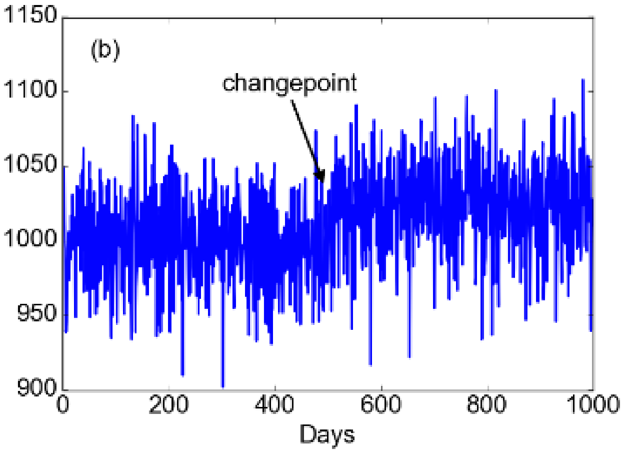
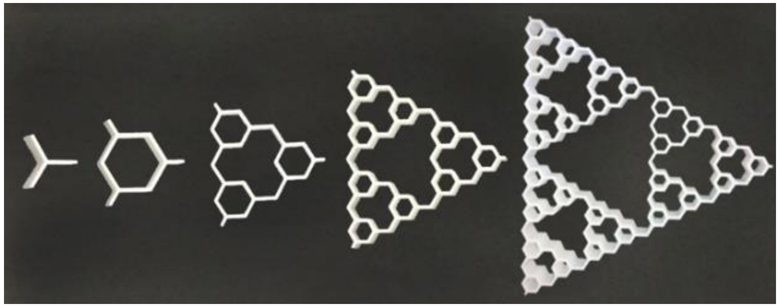


Image source: http://www.claudiobellei.com/

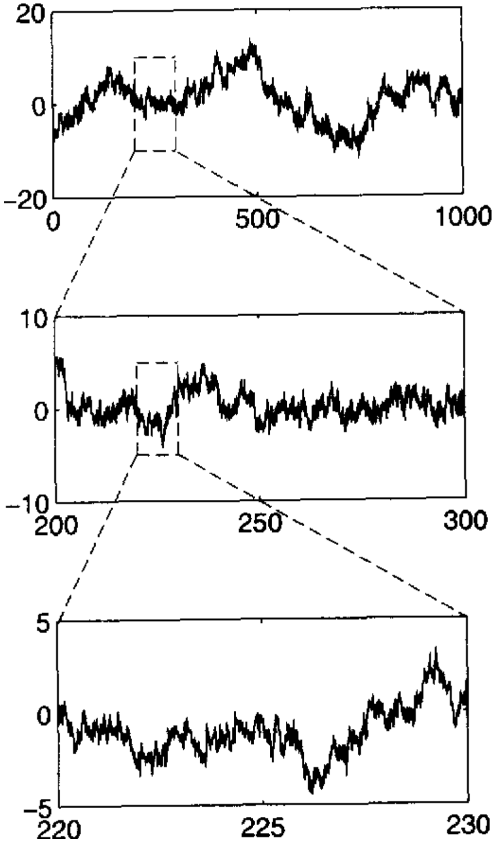
Preliminary Considerations

Properties of Network traffic

-Fractal-like (Self Similar) [1][2]



"Fractal-like"



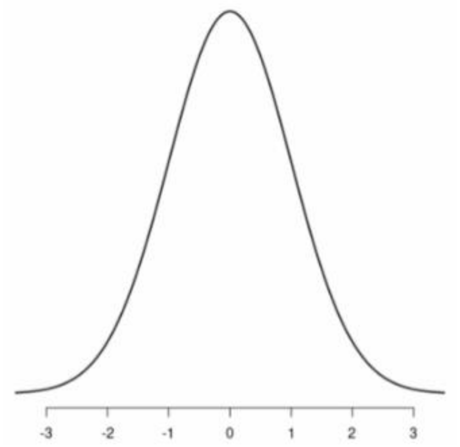
"Self Similar"

