Data Science for Cybersecurity
Hand-on Lab

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#infosecworld

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Data Science Tools

Data Science Tools

- **No-code and low-code**
  - Excel (spreadsheets and macros)
  - Orange (drag-and-drop machine learning)
- **Code-based tools**
  - Python (general language, many data science libraries)
  - R (statistics)
  - MATLAB (engineering)
- ***Many*** **other options**

The BETH Dataset

BETH Dataset

BETH* is a real cybersecurity dataset published in 2021 as a benchmark for anomaly detection researchers

- 8 million records, generated by 23 hosts, during 5 discontiguous hours
- Each host includes benign traffic as well as at most one single attack
- Each record is labeled as to whether it is “benign” or “malicious”

*Highnam, K., Arulkumaran, K., Hanif, Z., & Jennings, N. R. (2021). "BETH dataset: Real Cybersecurity Data for Anomaly Detection Research." ICML 2021 Workshop on Uncertainty and Robustness in Deep Learning. http://www.gatsby.ucl.ac.uk/~balaji/udl2021/accepted-papers/UDL2021-paper-033.pdf

BETH Dataset (cont.)

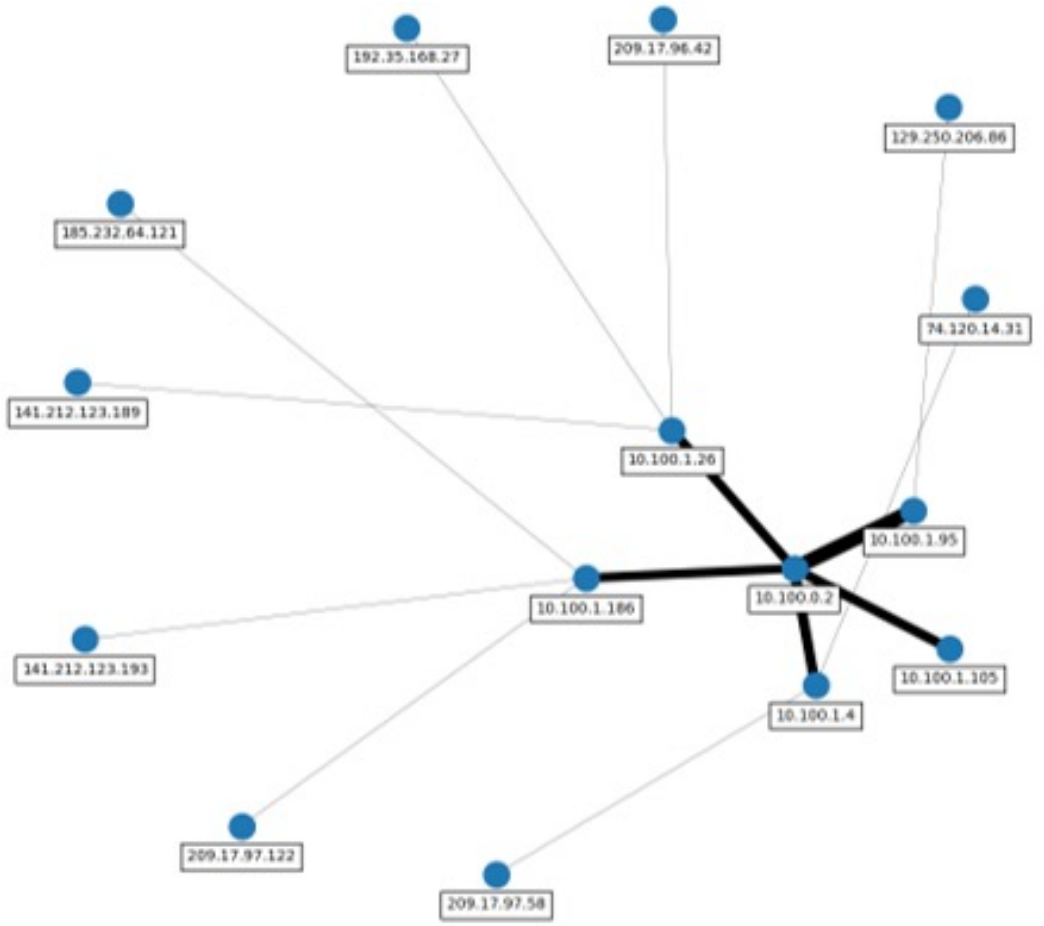
- **System log files**

timestamp	processId	threadId	parentProcessId	userId	mountNamespace	processName	hostName	eventId	eventName	stackAddresse	argsNum	returnValue	args	sus	evil
129.050634	382	382	1	101	4026532232	systemd-resolve	ip-10-100-1-217	41	socket	[1401591956	3	15	[{'name': 'do	0	0
129.051238	379	379	1	100	4026532231	systemd-network	ip-10-100-1-217	41	socket	[139853228(	3	15	[{'name': 'do	0	0
129.051434	1	1	0	0	4026531840	systemd	ip-10-100-1-217	1005	security_file_open	[1403628671	4	0	[{'name': 'pa	0	0
129.051481	1	1	0	0	4026531840	systemd	ip-10-100-1-217	257	openat	[]	4	17	[{'name': 'di	0	0
129.051522	1	1	0	0	4026531840	systemd	ip-10-100-1-217	5	fstat	[1403628671	2	0	[{'name': 'fd	0	0
129.051635	1	1	0	0	4026531840	systemd	ip-10-100-1-217	3	close	[1403628672	1	0	[{'name': 'fd	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

