Data Science & Cybersecurity

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Document Markings

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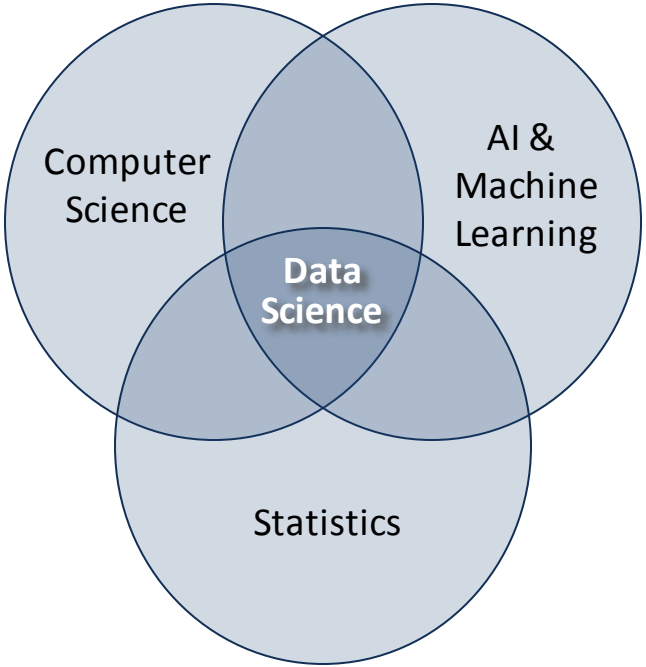
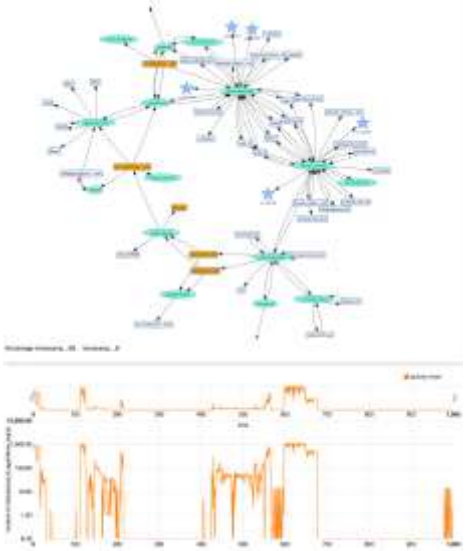
Application of Data Science to Cybersecurity

