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How Transactional Machine Learning (TML) Processing and Machine Learning Works? And Other Details

Dr. Sebastian Maurice
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TML Overview

- Transactional Machine Learning (TML) is a platform technology that performs high-speed processing and machine learning on **real-time data streams**

- TML is comprised of 3 Binaries (for Linux/Mac/Windows on AMD/ARM/PPC chipsets 32 and 64-bit) found on GitHub: https://github.com/smaurice101/transactionalmachinelearning

  1. MAADS-Viper (intelligent source/sink connector for Apache Kafka)
  2. MAADS-HPDE (Auto Machine Learning Technology)
  3. MAADS-Viperviz (Visualization Streaming over Websockets)

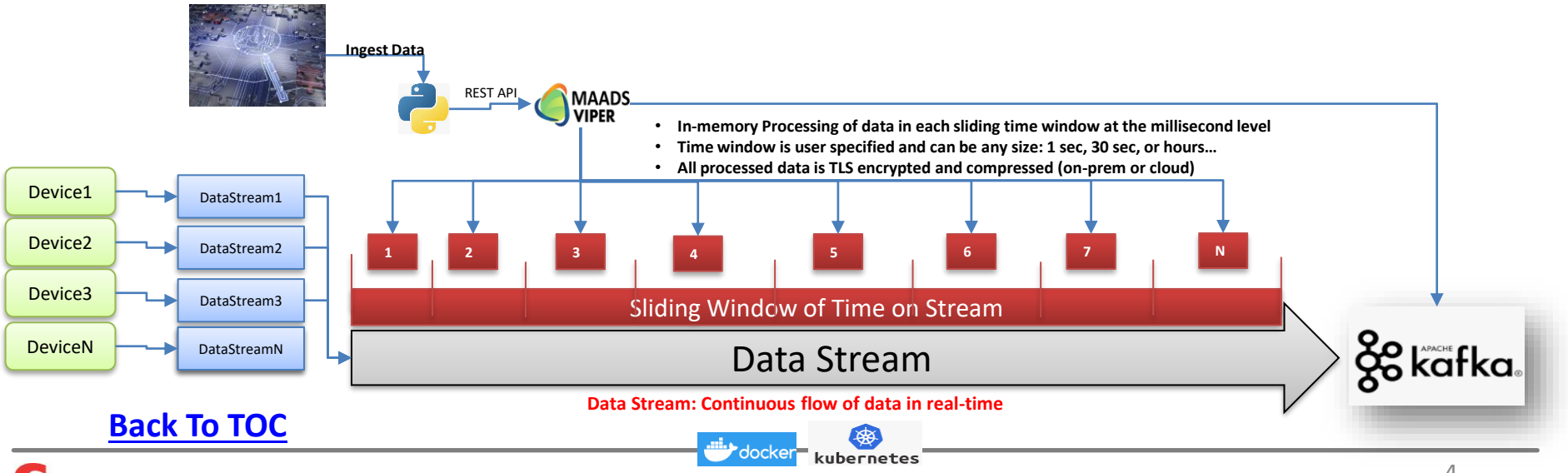
- Binaries are developed using Go programming language
- TML Solutions are developed using the MAADSTML Python Library: https://pypi.org/project/maadstml/

- TML Binaries are integrated with Apache Kafka (the platform for storing and managing real-time data): https://kafka.apache.org

- All TML Processing is performed In-Memory and TML does not use SQL queries for processing and machine leaning – **it processes devices at the ENTITY LEVEL – meaning each device (data) is processed individually.**
  - It is currently the only technology that performs, entity level, in-memory processing, AutoML, no SQL on data streams with Apache Kafka
  - TML solutions scale with Docker and Kubernetes
- Transactional Machine Learning Book can be found on Amazon
- TML is taught at Seneca in select courses

How TML Preprocessing works?

- All data streams from devices flow into Apache Kafka to a Kafka Topic
- TML performs **in-memory** processing of data in the Kafka Topic using TWO components across all **sliding time windows**
  - Python Script that uses the MAADSTML python library functions
  - MAADS-VIPER binary that can run in Linux, Mac, Windows (or other operating systems) on any Chip (32 or 64 bit) architecture (AMD, ARM, PPC, S390x, etc.)
- REST API connect MAADSTML python script to MAADS-VIPER
- 35+ different processing types: min, max, dataage, timediff, variance, anomaly prediction, outlier detection, etc…
- Apache Kafka is the central source of both input and output data – ***no external real-time database needed***
- ***No SQL queries are made for processing and machine learning***
- *Our technology can process unlimited number of devices (billions at high speed)*
- All TML solutions are containerized with Docker and scale with Kubernetes



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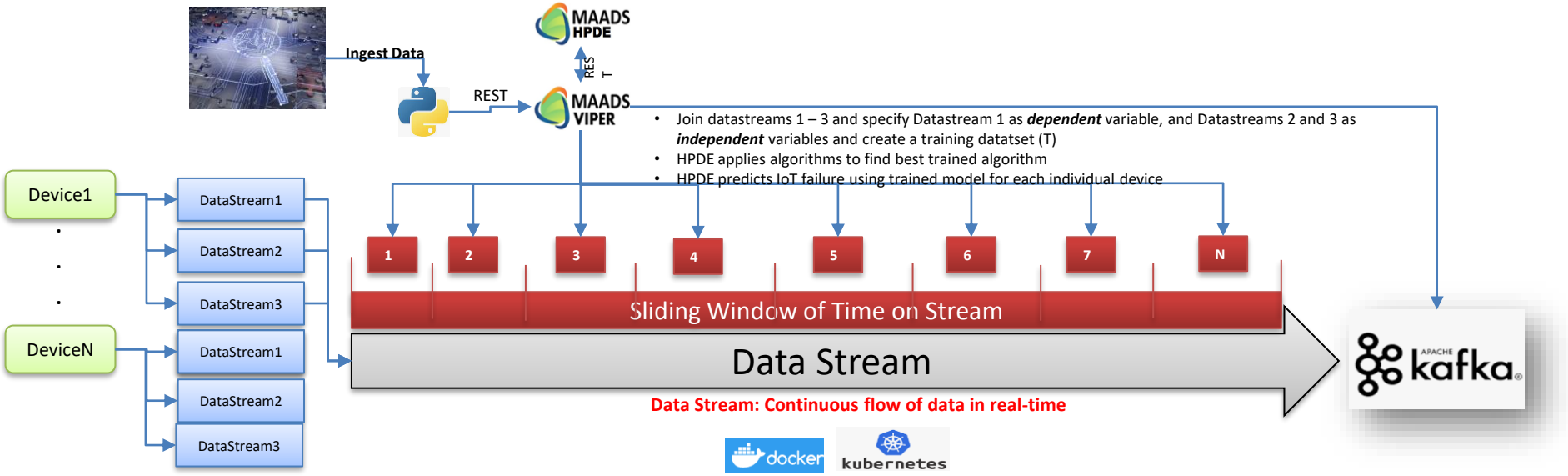
How TML Machine Learning works?

- All data streams from devices flow into Apache Kafka to a Kafka Topic
- TML performs **in-memory** machine learning of data in the Kafka Topic by **joining data streams** using THREE components across all **sliding time windows**:
  - Python Script that uses the MAADSTML python library functions
  - MAADS-VIPER binary that can run in Linux, Mac, Windows (or other operating systems) on any Chip (32 or 64 bit) architecture (AMD, ARM, PPC, S390x, etc.)
  - MAADS-HPDE binary that can run in Linux, Mac, Windows (or other operating systems) on any Chip (32 or 64 bit) architecture (AMD, ARM, PPC, S390x, etc.)

- REST API connect MAADSTML python script to MAADS-VIPER and MAADS-HPDE
- 5 different algorithm types: logistic regression, linear regression, gradient boosting, neural networks, ridge regression
- Apache Kafka is the central source of both input and output data for estimated parameters – ***no external real-time database needed***
- ***TML auto-creates individual machine learning models for each Device at the "entity" level and joins datastreams 1-3 for each device and user specifies "Dependent" variable streams, and "Independent" variables streams***
- *Our technology can build unlimited machine learning models (billions at high speeds) for unlimited number of devices (billions at high speed)*
- All TML solutions are containerized with Docker and scale with Kubernetes



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How TML Processes JSON data in real-time?

- TML uses json paths (fields) to extract data from JSONs
- It processsees a group of JSONs in a sliding time window by using a field called **Jsoncriteria – which requires a user to indicate how they want to extract data from a grouped or aggregate json messages in sliding time window**

- **A jsoncriteria has 7 fields:**
- jsoncriteria=
- 'uid=,filter:allrecords~\ ← **uid**: This is the json field to group by for example DSN or Device SerialNumber
- **subtopics=**~\ ← **subtopics:** This is the json field to the name of the field you want to process
- **values=**~\ ← **values:** This is the json field containing the value of the subtopic
- **identifiers=**~\ ← **identifier:** This is the json field containing any label or identifier for the values
- **datetime=**~\ ← **datetime:** This is the json field containing datetime, must be in UTC format – i.e. 2006-01-02T15:04:05
- **msgid=**~\ ← **msgid:** this is the json field containing further details about the values
- **latlong=**‘ ← This is json field contain latitude and longitude. You can use a “:” to combine lat:long

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How TML Processes JSON data in real-time? Example

- If I have:

- {"metadata":{"oem_id":"32795e59","oem_model":"SQR141U1XXW","dsn":"AC000W016399396","property_name":"Power","display_name":"Power (mW)","base_type":"integer","event_type":"datapoint"},"datapoint":{"id":"de3e8f0e-7faa-11ec-31cb-6b3a1eb15a96","updated_at":"2022-01-27T19:53:59Z","created_at":"2022-01-27T19:53:59Z","echo":false,"closed":false,"value":"0","metadata":{},"created_at_from_device":"2022-01-27T19:51:40Z","user_uuid":"f4d3b326-da9a-11eb-87af-0a580ae966af","discarded":false,"scope":"user","direction":"output"} , “lat”: 29.22, “long”: -141.22}
- {"metadata":{"oem_id":"32795e59","oem_model":"SQR141U1XXW","dsn":"AC000W016399396","property_name":"Current","display_name":"Current (mA)","base_type":"integer","event_type":"datapoint"},"datapoint":{"id":"de422f10-7faa-11ec-3925-f218ec2b4e1d","updated_at":"2022-01-27T19:53:59Z","created_at":"2022-01-27T19:53:59Z","echo":false,"closed":false,"value":"0","metadata":{},"created_at_from_device":"2022-01-27T19:51:40Z","user_uuid":"f4d3b326-da9a-11eb-87af-0a580ae966af","discarded":false,"scope":"user","direction":"output"} , “lat”: 28.22, “long”: -140.22}
- {"metadata":{"oem_id":"32795e59","oem_model":"SQR441U1XXW","dsn":"AC000W016399127","property_name":"EnergyUsed","display_name":"Energy Used (mWh)","base_type":"integer","event_type":"datapoint"},"datapoint":{"id":"de3f833c-7faa-11ec-b4ba-126e4b986056","updated_at":"2022-01-27T19:53:59Z","created_at":"2022-01-27T19:53:59Z","echo":false,"closed":false,"value":"2668340","metadata":{},"created_at_from_device":"2022-01-27T19:51:31Z","user_uuid":"c4d88504-64b4-11eb-902d-0a580ae9bff0","discarded":false,"scope":"user","direction":"output"} , “lat”: 24.22, “long”: -149.22}
- {"metadata":{"oem_id":"32795e59","oem_model":"SQR441U1XXW","dsn":"AC000W016399127","property_name":"EnergyUsed24hr","display_name":"Energy Used 24hr (mWh)","base_type":"integer","event_type":"datapoint"},"datapoint":{"id":"de475850-7faa-11ec-dfce-f2bfc16ef579","updated_at":"2022-01-27T19:53:59Z","created_at":"2022-01-27T19:53:59Z","echo":false,"closed":false,"value":"0","metadata":{},"created_at_from_device":"2022-01-27T19:51:31Z","user_uuid":"c4d88504-64b4-11eb-902d-0a580ae9bff0","discarded":false,"scope":"user","direction":"output"}, “lat”: 23.22, “long”: -143.22}