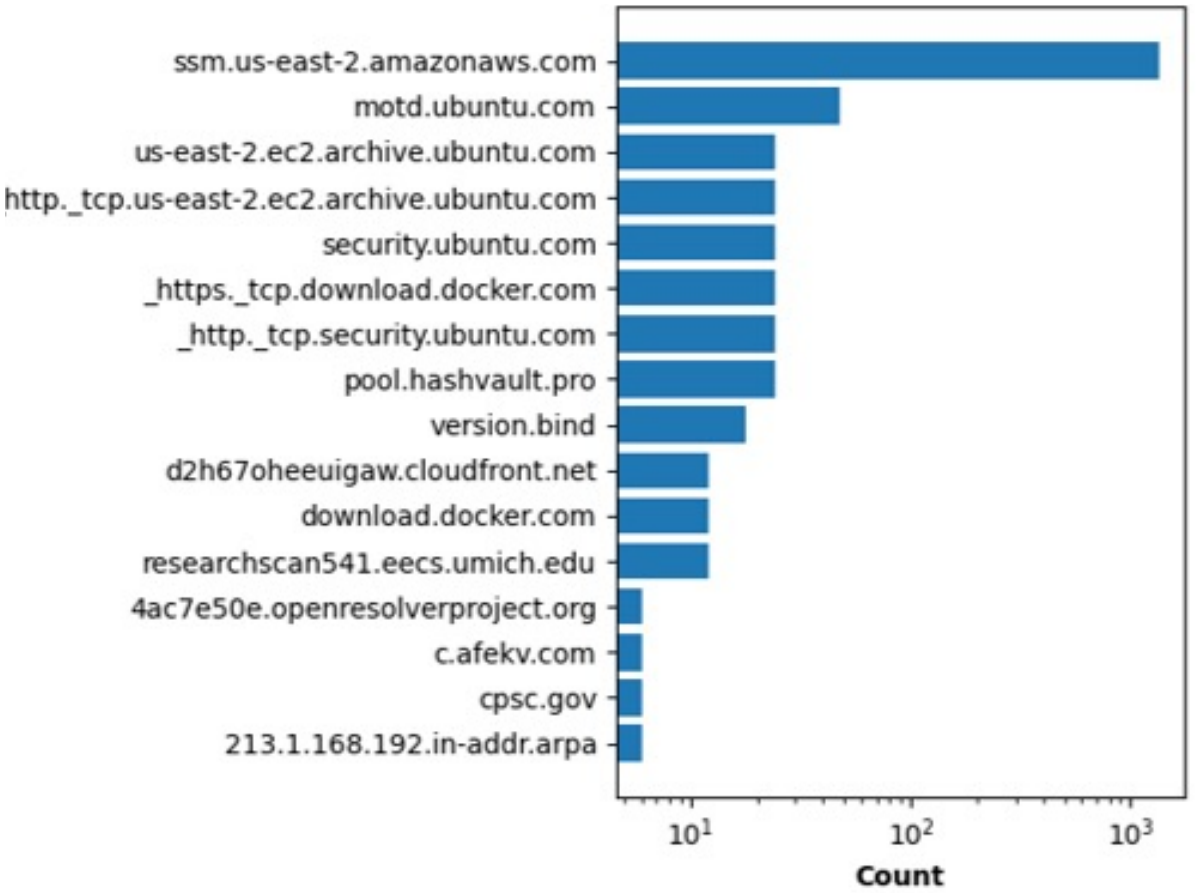
- **DNS query log files**

Timestamp	SourceIP	DestinationIP	DnsQuery	DnsAnswer	DnsAnswerTTL	DnsQueryNames	DnsQueryClass	DnsQueryType	NumberOfAnswers	DnsResponseCode	DnsOpCode	SensorId	sus	evil
2021-05-16T17:13:14Z	10.100.1.95	10.100.0.2	ssm.us-east-2.amazonaws.com			ssm.us-east-2.am	['IN']	['A']	0	0	0	ip-10-100-1-95	0	0
2021-05-16T17:13:14Z	10.100.0.2	10.100.1.95	ssm.us-east-2.ama	['52.95.19.240']	['17']	ssm.us-east-2.am	['IN']	['A']	1	0	0	ip-10-100-1-95	0	0
2021-05-16T17:13:14Z	10.100.1.95	10.100.0.2	ssm.us-east-2.amazonaws.com			ssm.us-east-2.am	['IN']	['AAAA']	0	0	0	ip-10-100-1-95	0	0
2021-05-16T17:13:14Z	10.100.0.2	10.100.1.95	ssm.us-east-2.amazonaws.com			ssm.us-east-2.am	['IN']	['AAAA']	0	0	0	ip-10-100-1-95	0	0
2021-05-16T17:13:16Z	10.100.1.186	10.100.0.2	ssm.us-east-2.amazonaws.com			ssm.us-east-2.am	['IN']	['A']	0	0	0	ip-10-100-1-186	0	0
2021-05-16T17:13:16Z	10.100.0.2	10.100.1.186	ssm.us-east-2.ama	['52.95.21.209']	['41']	ssm.us-east-2.am	['IN']	['A']	1	0	0	ip-10-100-1-186	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