Areas we have worked in

Data Science

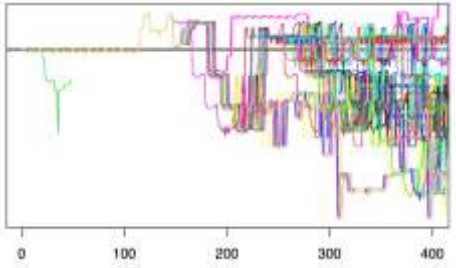


Malware family classification

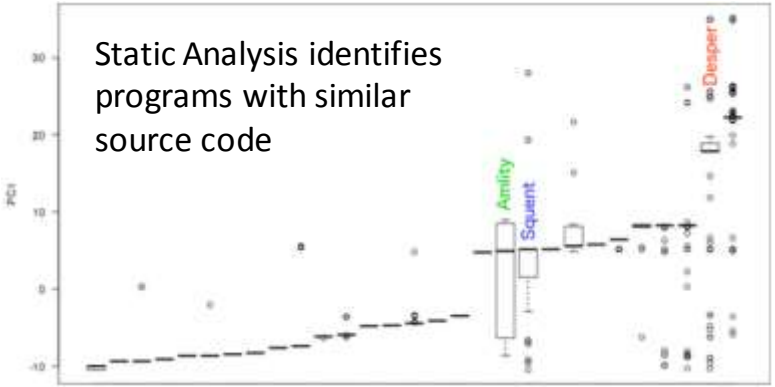


Signal Flow graph highlights behavior relating different malware families

Program instruction analysis shows similarity and diversion of behavior

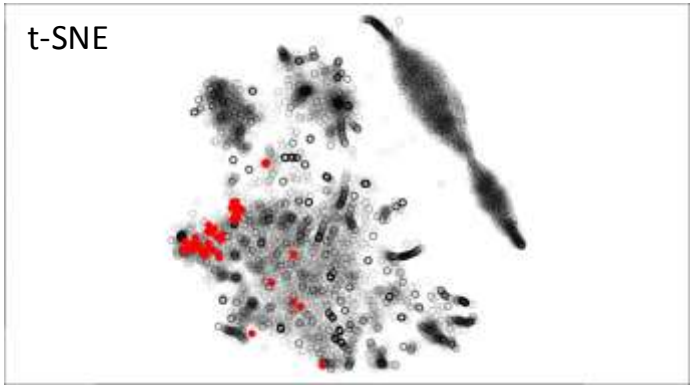


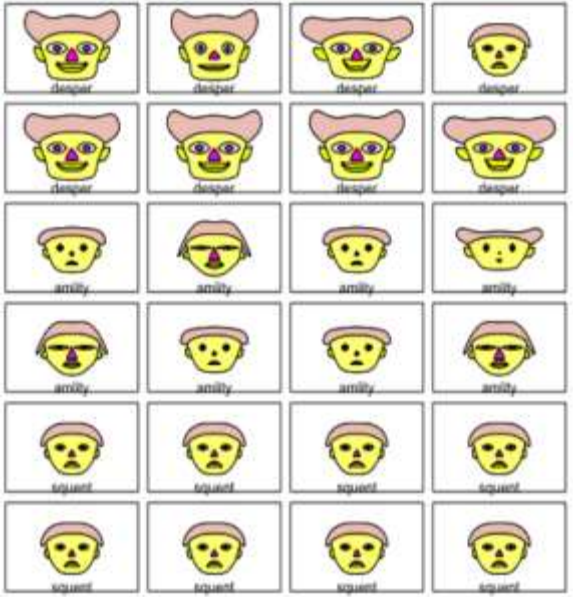
Static Analysis identifies programs with similar source code



Malware family classification – Visualization

Simplify visualization of extremely complex data through the use of dimensionality reduction and associated visualization techniques