- I can extract, group and process them by specifying the following JSON criteria:
- jsoncriteria=
- 'uid= metadata.dsn,filter:allrecords~\ ← **uid**: This is the json field to group by for example DSN or Device SerialNumber
- subtopics= metadata.property_name~\ ← **subtopics:** This is the json field to the name of the field you want to process
- values= datapoint.value~\ ← **values:** This is the json field containing the value of the subtopic
- identifiers= metadata.display_name~\ ← **identifier:** This is the json field containing any label or identifier for the values
- datetime= datapoint.updated_at~\ ← **datetime:** This is the json field in UTC format – i.e. 2006-01-02T15:04:05
- msgid= datapoint.id ~\ ← **msgid:** this is the json field containing further details about the values
- latlong=lat:long‘ ← This is json field contain latitude and longitude. You can use a “:” to combine lat:long

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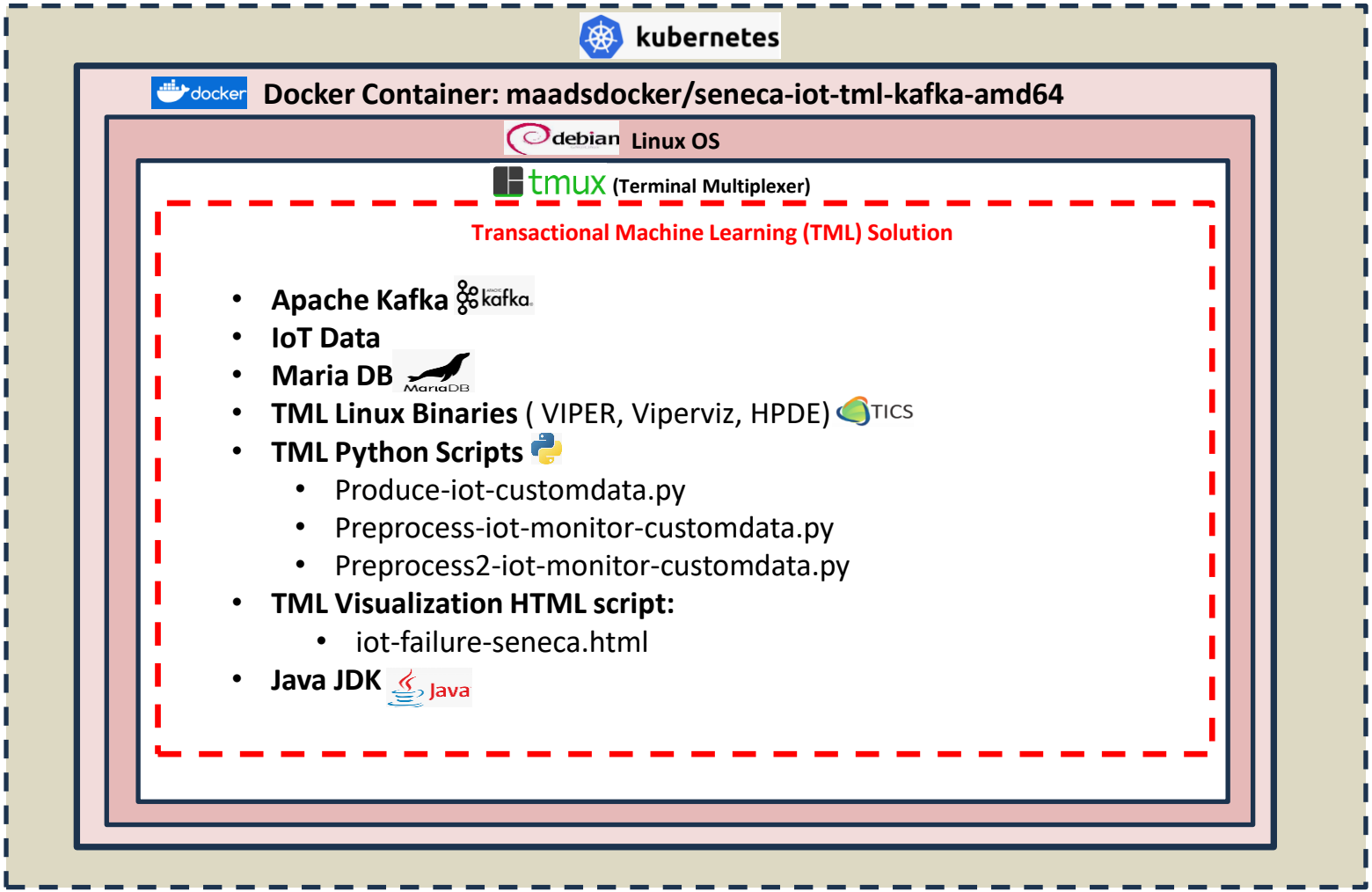
TML Solution Container (Linux/Mac)



Mac user: maadsdocker/seneca-iot-tml-kafka-mac

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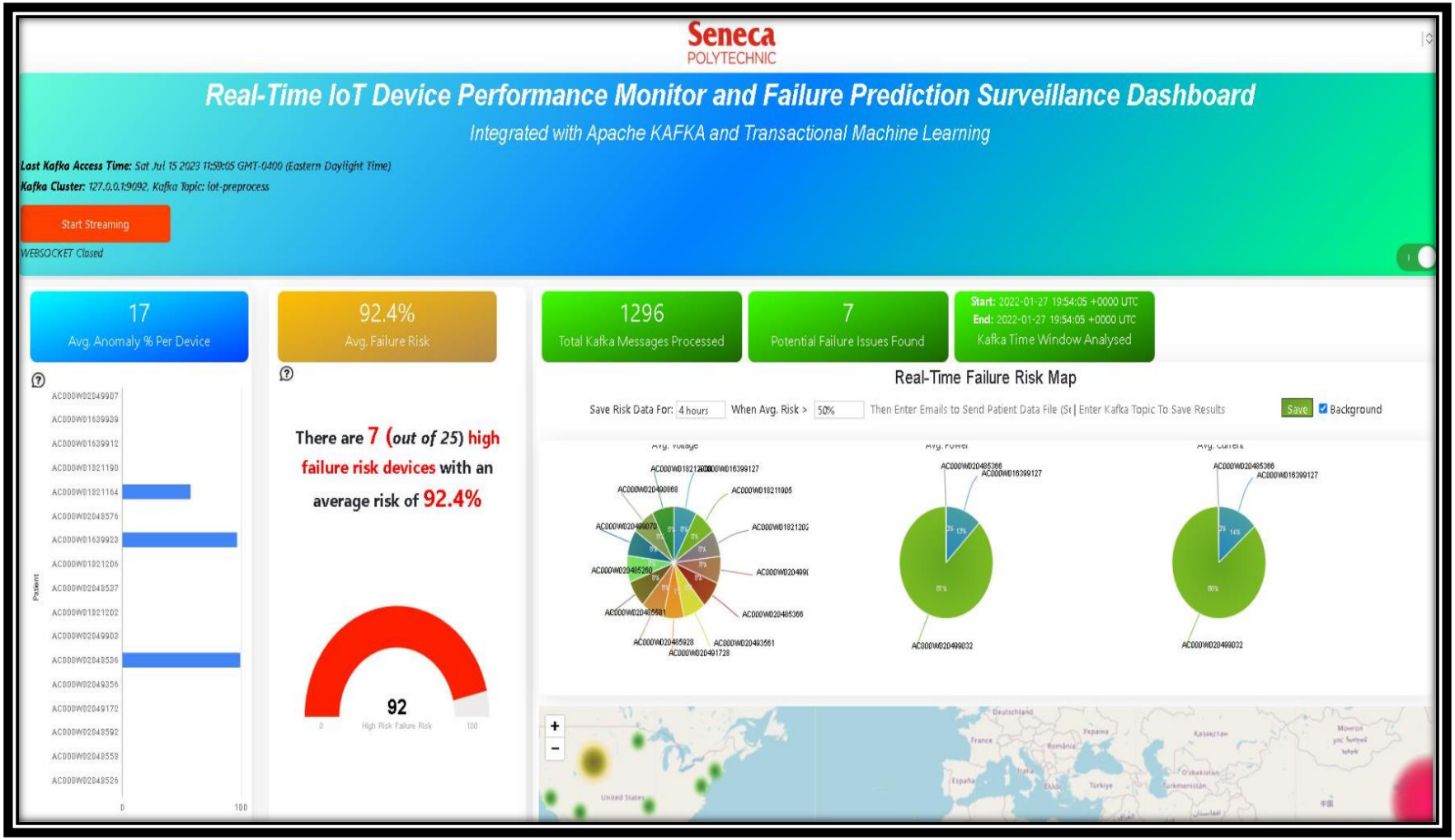
TML IOT Dashboard



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TML LOG STREAMING

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VIPER LOG STREAM: *viperlogs*

Last Kafka Access Time: Sat Aug 19 2023 11:16:11 GMT-0400 (Eastern Daylight Time)

Kafka Cluster: 127.0.0.1:9092, Kafka Topic: viperlogs

Stop Streaming

Download Table as CSV | Download JSON

Status: WEBSOCKET OPEN..Receiving Kafka messages from VIPERviz (RUNNING..)