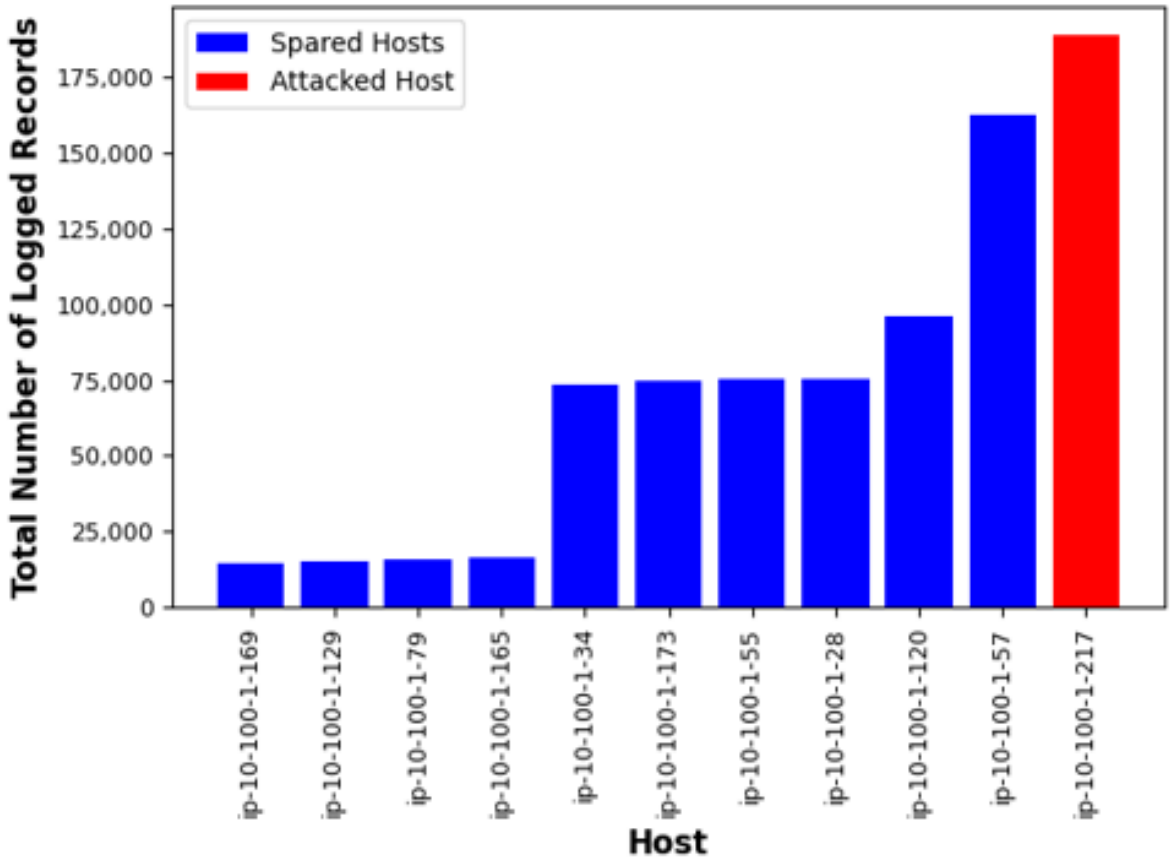
DNS Query Traffic between IP Addresses



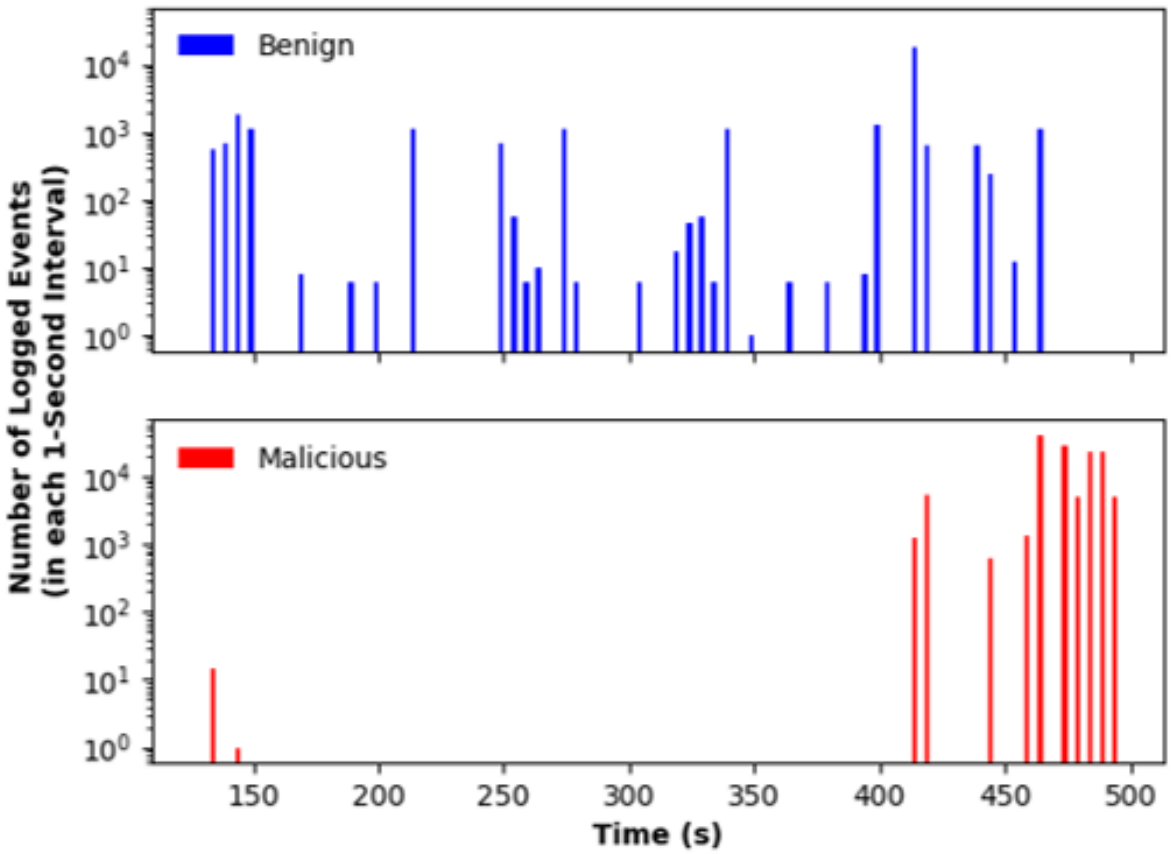
DNS Query Volume by Domain



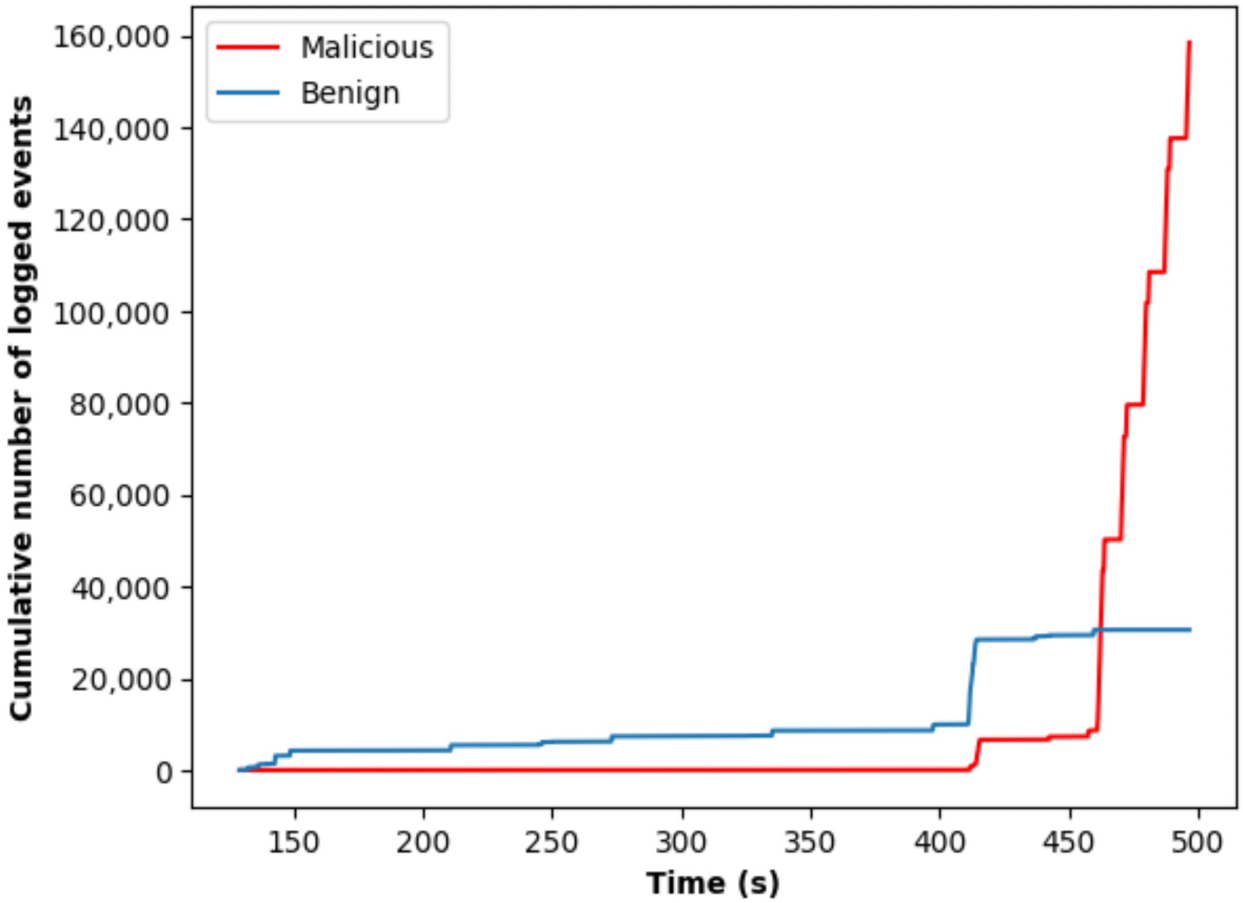
Logged Events by Host



Logged Events in Time on the Attacked Host



Logged Events in Time on the Attacked Host



Lab Environment Setup

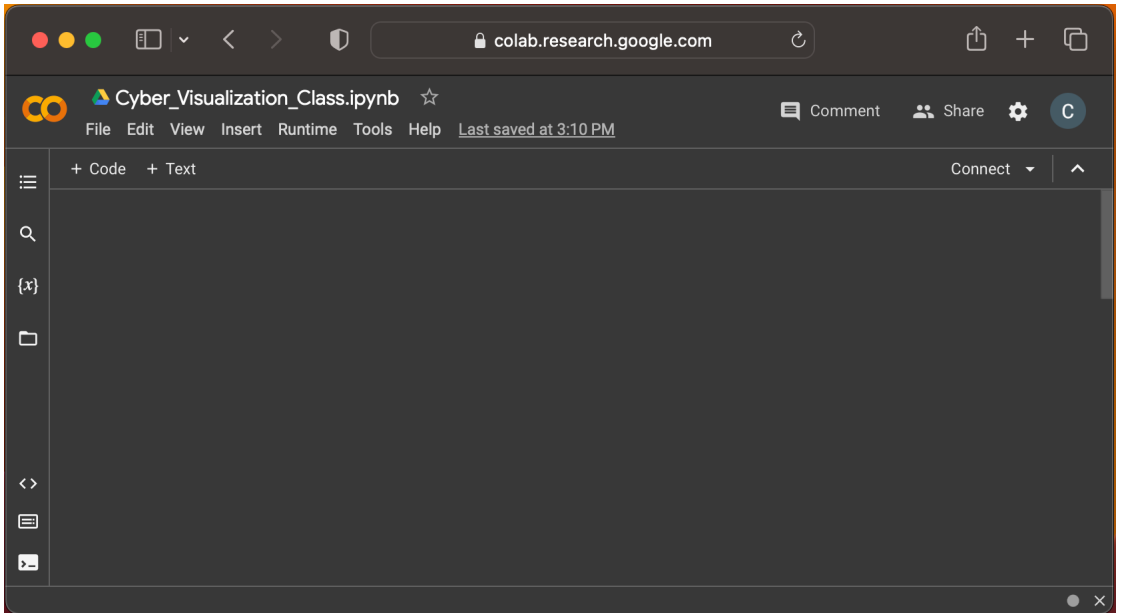
Environment Options