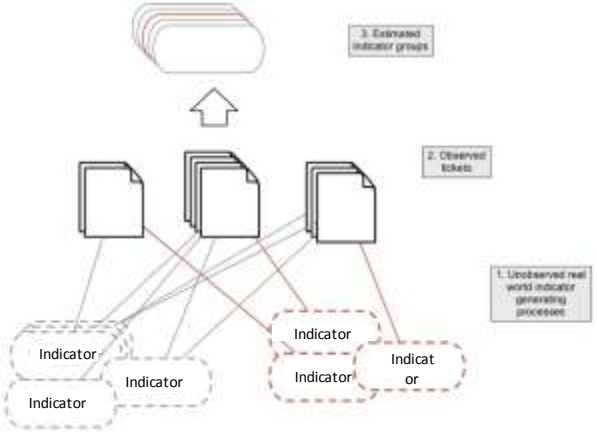




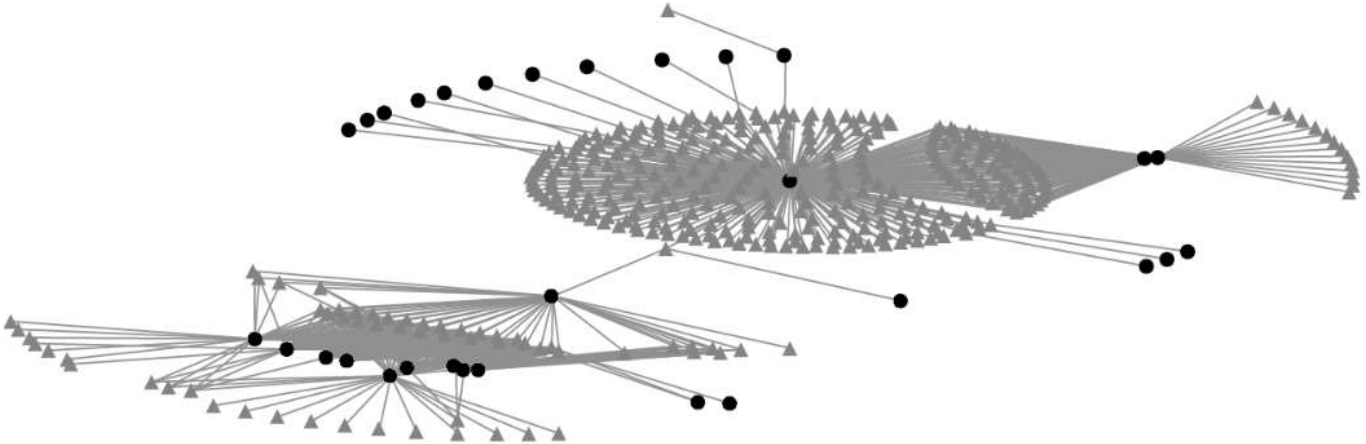
Chernoff face experiment

Incident Ticket analysis

Collections of incident tickets often contain hidden trends, revealing attacker methods and techniques that are invisible in individual tickets. Natural Language Processing helps find these trends.



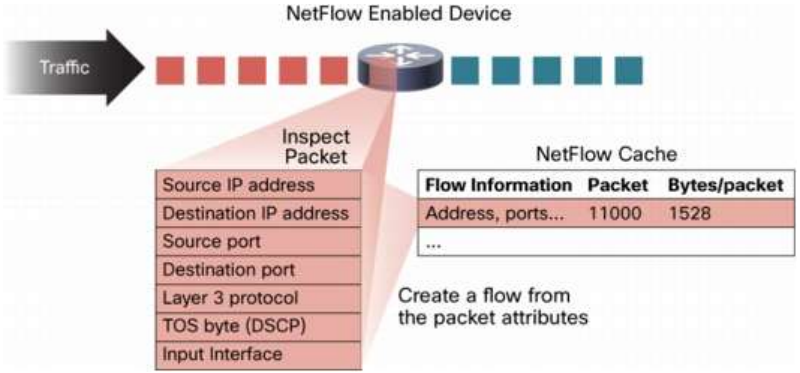
Incident Ticket analysis – Visualization



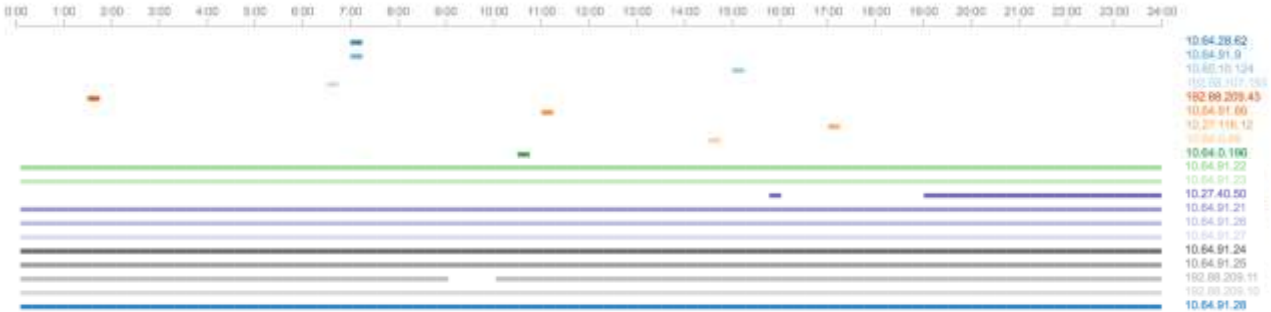
A subset of the ticket-indicator graph
(for a small set of selected indicators)

- Tickets are grey triangles
- Indicators are black circles
- Edges connect tickets to the indicators they contain

Network traffic classification



Netflow data summarizes network traffic, losing significant information. Numerous techniques exist to infer information from the flows themselves.