	Generated	Message	Service	Service Host	Service Port	Kafka Cluster	Offset	Partition
1	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5368 UTC] INFO [parsesubtopics Record(s) found=Voltage. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,845	0
2	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5368 UTC] INFO [parsesubtopics Record(s) found=Voltage. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,851	0
3	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5368 UTC] INFO [parsesubtopics Record(s) found=Voltage. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,854	0
4	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5368 UTC] INFO [parsesubtopics Record(s) found=Voltage. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,855	0
5	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5368 UTC] INFO [parsesubtopics Record(s) found=EnergyUsed24hr. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,856	0
6	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5368 UTC] INFO [parsesubtopics Record(s) found=EnergyUsed. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,846	0
7	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5368 UTC] INFO [parsesubtopics Record(s) found=EnergyUsed. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,852	0
8	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5368 UTC] INFO [parsesubtopics Record(s) found=EnergyUsed. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,853	0
9	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5368 UTC] INFO [parsesubtopics Record(s) found=Current. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,849	0
10	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5368 UTC] INFO [parsesubtopics Record(s) found in Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,859	0
11	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5367 UTC] INFO [parsesubtopics Record(s) found=Voltage. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,842	0
12	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5367 UTC] INFO [parsesubtopics Record(s) found=Voltage. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,850	0
13	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5367 UTC] INFO [parsesubtopics Record(s) found=Power. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,829	0
14	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5367 UTC] INFO [parsesubtopics Record(s) found=Power. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,832	0
15	2023-08-19T15:16:02.629+00:00	[Sat, 19 Aug 2023 15:16:01.5367 UTC] INFO [parsesubtopics Record(s) found=Power. In Topic=iot-mainstream - Viper writing results to preprocesstopic=iot-preprocess. YOU ARE STREAMING!]	VIPER	172.17.0.2	41,575	127.0.0.1:9092	16,835	0

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STEPS TO RE-CREATING TML IOT SOLUTION FOR STUDENTS on WSL (Windows Subsystem for Linux)

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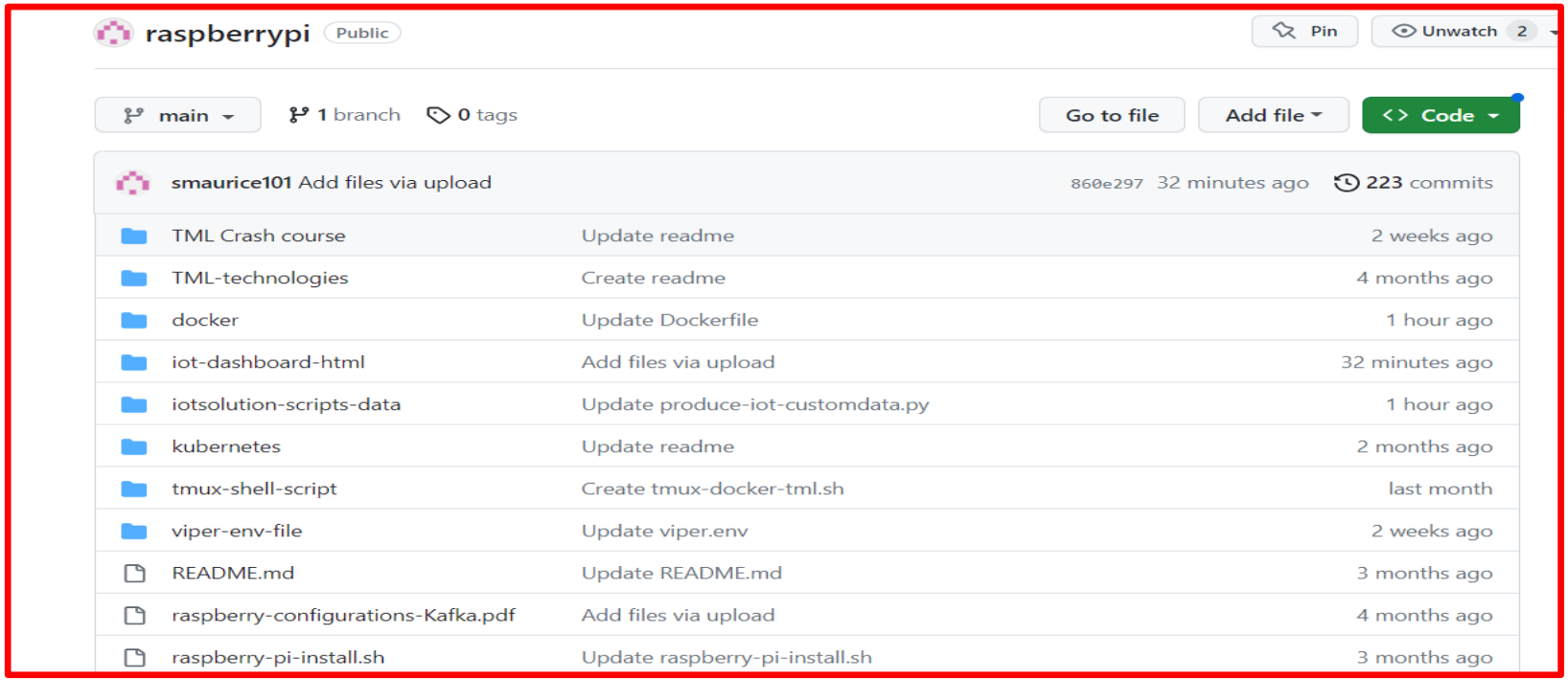
TML Student Solution: Re-Creating TML Solution

- Students can build their own streaming solution
- Before building your own solution – students re-create the solution **in Slide 6 and 7 to learn the components**

STEPS TO TAKE TO RE-CREATE IOT SOLUTION:

1. **Create your own Git Repository (DO NOT ADD readme.md) by cloning:**
   a) **https://github.com/smaurice101/raspberrypi.git (you should see image below in YOUR OWN Github Account)**



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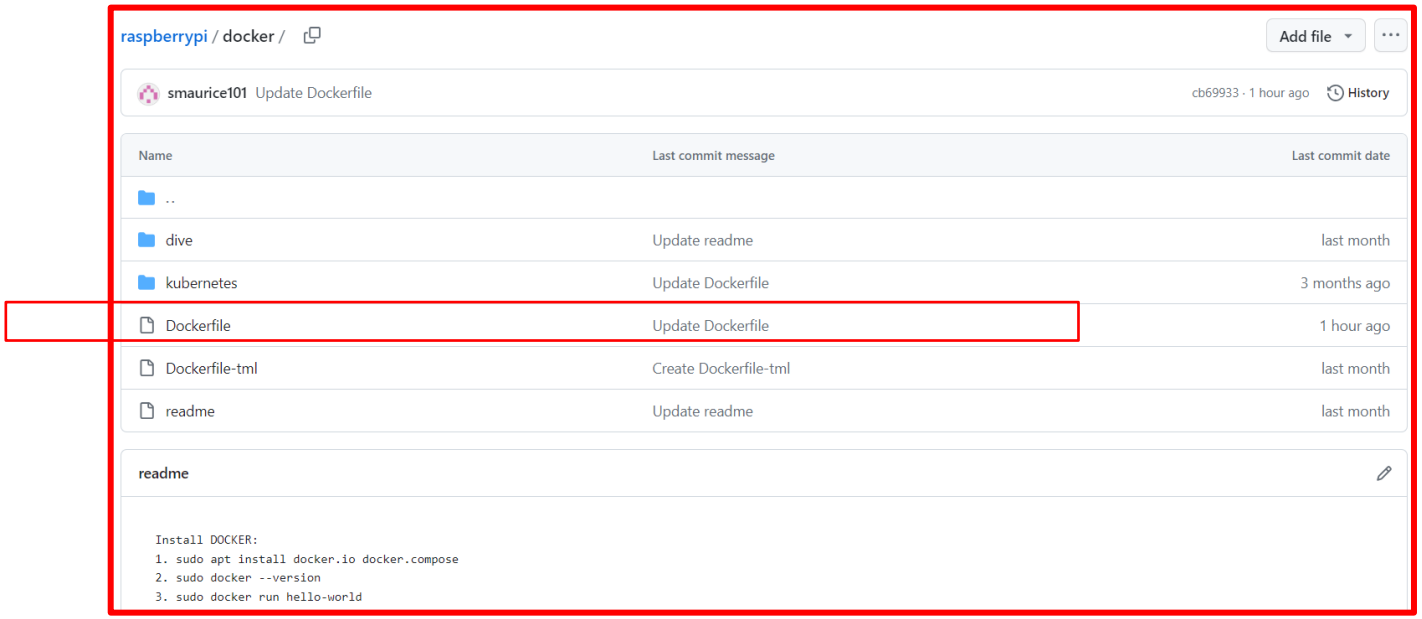
TML Student Solution: Re-Creating TML Solution

STEPS TO TAKE TO RE-CREATE IOT SOLUTION:

2. **Install docker in Linux VM or WSL (WSL is recommended):**
    1. **Run:** sudo apt install docker.io docker.compose
3. In your raspberry pi repo – GOTO **docker** folder
    1. **Copy** the **Dockerfile to your LOCAL computer** **(NOTE: File name MUST be exactly Dockerfile – no file extensions)**



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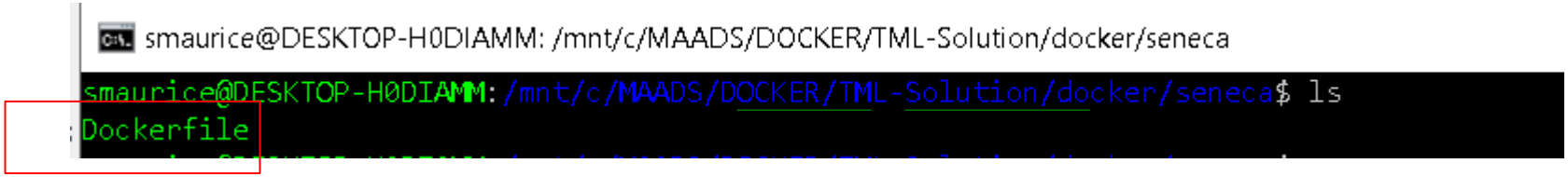
TML Student Solution: Re-Creating TML Solution

STEPS TO TAKE TO RE-CREATE IOT SOLUTION:

4. Go to the location where you stored Dockerfile on your LOCAL computer
    1. **Confirm Dockerfile exists**



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TML Student Solution: Re-Creating TML Solution

STEPS TO TAKE TO RE-CREATE IOT SOLUTION:

5. **Create** a Dockerhub Account: **https://hub.docker.com/**
   - My account is: **maadsdocker** **(REPLACE WITH YOUR OWN DOCKER HUB ACCOUNT)**

6. **RUN** docker build in the SAME folder where Dockerfile is saved:
   1. **Run: docker build -t maadsdocker/seneca-iot-tml-kafka-amd64 --build-arg CHIP=AMD64 --network=host .**
   2. **NOTE: The " . " at the end – this must be there**
   3. **NOTE: DO NOT USE YOUR GITHUB Account in docker build command**
   4. **NOTE: IF YOU ARE MAC USER – REPLACE CHIP=AMD64 with CHIP=MAC**
   5. You can choose any container name you wish

```
smaurice@DESKTOP-H0DIAMM:/mnt/c/MAADS/DOCKER/TML-Solution/docker/seneca$ docker build -t maadsdocker/seneca-iot-tml-kafk
a-amd64 --build-arg CHIP=AMD64 --network=host .
```

TIP: After you did your normal build – you can use the FASTER Docker Build command:
docker build -t maadsdocker/seneca-iot-tml-kafka-amd64 --build-arg CHIP=AMD64 --build-arg CACHEBUST=$(date +%s) --network=host .