Image source: Wikipedia

Preliminary Considerations

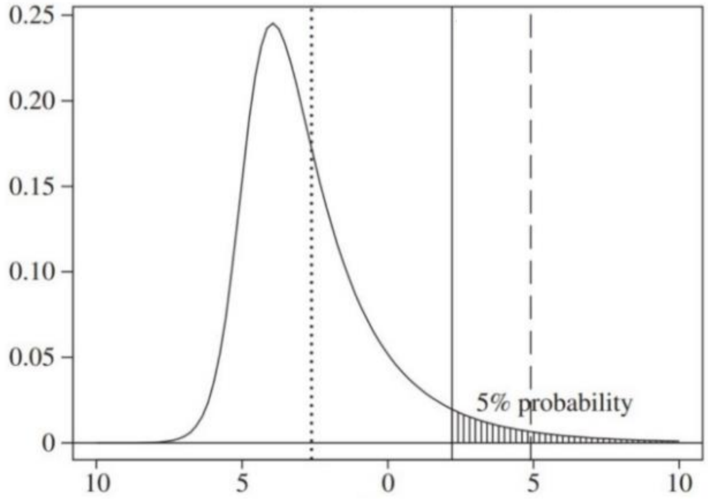
Properties of Network traffic

-Heavy Tail Distribution [3]



"Gaussian"

VS

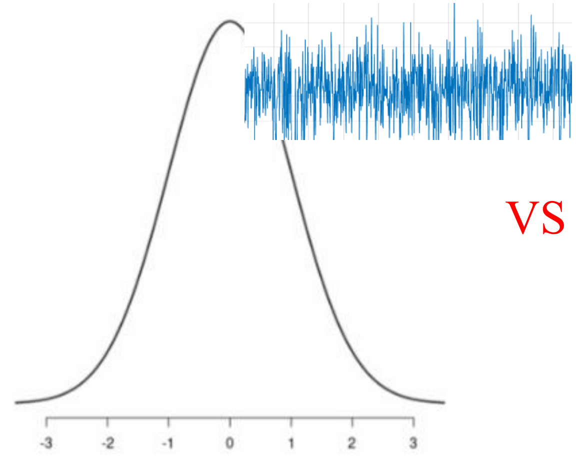


"Heavy-Tail"

