



Monitoring Trends in Network Flow for Situational Awareness

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Introduction

Network monitoring plays a vital role in network security and network situational awareness

Monitoring > traffic data over time

Time series data > Spikes, trends, periodicities

Some attacks may result in other changes in patterns

Underlying patterns often difficult to discern



Overview

Propose some new metrics to track changes

Four groups of metrics

Estimate *relative changes*

Output can be displayed as a dashboard

Possible extensions

References



Proposed metrics

A) Parameters from the distribution

{Mean; Std. Dev. Skewness Kurtosis}

B) Percentile-based

{10% 30% 70% 90%]

- Robust around median
- Remove outliers



Time Series-based Metrics

Time domain

- > autocorrelation (by lags)
- > partial autocorrelation (by lags)

ARIMA models

- > “autoregressive” component (PACF)
- > “moving average” components (ACF)

C) Track ACF(1) ACF(2) ACF(3) PACF(2) PACF(3)

Can be extended to more lags



Other time series properties

D) Trends and Variances

Linear trend

Quadratic trend

Burstiness (alternative measures)

Heteroscedasticity (variance of the variance)

Extension: “Self-similarity”



Estimation

For all measures:

$$D = [m(2) - m(1)]/m(1) \quad \sim \text{Relative change}$$

- Display on dashboard
- Keep repeating over each pair of consecutive periods

Alerts based on thresholds:

$$D > T$$



Situational Awareness and Alerts

Setting a threshold:

CI-based | Need trial data; location specific

Set from empirical experience

Calibrate to balance FPs and FNs



Setting Alerts | Threshold

1. Any individual $D > T$
2. Function of the D s: $A(\underline{D}; \underline{w}) > L$
3. Special case: Alert when n out of the 16 D s are greater than T
4. Calibrate thresholds for the individual D s

Indicator $I(i) = 1$ if any $D(i) > T(i)$

0 otherwise

> Alert if $\sum I(i) \geq n$



Simplified Algorithm

Select an IP set (or IP) of interest

Select other conditions (service/protocol/ports/etc.)

Decide on time periods to compare (24 hours or other)

Decide on bin size (time slices to compute the time series)

Set data collection for two preceding time periods

Collect the two time series data

Estimate the 16 metrics (4 each in the four groups)

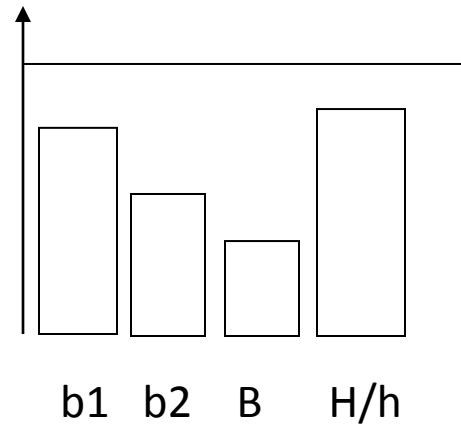
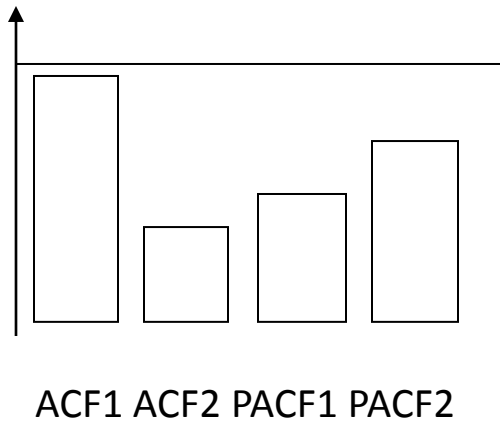
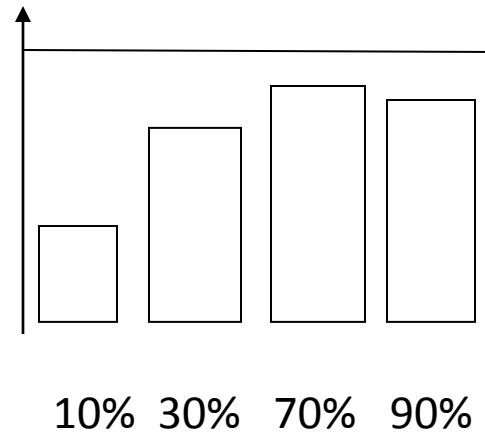
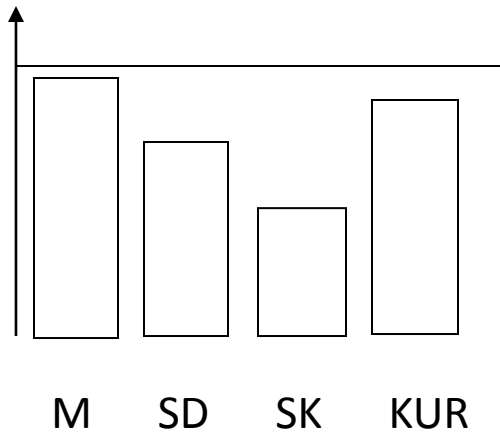
Decide on thresholds

Display

/(Set alerts)



Example of a dashboard



Conclusions and Future Directions

Proposed some new metrics to extract more information from flow data

Try out with known test cases

Try alternative metrics

Develop and validate interpretation of these metrics

Generalize to other analyses: DNS traffic



References

Statistics

Statistics for Business and Economics

D. R. Anderson, D. J. Sweeney and T. A. Williams

Multivariate Data Analysis

J. F., B. Black, B. Babin and R. E. Anderson

Statistics for Business and Economics

J. T. McClave, P. George Benson and Terry Sincich

Time Series

Introduction to Time Series and Forecasting - P. J. Brockwell and R. A. Davis

Introduction to Time Series Analysis and Forecasting

D. C. Motgomery, C. L. Jennings and M. Kulhaci

Times Series Analysis – G. E. P. Box, G. M. Jenkins and G. C. Reinsel



Security Metrics

IT Security Metrics

L. Hayden

Complete Guide to Security and Privacy Metrics

D. S. Herrmann

Security Metrics

A. Jaquith

Statistical Packages: Any standard package



THANK YOU!

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