OR FOR MAC USERS:
docker build -t maadsdocker/seneca-iot-tml-kafka-amd64 --build-arg CHIP=MAC --build-arg CACHEBUST=$(date +%s) --network=host .

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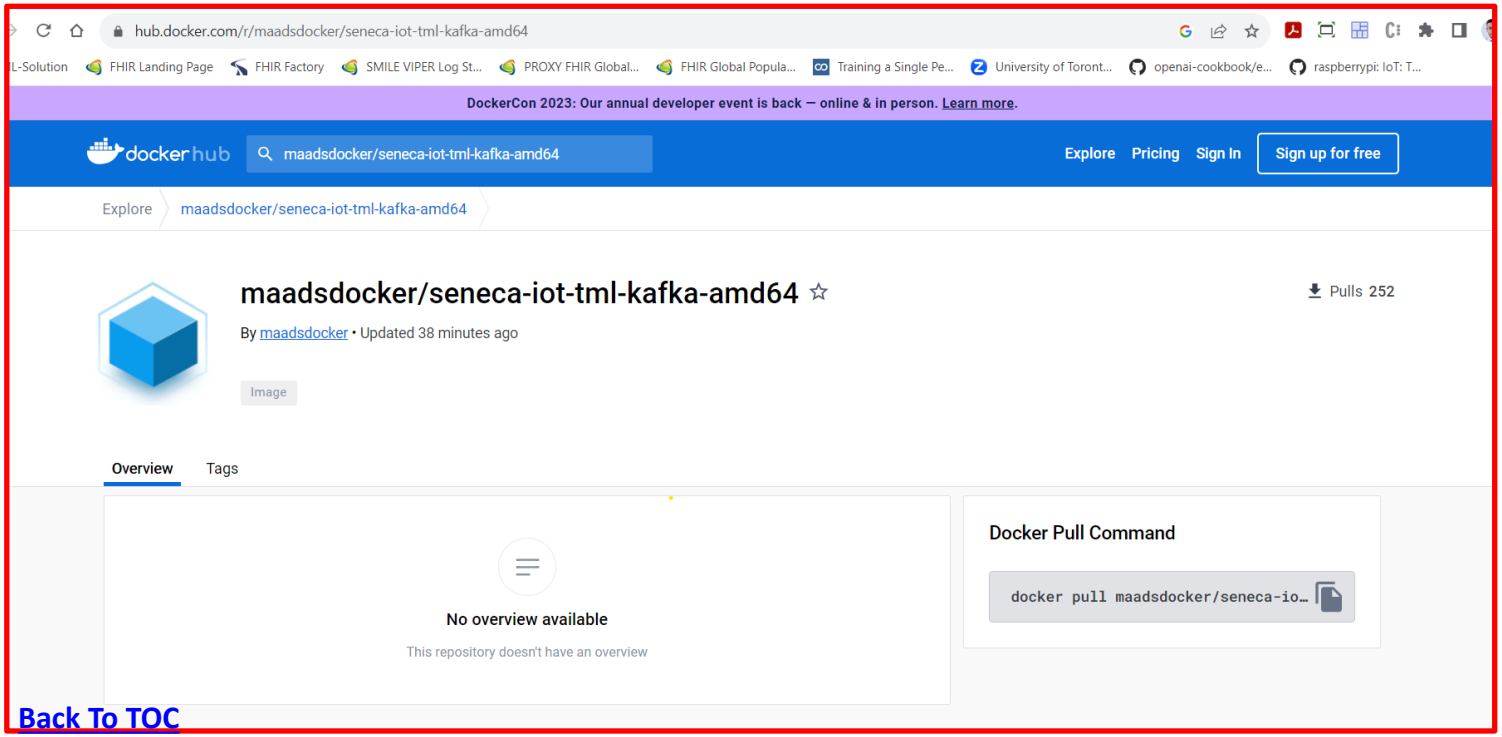
TML Student Solution: Re-Creating TML Solution

STEPS TO TAKE TO RE-CREATE IOT SOLUTION:

7. If your Docker build is successful you now have a Docker Container called: **seneca-iot-tml-kafka-amd64**
8. **You can now PUSH your container to your Docker Hub account:**
   - **Run: docker push maadsdocker/seneca-iot-tml-kafka-amd64**
9. If your Push is successful you will see your container in Docker Hub under your account



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TML Student Solution: Re-Creating TML Solution

STEPS TO TAKE TO RE-CREATE IOT SOLUTION:

10. **Run your container:**
    1. **Run: docker run -p 9005:9005 maadsdocker/seneca-iot-tml-kafka-amd64**
    2. **NOTE: The " -p" this will FORWARD Port 9005 and map HOST Port 9005 to CONTAINER Port 9005**
    3. **You MUST port forward for TML Dashboard to work**

```
smaurice@DESKTOP-H0DIAMM:/mnt/c/MAADS/DOCKER/TML-Solution/docker/seneca$ docker run -p 9005:9005 maadsdocker/seneca-iot-
tml-kafka-amd64
```

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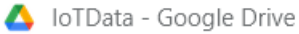
TML Student Solution: Re-Creating TML Solution

STEPS TO TAKE TO RE-CREATE IOT SOLUTION:

11. RAW DATA FOR SOLUTION:

1. https://docs.google.com/uc?export=download&id=1yRgDYrWnHu74NYX9GMAVDjR10ZyfoZvh



Students can change this path to their own data.

- Insert your file ID into this URL (https://drive.google.com/uc?export=download&id=), then surround the URL with quotes so that Bash doesn't misinterpret the &, like so:
- Get file ID by going to share -> copy link -> then get id from COpy link: https://drive.google.com/file/d/1mGcHQC7IxiTFYeUSFof3fDppVSC4rq3v/view?usp=drive_link
- Specifically, you will need to use this URL: https://drive.google.com/uc?export=download&id=
- YOU WILL NEED TO ADD THE id FOR YOUR FILE - THIS CAN BE FOUND BY RIGH-CLICKING ON YOUR FILE IN GOOGLE DRIVE - CHOOSE SHARE -> THEN COPY LINK -THEN COPY THE TEXt BETWEEN /d and /view.
- For example, here is a similar link: https://drive.google.com/file/d/1mGcHQC7IxiTFYeUSFof3fDppVSC4rq3v/view?usp=drive_link
- The id is 1mGcHQC7IxiTFYeUSFof3fDppVSC4rq3v. The download url will be: https://drive.google.com/uc?export=download&id=1mGcHQC7IxiTFYeUSFof3fDppVSC4rq3v

This url will need to be replaced in Dockerfile to download your IoTData.zip

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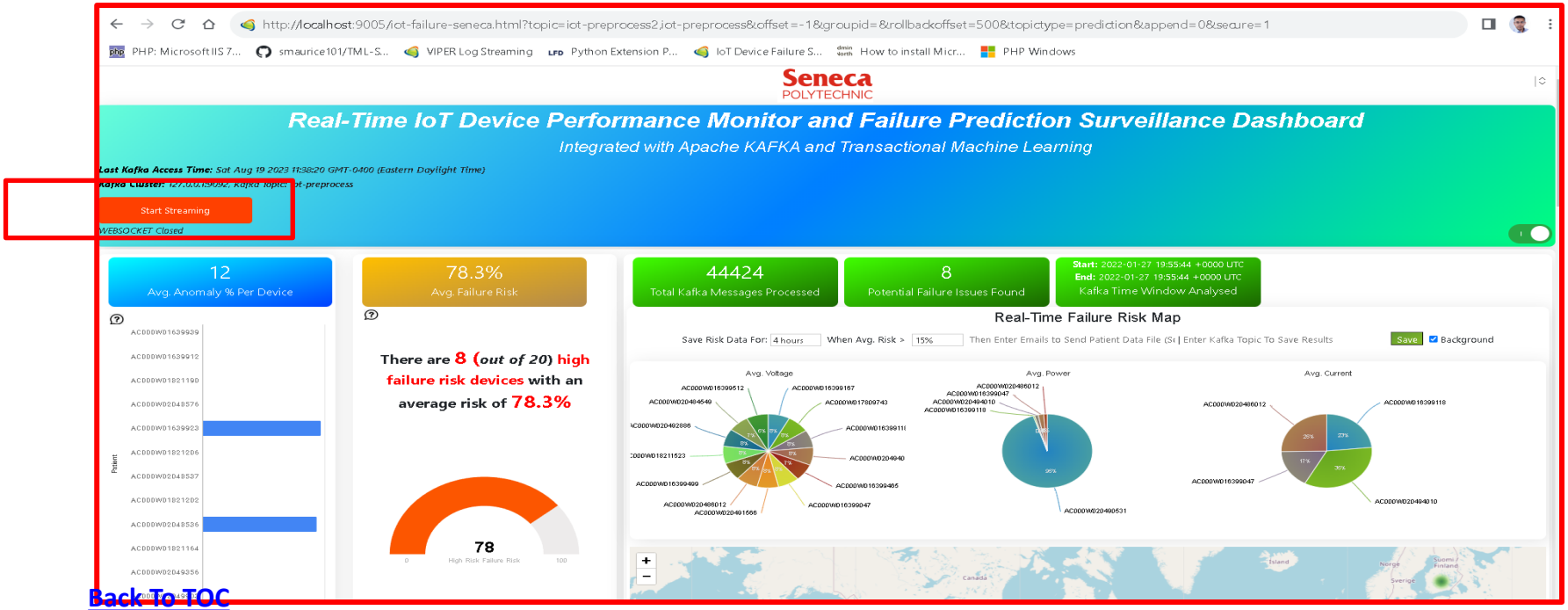
TML Student Solution: Re-Creating TML Solution

STEPS TO TAKE TO RE-CREATE IOT SOLUTION:

12. **RUN TML DASHBOARD:**
    1. **Open a Browser on the machine running the container**
    2. ***PASTE This URL in your browser:*** ***http://localhost:9005/iot-failure-seneca.html?topic=iot-preprocess2,iot-preprocess&offset=-1&groupid=&rollbackoffset=500&topictype=prediction&append=0&secure=1***
    3. ***CLICK START STREAMING BUTTON***