Preliminary Considerations

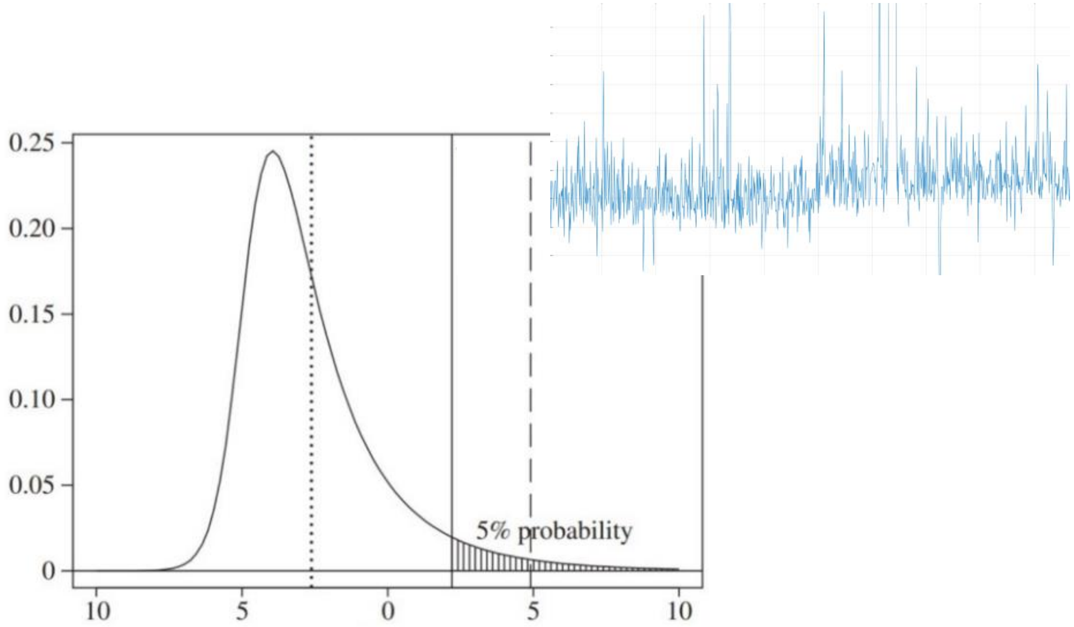
Properties of Network traffic

-Heavy Tail Distribution [3]