Other Applications

APT Defense

Relation of kinetic and cyber actions

Automated forecasting and detection of cyber-attacks

Static code analyzer behavior

OSINT Analysis

Technical debt estimation

Cognitive support for assurance using Watson

Optimizing planning budgets for travel

Email sentiment analysis

IoT based search-and-rescue

Application of Data Science to Cybersecurity

Selected current projects

Deepfake LINE

What is a deepfake?

"Believable media generated by a deep neural network"

-- Mirsky and Lee (2020)

Conceptual Example of a Faceswap Deepfake
The target's face is placed on the source's face.

Deepfakes are no longer theoretical threats only

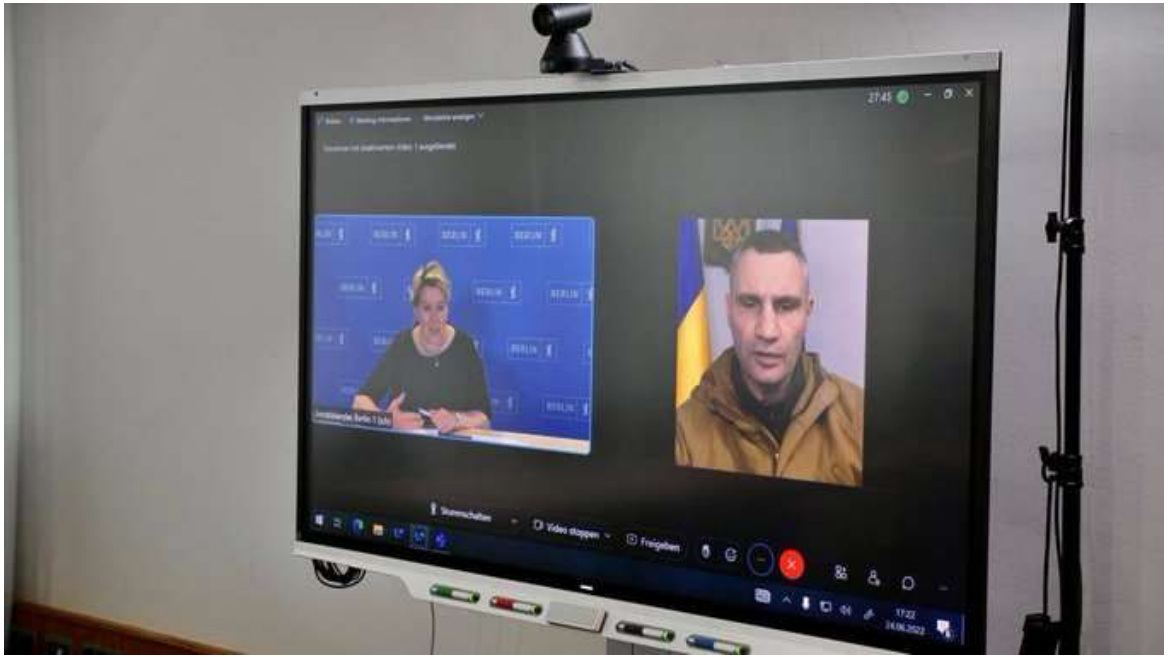


Image from DW.com. The righthand side image is an example of a deepfake used to impersonate the mayor of Kyiv. Brackets are ours.

Potential Dangers:

- Impersonation of political figures and celebrities
- Defamation of citizens
- Mis-, dis-, and mal-information
- >700k hours of video uploaded to web every day!

We need robust detectors!

And more deepfakes in the news…

A Deepfake Phone Call Dupes An Employee Into Giving Away $35 Million

Think your business is too small to be fooled? Think again.

By Gene Marks

January

A Telegram bot network is being used to create deepfake nudes

It has produced naked images of at least 104,000 women.

Deepfakes come to remote job interviews

Is that a real person you're interviewing, or are you talking to a stolen identity?