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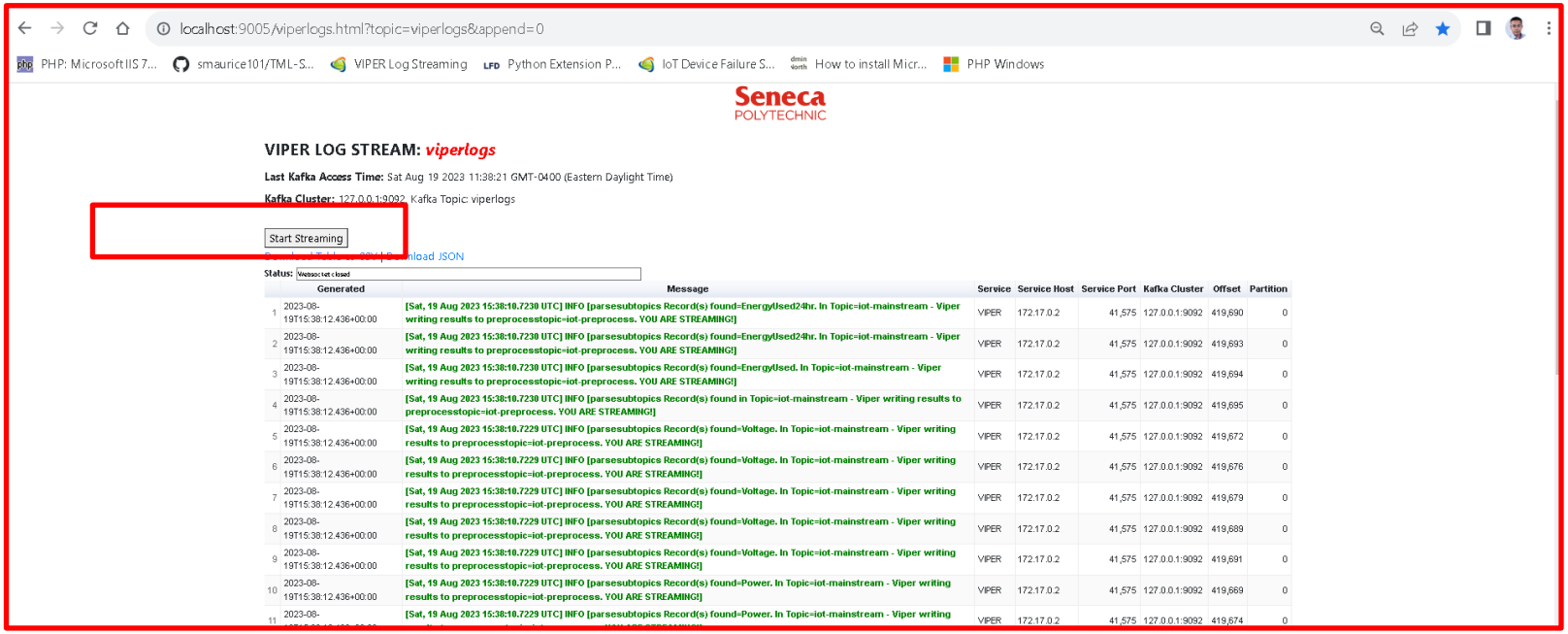
TML Student Solution: Re-Creating TML Solution

STEPS TO TAKE TO RE-CREATE IOT SOLUTION:

13. RUN TML LOG STREAMING:

1. **Open a Browser on the machine running the container**
2. ***PASTE This URL in your browser:*** ***http://localhost:9005/viperlogs.html?topic=viperlogs&append=0***
3. ***Click Start Streaming button***



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YOU ARE NOW STREAMING!

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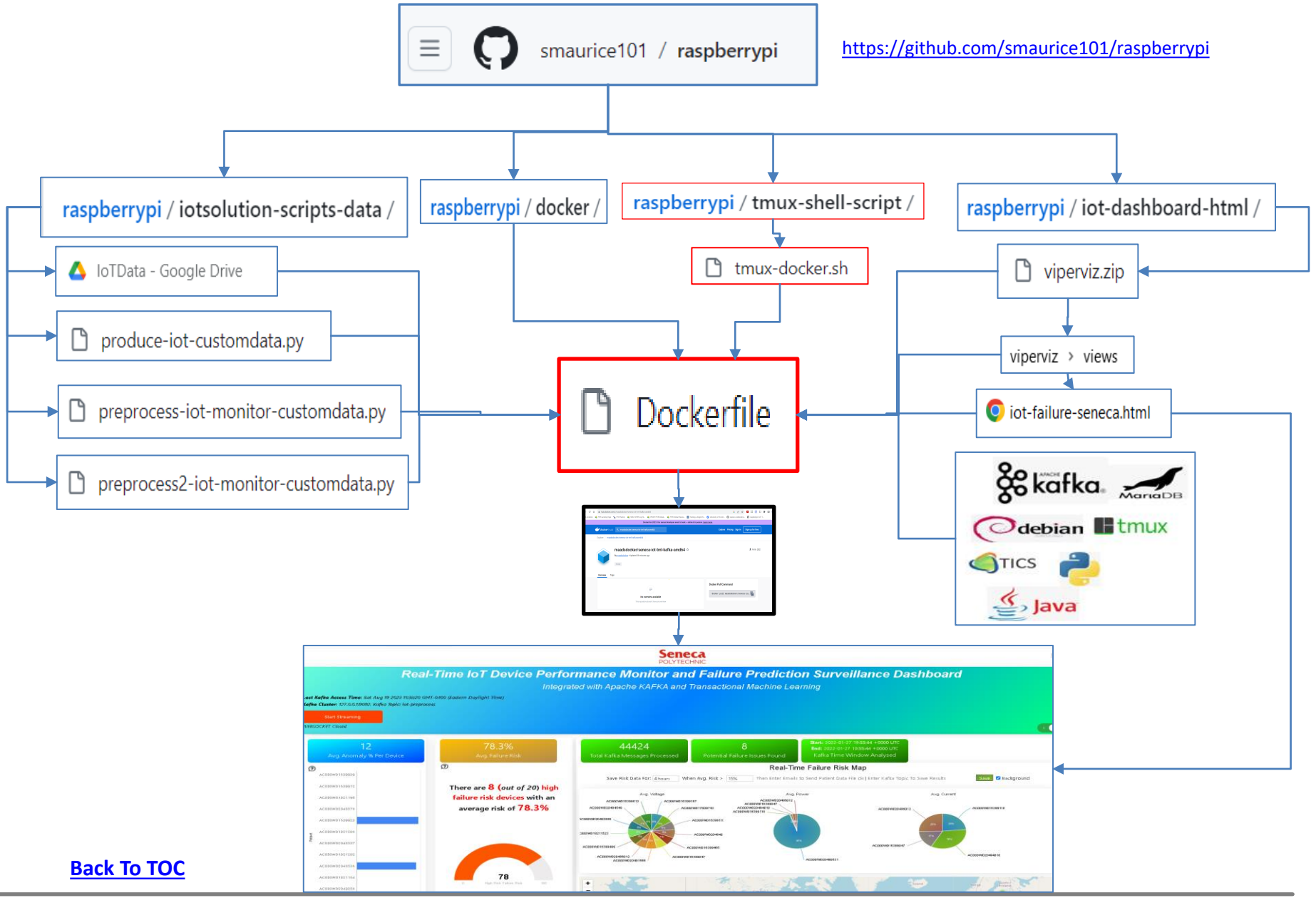
TML SOLUTION COMPONENTS



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APPENDIX A

VMWare Setup

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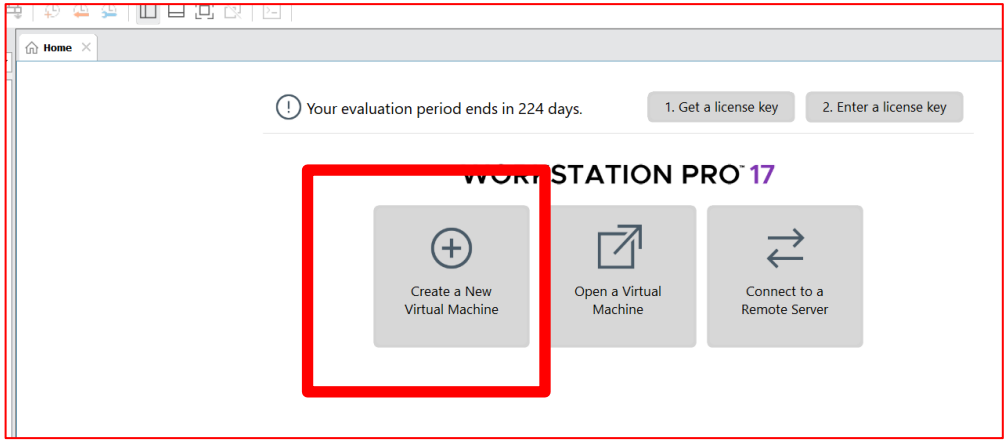
VMWare VM Setup Recommendations

- Students can use WSL (Windows subsystem for Linux) or VMWare (from myapps)
  - We will discuss the VMWare Setup
- Students should run their VM off a USB 3.0 (fast USB) drive preferably 250G or more
- VM OS should be Linux Ubuntu – the ISO can be downloaded from https://ubuntu.com/download/desktop

Steps to Creating a VM:

1. Plug in your USB drive – lets say it is assigned DRIVE E: (your drive may differ – if so replace E: with your drive)
2. Start VM – and CLICK **Create a New Virtual Machine**:



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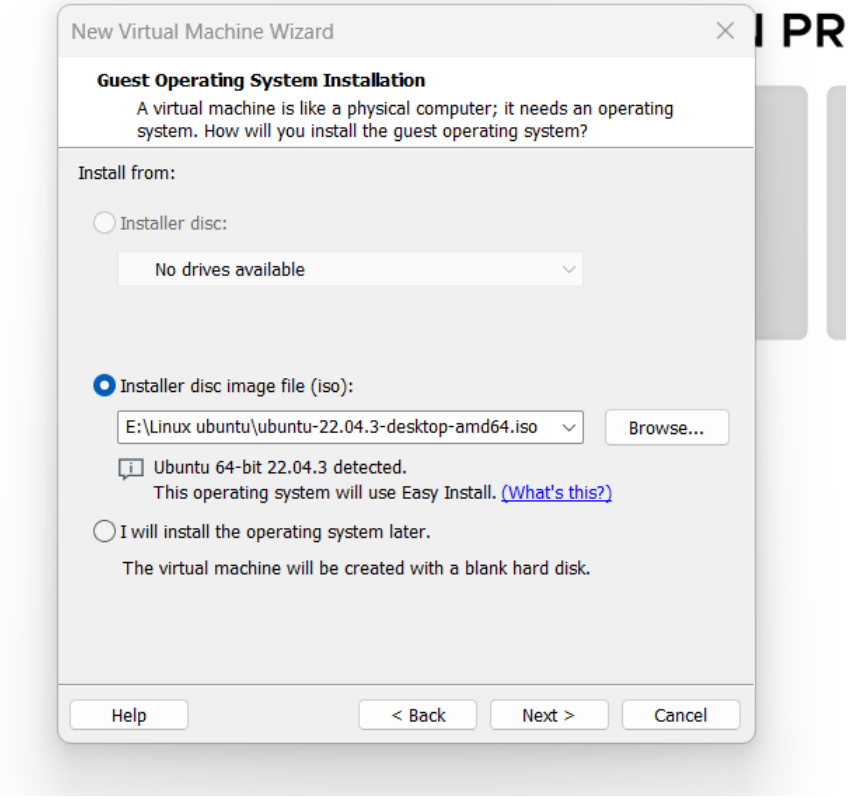
VMWare VM Setup Recommendations