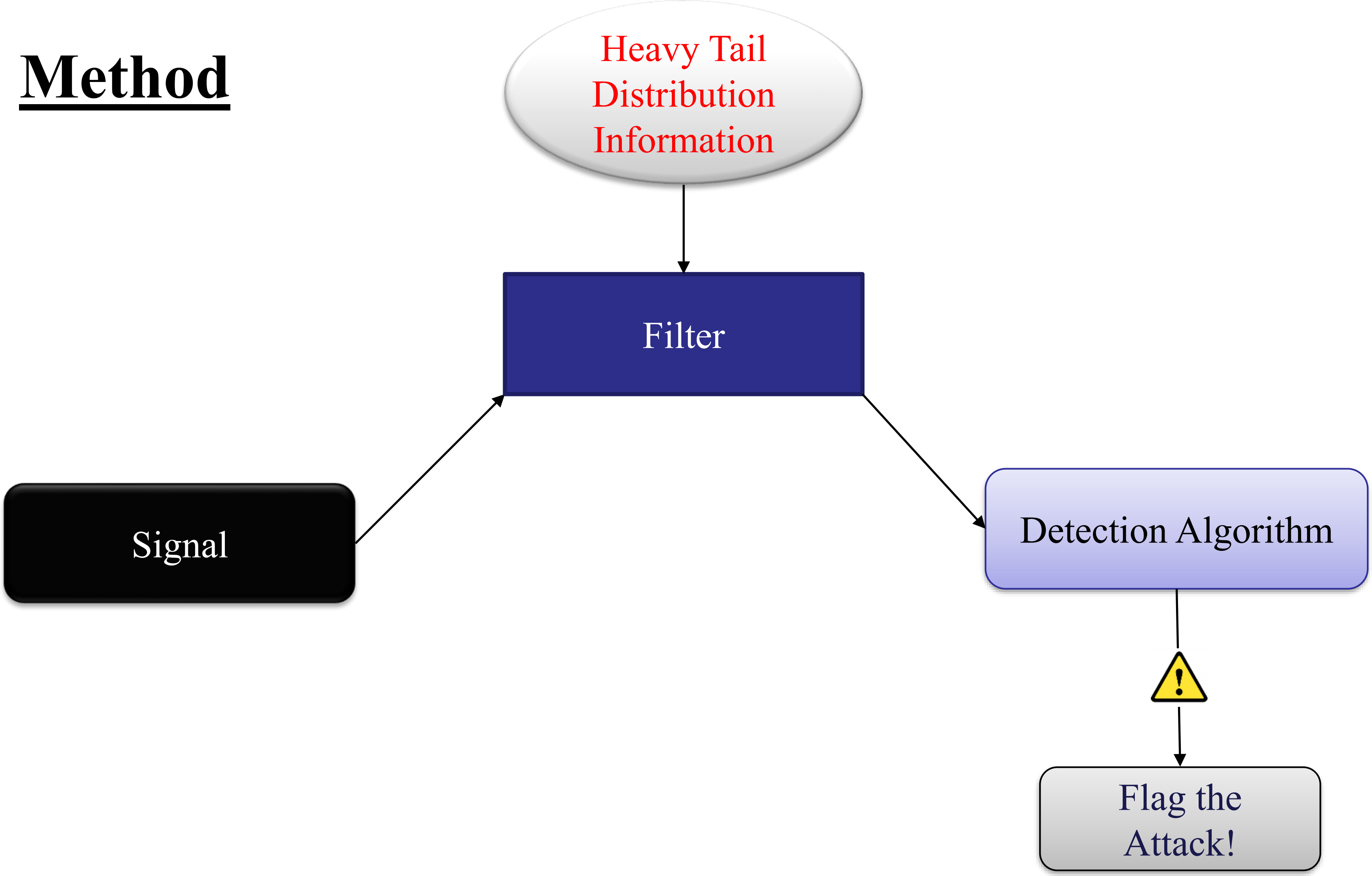
VS

“Gaussian”



“Heavy-Tail”

Method


Heavy Tail Distribution Information
Filter
Signal
Detection Algorithm
⚠
Flag the Attack!

Hypothesis

- Consideration of heavy tailed-ness of the signal while filtering will improve the results:

Expected benefits:

-Lower false-alarm rate

-Faster volume change-point detection

The Filter Setup

Currently the filter is assuming an autoregressive AR(p) model of the traffic signal with heavy tail residual

Filter's Task:

Detect changes in the coefficients of the autoregressive model

$$Y_k = H_k X_k + V_k$$

$$H = \begin{bmatrix} Y_{k-1} & Y_{k-2} & \dots & Y_{k-m} \end{bmatrix}, \; X = \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_m \end{bmatrix}$$