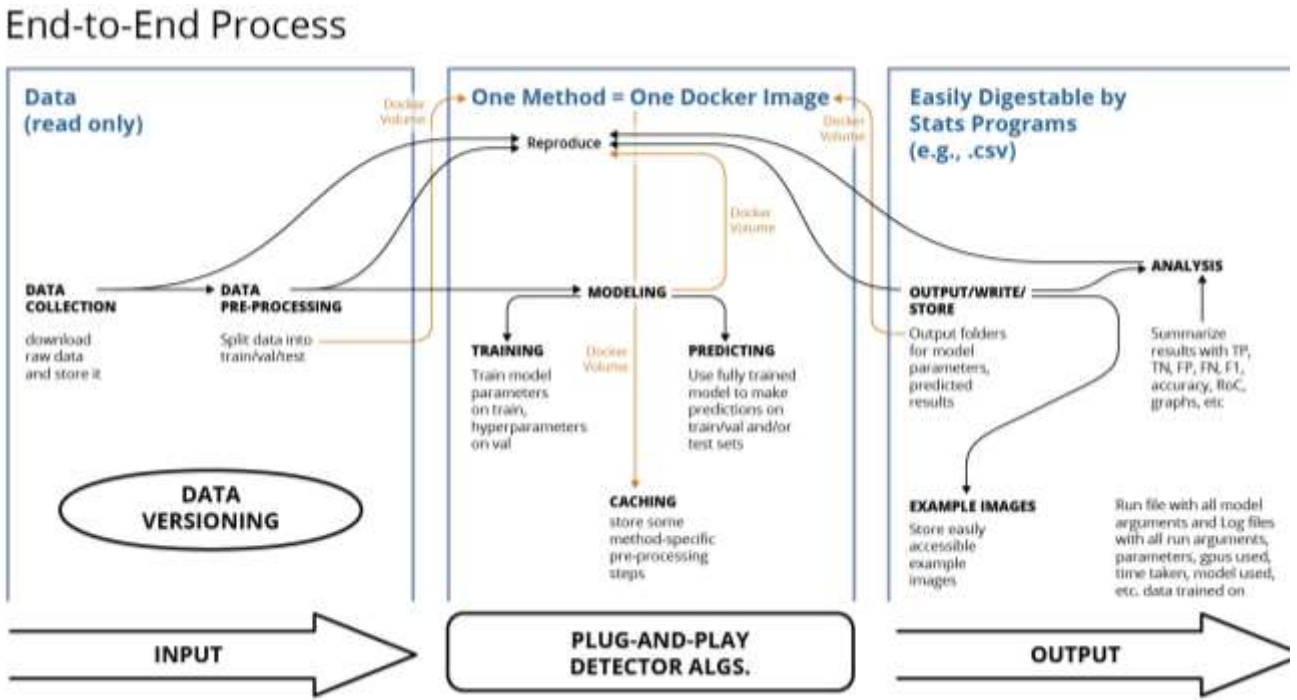
By Mike Elgan

Contributing Columnist, Computerworld | JUL 7, 2022 4:30 AM PDT

But there are differences between real and deepfake images

- Hairline
- Edges of eyes
- Corners of mouth
- Chin
- Eyebrows
- Nose

Our AI/ML solution: Deepfake Detection Pipeline (DDP)



DDP is reproducible, portable, and modular

Future Directions

Current work is focused on deepfake people in images & video

Future directions of work may include:

- Deepfake audio
- Deepfakes objects
- Object detection
- Object classification
- Cyber-physical sensing

NSA 5G (& Future G) Trust Modeling/Trust Decay

AI/ML Model Description

- Implement a trust score (*T)* between 0 and 1 for each device
  - 1 = high trust
  - 0 = low trust