Steps to Creating a VM:

3. Choose Typical (Recommended) Setup and Click Next

4. In the next screen **Browse to your Downloaded Linux ISO on Your USB Drive and Click Next**



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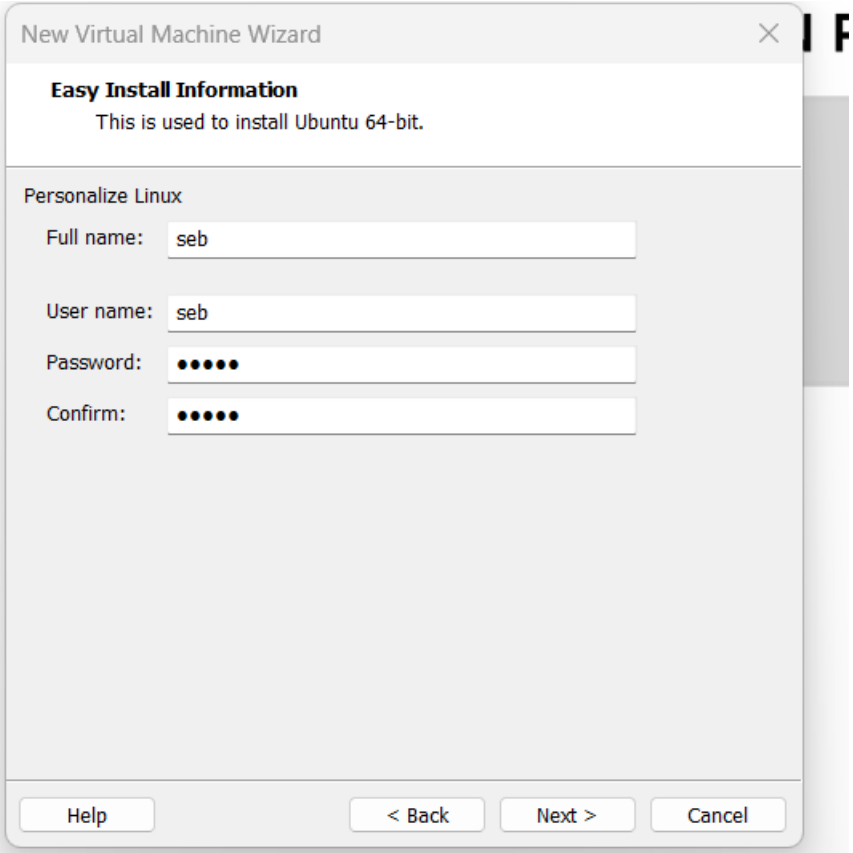
VMWare VM Setup Recommendations

Steps to Creating a VM:

5. Enter your Name, and username/password (choose a simple username and password so you **do not forget it**)



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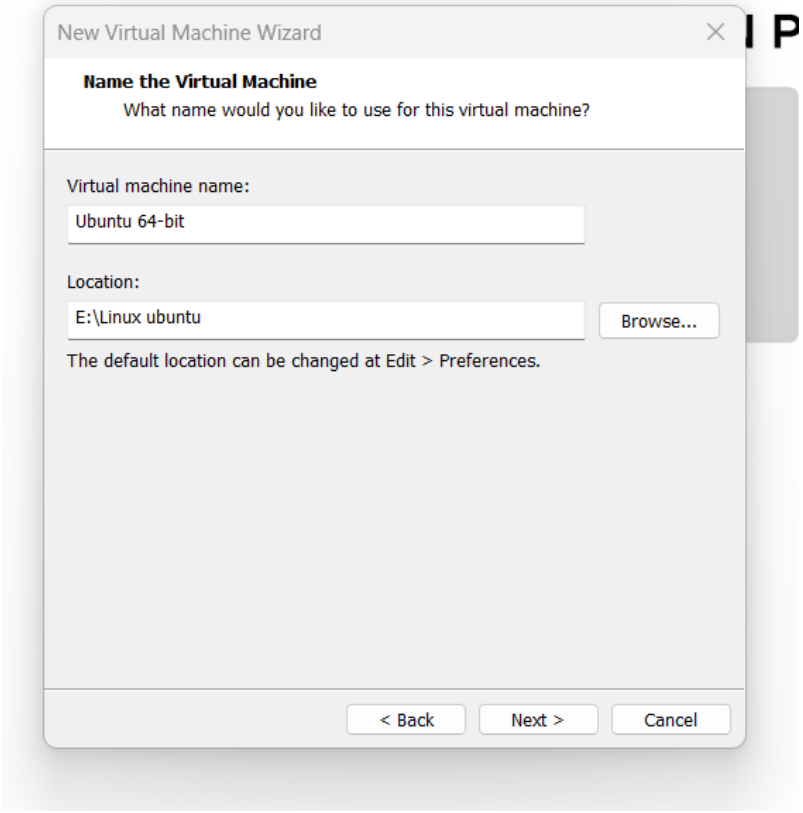
VMWare VM Setup Recommendations

Steps to Creating a VM:

6. Change the Default Location of Your VM to your USB drive (Drive E) click NEXT – *(you may want to create a Linux Ubuntu Folder on Drive E to keep your VM files separate form other files on your USB)*



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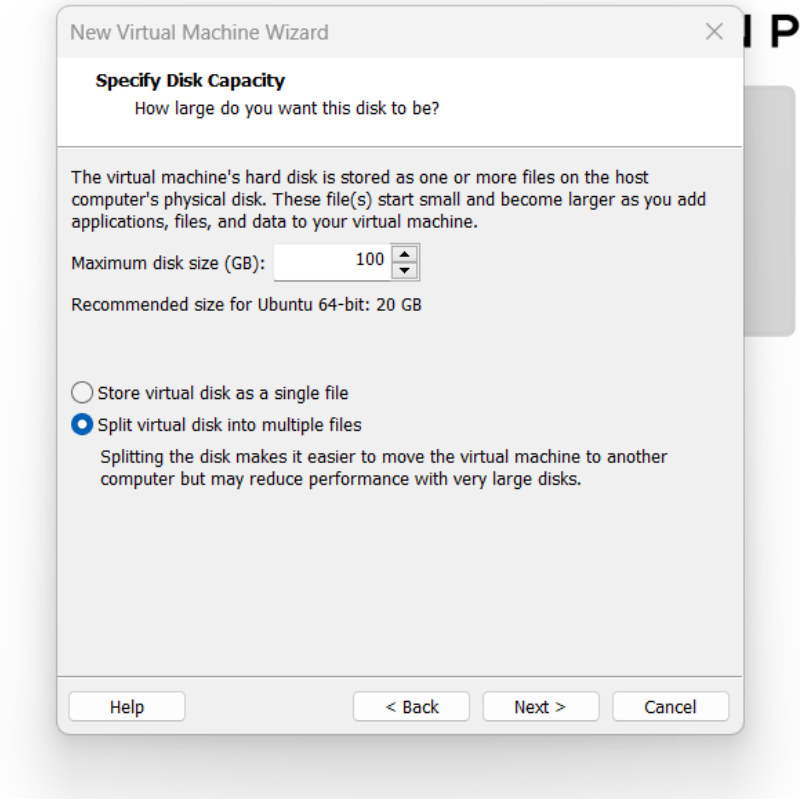
VMWare VM Setup Recommendations

Steps to Creating a VM:

7. Choose 100GB for Maximum disk space AND Split virtual disk into multiple files click NEXT



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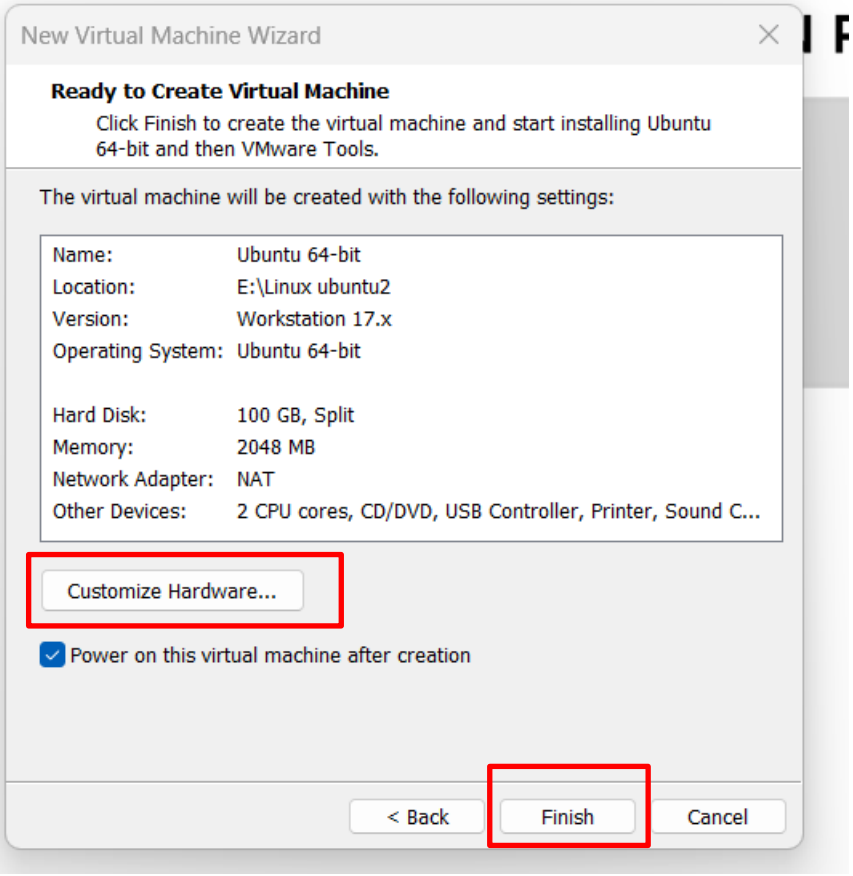
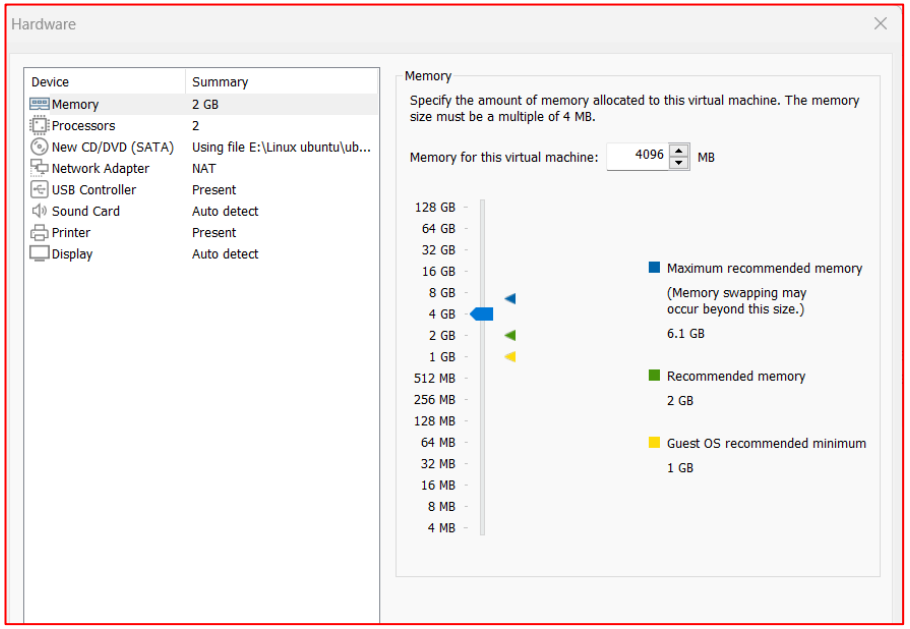
VMWare VM Setup Recommendations