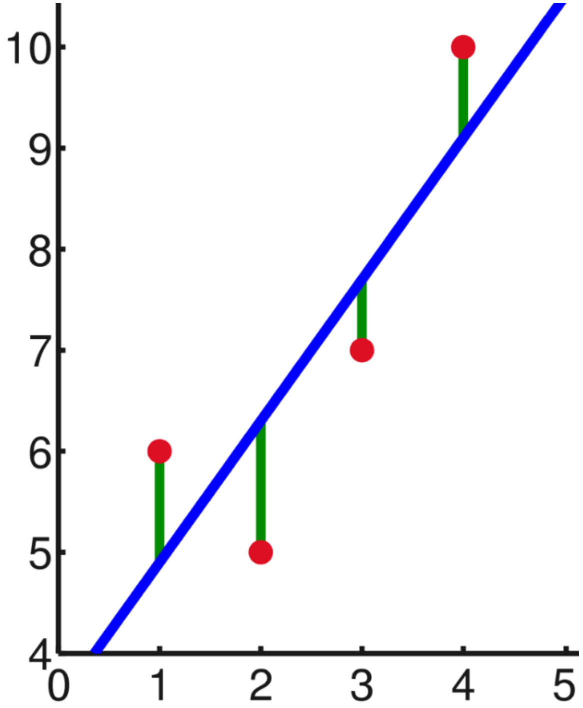
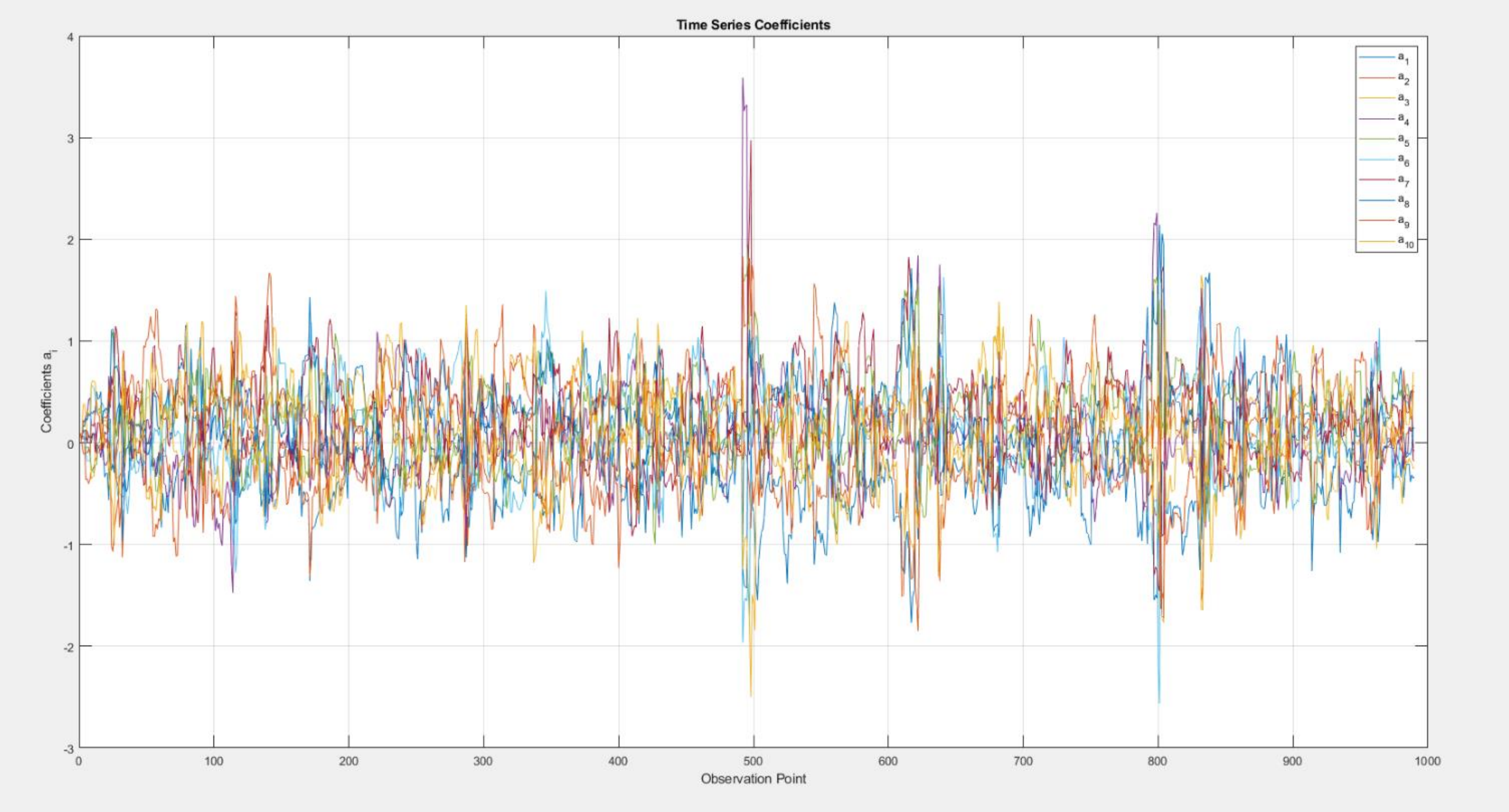
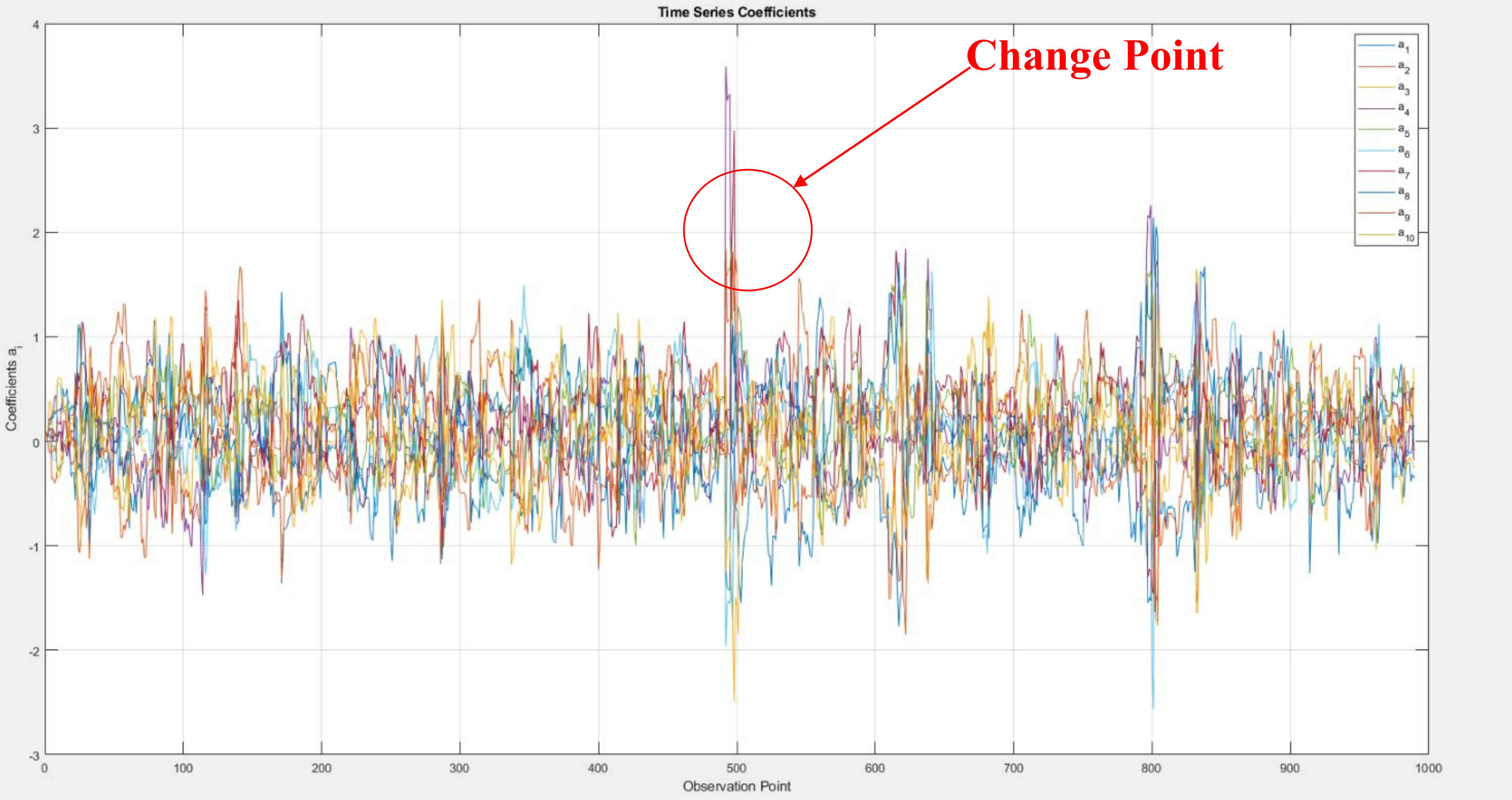