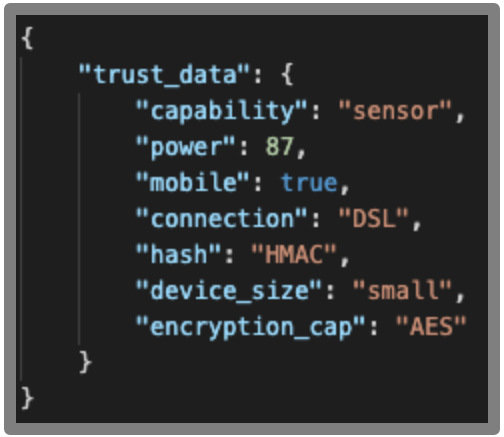
- Trust score is a function of
  - Time (probably decreases over time, but not always)
  - Individual device profile
  - Slice profile (or data analytics)

Trust Model Data = Message + UE (device) Profile + Slice Profile
Security: High

Message

```
{
    "message": {
        "contents": "Hello World",
        "sender": "10.33.48.19",
        "receiver": "10.29.22.13",
        "time": "2022March21_1420_GMT"
    }
}
```

UE Profile



```
{
    "trust_data": {
        "capability": "sensor",
        "power": 87,
        "mobile": true,
        "connection": "DSL",
        "hash": "HMAC",
        "device_size": "small",
        "encryption_cap": "AES"
    }
}
```

Slice Profile

```
{
    "slice_profile": {
        "id": "qiou783",
        "security": "high",
        "n_registered_dev": 242,
        "n_active_dev": 98,
        "n_sent_by": {
            "10.33.48.19": 14
        },
        "trust_scores": [
            {"t0": {"10.33.48.19": 0.72}},
            {"t1": {"10.33.48.19": 0.87}},
            {"tn": {"10.33.48.19": 0.66}}
        ]
    }
}
```

Trust Score Model

$T_{SR}(t) = logit^{-1}(-\gamma^2 t - (\boldsymbol{X\beta}))$;
If $T_{SR}(t) < T^* \; then \; we \; do \; not \; trust \; sender$
such that *Probability*(we trust sender when we shouldn't) $\leq \alpha$

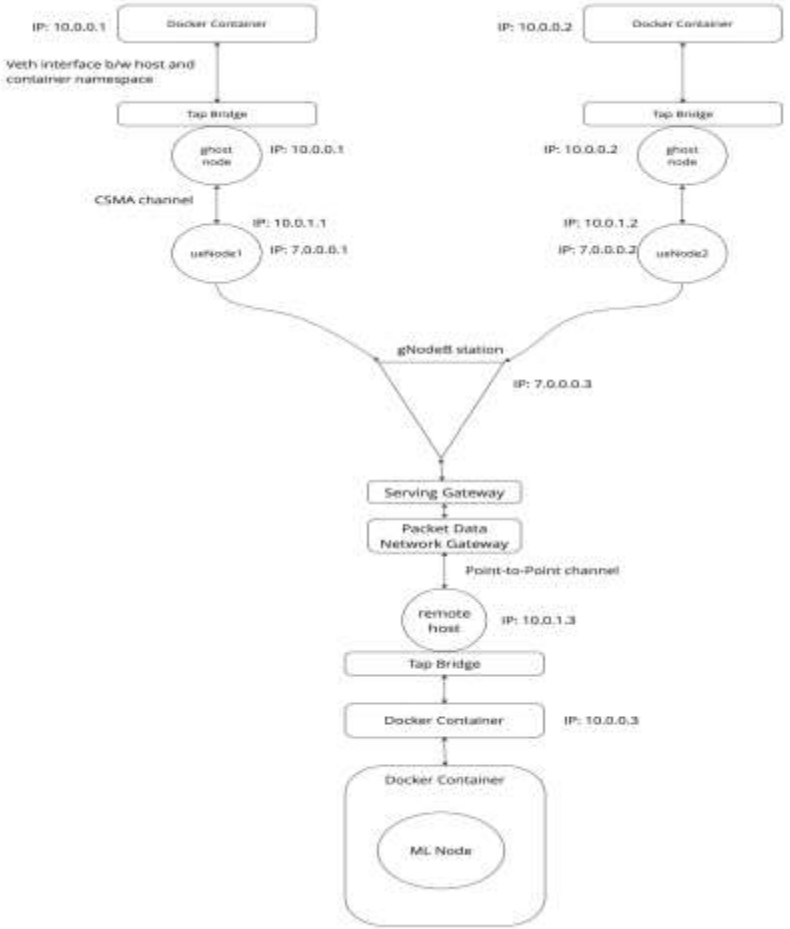
- $T_{SR}(t) =$ trust of sender by receiver at time t
- T^* = minimum trust threshold
- S = sender
- R = receiver
- α in [0,1] = maximum level of acceptable false positives
- t = time
- **X** = other features in metadata (message + UE + slice profile)
- T trust in [0,1] with 1 = max trust, 0 = no trust
- (γ), $(\boldsymbol{\beta})$, (T^*) = parameters to learn