- **Option 1: Google Colab (recommended)**
  - Write and execute code in a browser
  - No installation required
  - Requires gmail account
  - https://colab.research.google.com

- **Option 2: Student-preferred python environment**

Getting Started

- Sign into your gmail account in your browser
- Go to https://colab.research.google.com
- Click “File → New Notebook”



Tour of Google Colab Functionality

- Add and execute code cells
- Add formatted text cells
- Import data

Hands-on Exercise

Install and Import Libraries

```
!pip install umap-learn
import umap
```

Read .csv into Pandas Dataframe

```
df = pandas.read_csv('data.csv')
df.dtypes
```

View First 5 Records

```
df.head()
```

Histograms of the Raw Data

```
df.hist(figsize=(12, 10))
plt.tight_layout()
```

Histograms of the Engineered Features

```
df_eng, X, y = preprocess(df)
df_eng.hist(figsize=(12, 10))
plt.tight_layout()
```

Correlations Plot

```
correlations = df_eng.corr()
seaborn.heatmap(correlations, cmap='vlag')
plt.show()
```

UMAP Dimensionality Reduction

```
manifold = umap.UMAP().fit(X)
X_reduced = manifold.transform(X)
```

Fit Anomaly Detection Model

```
model = sklearn.ensemble.IsolationForest().fit(X)
```