Metrics to Characterize Temporal Patterns in Lifespans of Artifacts

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INTRODUCTION

This paper presents analysis of artifact lifespans

Based on observations over time

- Presence or absence of vulnerabilities seen
    - Network links up or down
    - Servers active or idle
- Seen or Unseen at t (1/0)

Lifecycle → Lifespan → Analysis

→ Stochastic Point Processes (Marked)

Illustrative examples presented ← *Simulated data*

Metrics for Pattern & Anomaly Detection

The goal is to track metrics

– Baseline them

– Establish thresholds

Alerts – Validation – Action

Background

Here we focus on Life History-based metrics

Many approaches to analyzing life histories

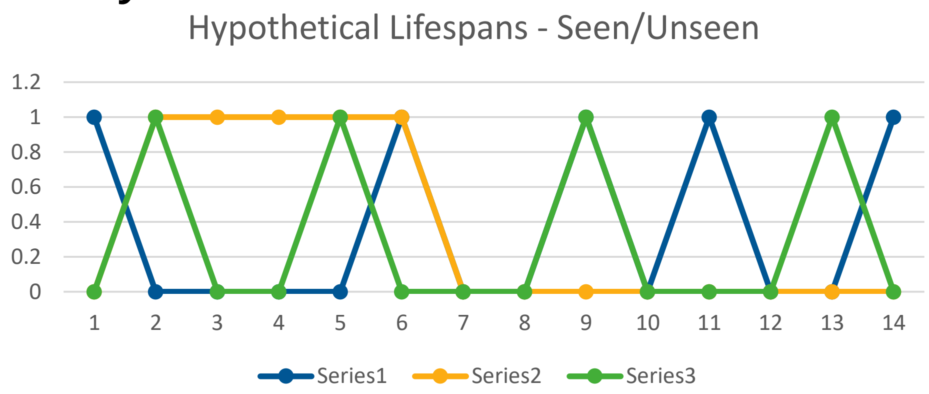
Not much analysis done for lifespans of artifacts

Development of appropriate metrics for lifespans that are not traditional lifecycles

Analyze time series constructed from temporal data (records)

Modeling Challenges

Not a traditional lifecycle



Something like a renewal process

Heterogeneous across the vulnerabilities

Need metrics to capture the lifespan features

Some existing metrics can be useful

Need some new concepts

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New Metrics for Lifespans/Point Processes

Existing: Lifetimes (Π), Seen (Ψ), Mean Times Seen (<T>), etc.

New:

1) Transilience Φ: Count of ‘seen - then unseen’ sequences | W

2) Sequacity Ξ: Count of seen consecutively | W

3) Conformity 𝒞: How close an artifact is to the median value of the metric across all the artifacts?

Data, Methodology, Analysis

Simulated Lifespans of Vulnerabilities

← Mentions over time (1 or 0) by day

* 8 Lifespans & 14 days

Compute the metrics (Features) for each vulnerability

+ Functions of the metrics → New Freatures

9 Metrics or Features in all

Results of the Analysis (Simulated Data)

PI	14	14	5	12	8	10	14	14
PSI	10	5	5	4	5	9	11	10
(PI-PSI)	4	9	0	8	3	1	3	4
PHI10	3	4	1	4	4	2	3	4
PI/(PI-PSI)	3.5	1.6	99	1.5	2.7	10	4.7	3.5
KSI	6	0	4	0	1	7	7	5
(KSI/PSI)	0.6	0	0.8	0	0.2	0.8	0.6	0.5
T	2.5	1	5	1	1.25	4.5	2.25	2
|T-2.13|	0.38	1.13	2.88	1.13	0.88	2.38	0.13	0.13
C	2.67	0.89	0.35	0.89	1.14	0.42	8.00	8.00

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Discussion of the Results

Summary:

Independent in theory but correlated in real data

Different datasets will exhibit different correlations

Truncated data (W) – Skewness in the distributions

Potential Applications and Benefits:

Overall goal:

- Extract features of lifespans
- Understand patterns
- Cluster artifacts into similar groups
- Correlate patterns with particular malware

Implications & Conclusions

These metrics help examine deeper temporal patterns:

Key to detecting subtle changes and surreptitious anomalies

Proposed 3 metrics that can be computed

and tracked with relative ease

Based on stochastic point process models;

all have intuitive interpretation

Properties match requirements to identify patterns

Future Work

More data on lifespans: Baselining and thresholds

Further validation of the metrics

Performance in detecting changes and anomalies in real data

Additional metrics to detect and track patterns

Implementation in information assurance analytics

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Thank you!

Questions?

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