Simulation Architecture: Overview

A network of nodes are connected in a client-server arrangement.

Packets flow into a server node that collects the data which is fed to an ML model.

Data is outputted as data packets and an ML model trained on the kind of data it received.



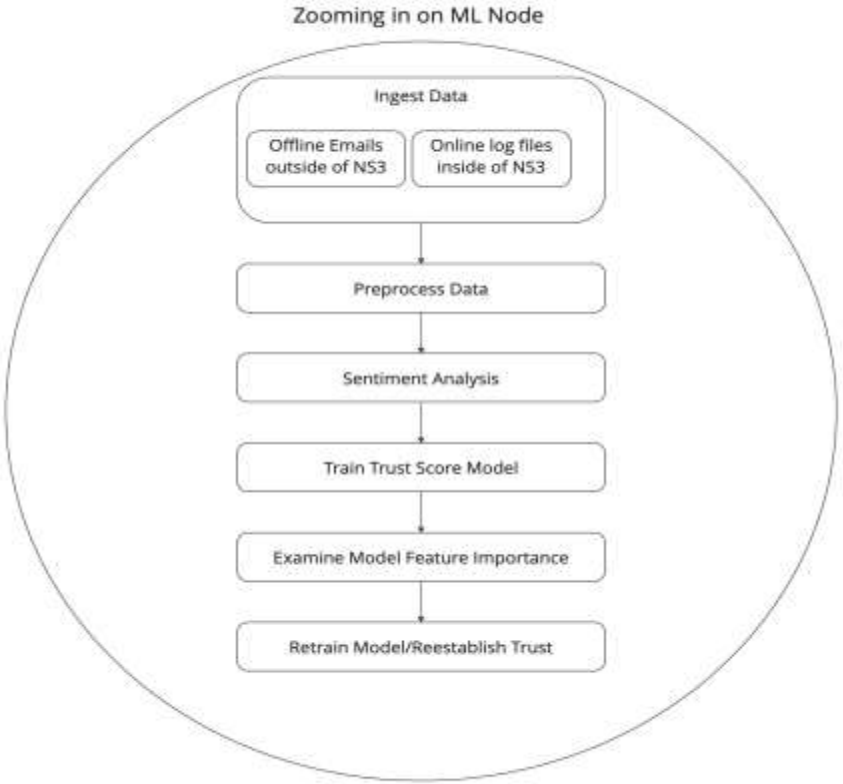
ML Node

A singular independent and adaptive AI/ML node will act as a quasi-trust manager and track device trustworthiness (trust score) and node behavior.

Organizing that node involves simulating the communication/info exchange between different nodes. We must consider the frequency of info exchange and how to go about asking for info. There will be other trust related parameters as well.

As seen on the previous slide, ML node/trust calculating engine will be in its own (Docker) container. If any nodes are questionable, then we want those nodes to become unavailable in the network, rather than just starting and stopping the data being streamed.

ML Pipeline



Future Directions

Current work is focused on trust of devices on wireless networks

Many areas where trust estimation is relevant:

- Messaging & communication
- OSINT credibility
- Intelligence analysis
- Open-source code trust-ability