Image source: Wikipedia

Some Results




Time Series Coefficients
Change Point
Coefficients a_i
Observation Point
4
3
2
1
0
-1
-2
-3
0
100
200
300
400
500
600
700
800
900
1000
a_1
a_2
a_3
a_4
a_5
a_6
a_7
a_8
a_9
a_{10}

Future Work

- Develop a more sophisticated detection algorithm to accompany the filter

- Carry out extensive Monte Carlo testing of the presented filtering method

- Compare the (filtering + detection algorithm) to the state-of-the-art or other broadly used detection methods

Image source: https://www.horizoninternettechnologies.com/

References

[1] Gonzalez, J., & Bollmann, C. A. (2019, December). Aggregated impulses: Towards explanatory models for self-similar alpha stable network traffic. In *2019 13th International Conference on Signal Processing and Communication Systems (ICSPCS)* (pp. 1-10). IEEE.

[2] Willinger, W., Govindan, R., Jamin, S., Paxson, V., & Shenker, S. (2002). Scaling phenomena in the Internet: Critically examining criticality. *Proceedings of the National Academy of Sciences*, *99*(suppl 1), 2573-2580.

[3] Willinger, W., Paxson, V., & Taqqu, M. S. (1998). Self-similarity and heavy tails: Structural modeling of network traffic. *A practical guide to heavy tails: statistical techniques and applications*, *23*, 27-53.

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