Steps to Creating a VM:

8. Click Customize Hardware and choose minimum of 4GB for memory then Click Finish





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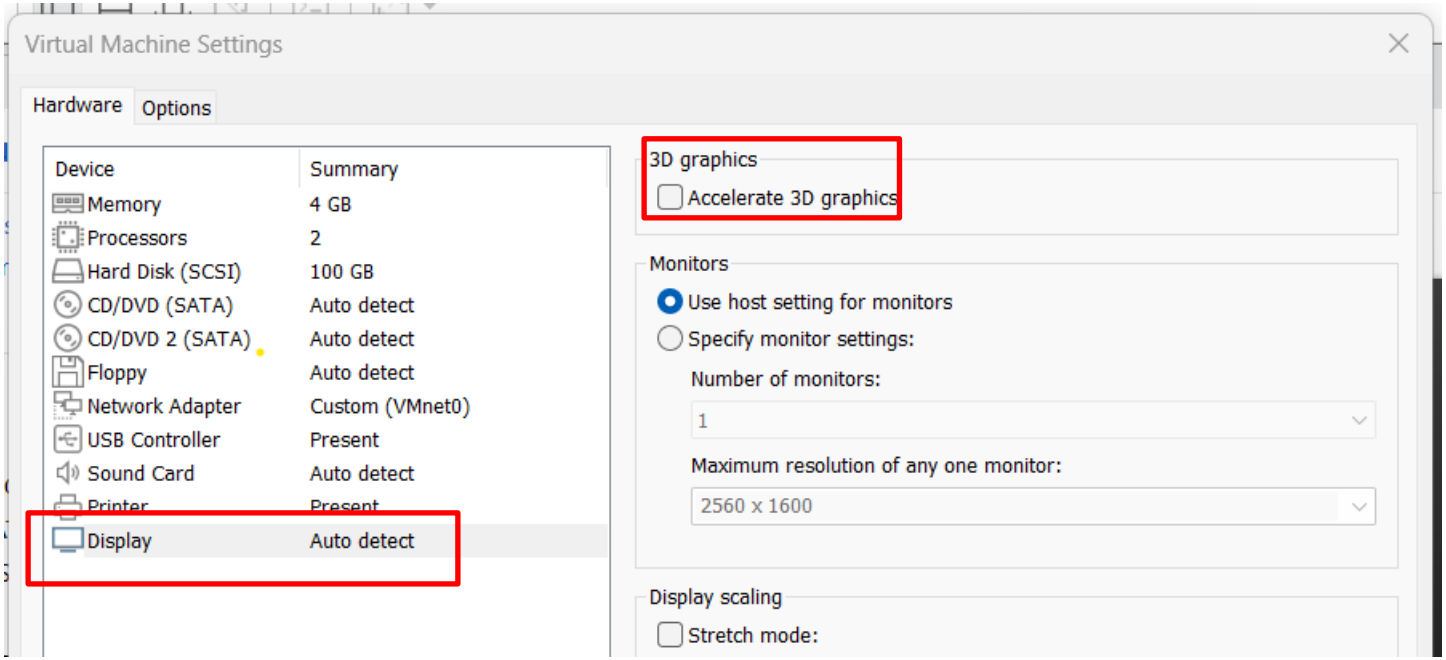
VMWare VM Setup Recommendations

Steps to Creating a VM:

8b. Make sure to Uncheck 3D Graphics



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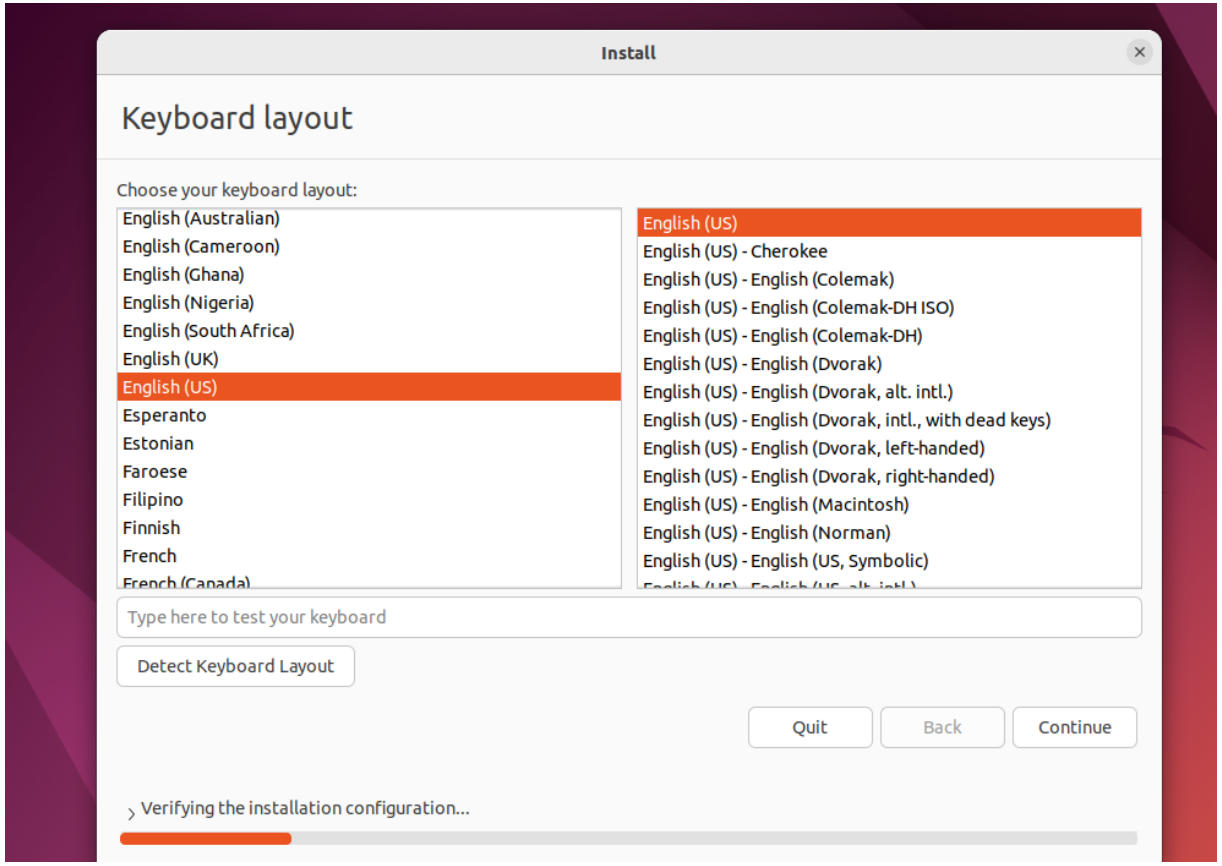
VMWare VM Setup Recommendations

Steps to Creating a VM:

9. Linux Ubuntu will Start Installing – Click Continue



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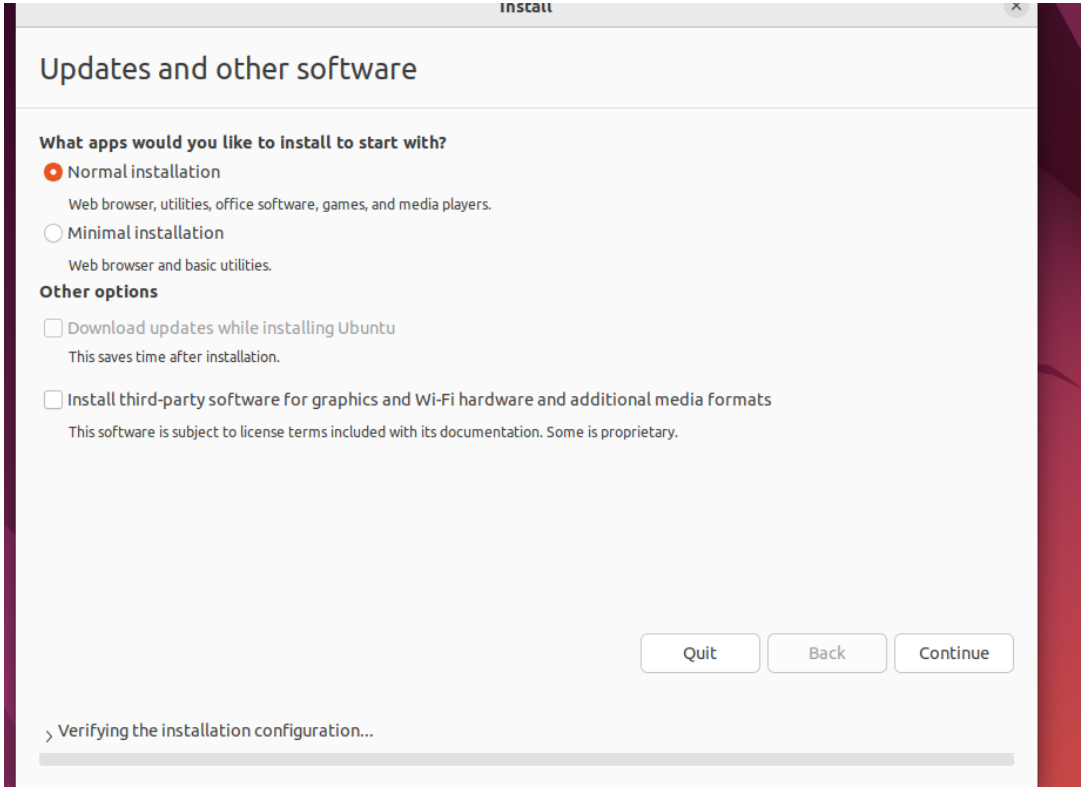
VMWare VM Setup Recommendations

Steps to Creating a VM:

9. Linux Ubuntu will Start Installing - Click Continue



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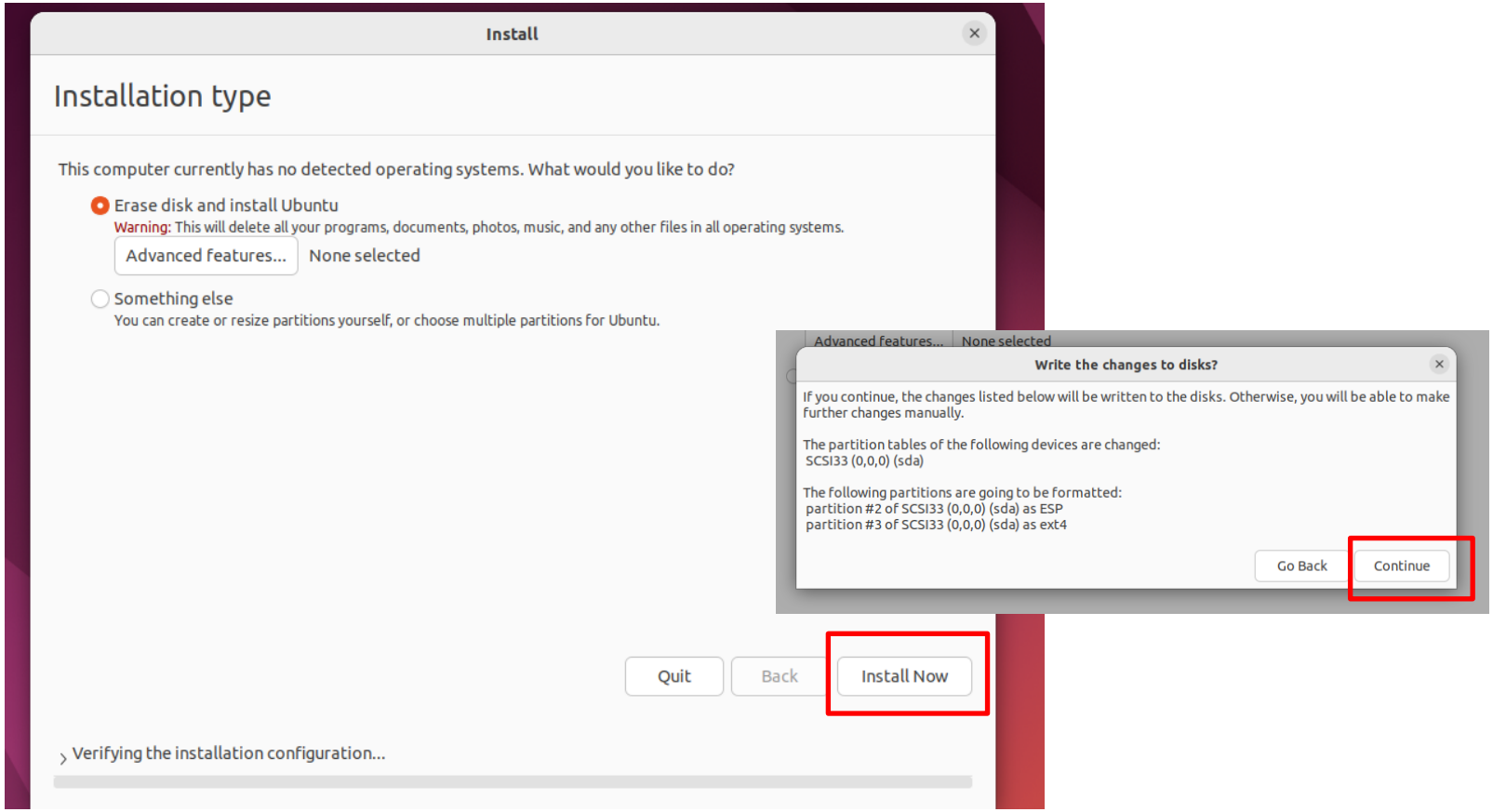
VMWare VM Setup Recommendations

Steps to Creating a VM:

9. Linux Ubuntu will Start Installing – **Click Install Now and Click Continue for rest of screens**



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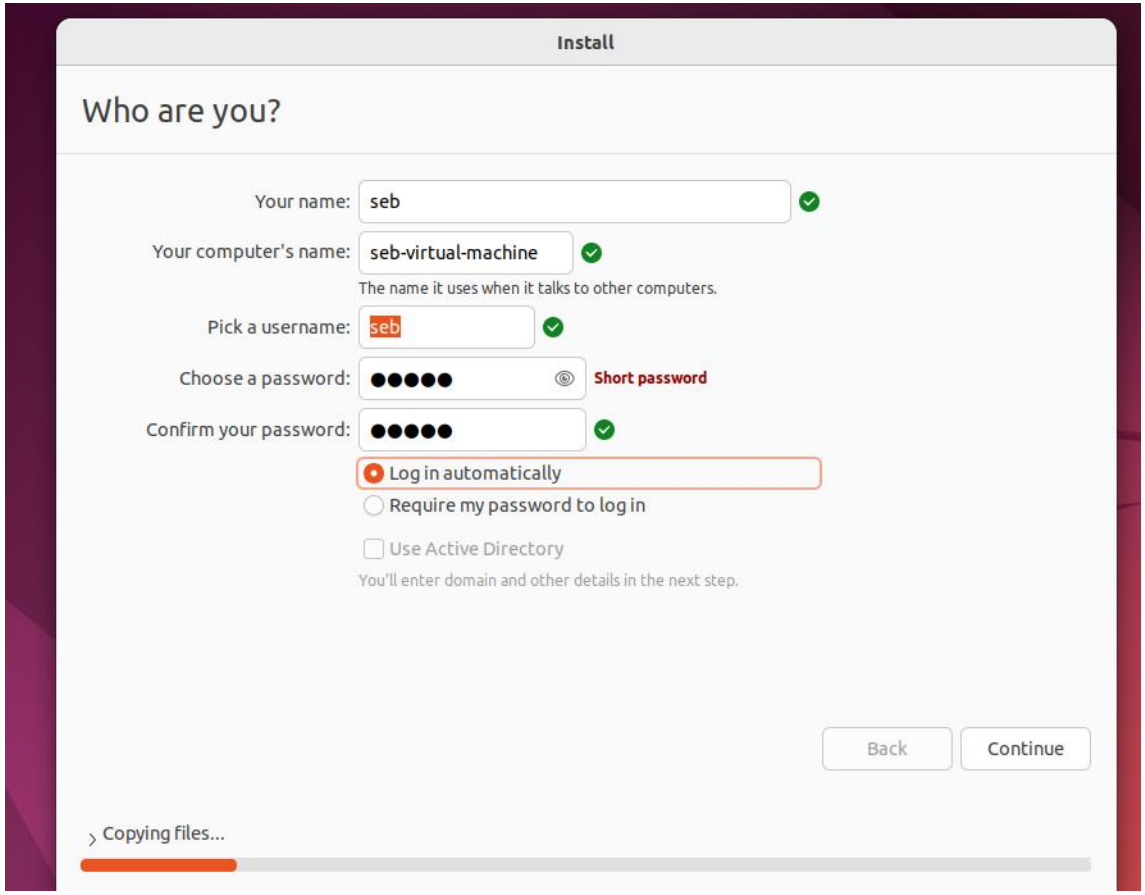
VMWare VM Setup Recommendations

Steps to Creating a VM:

10. Who are you? Enter information and click Continue



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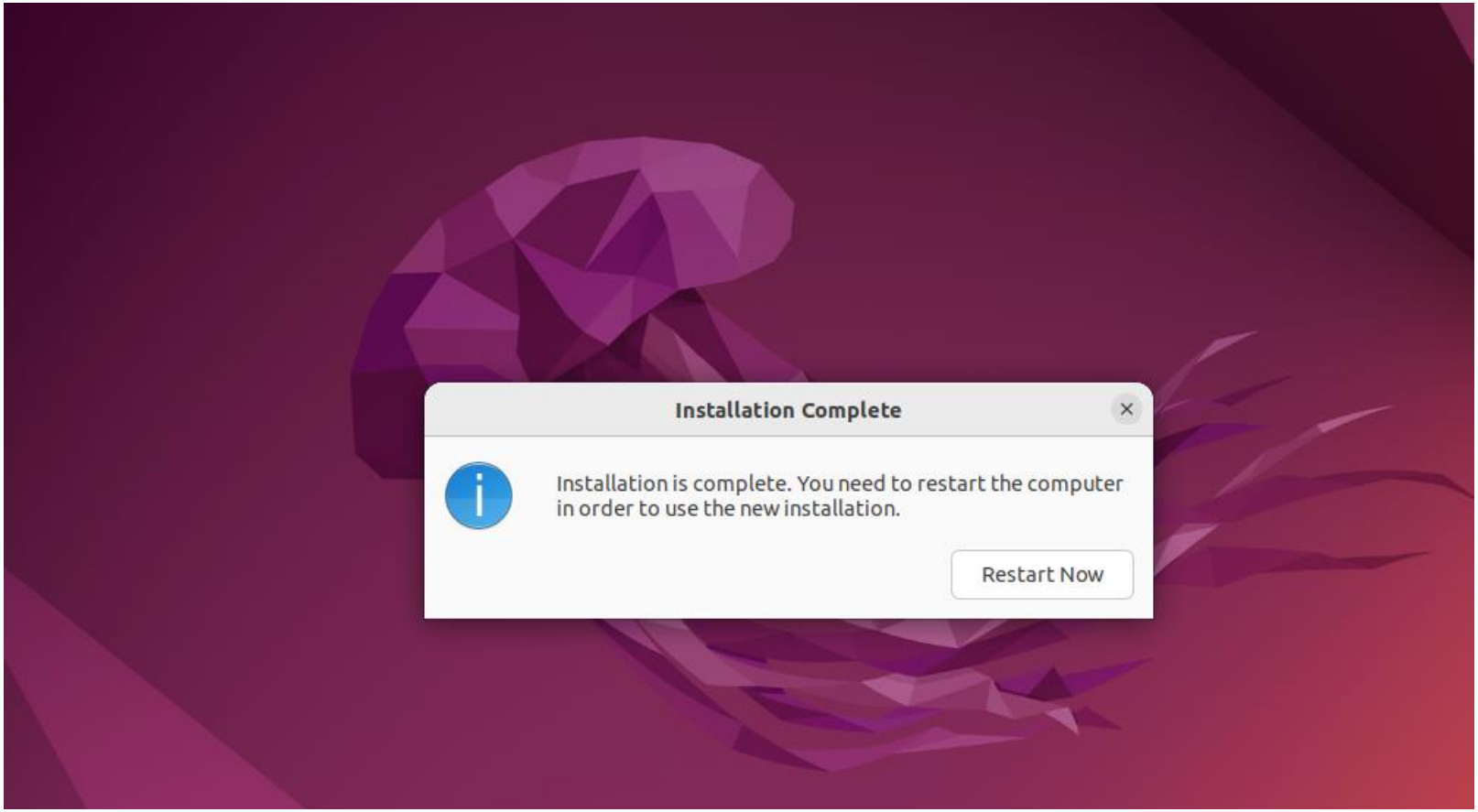
VMWare VM Setup Recommendations

Steps to Creating a VM:

11. Restart VM to complete installation



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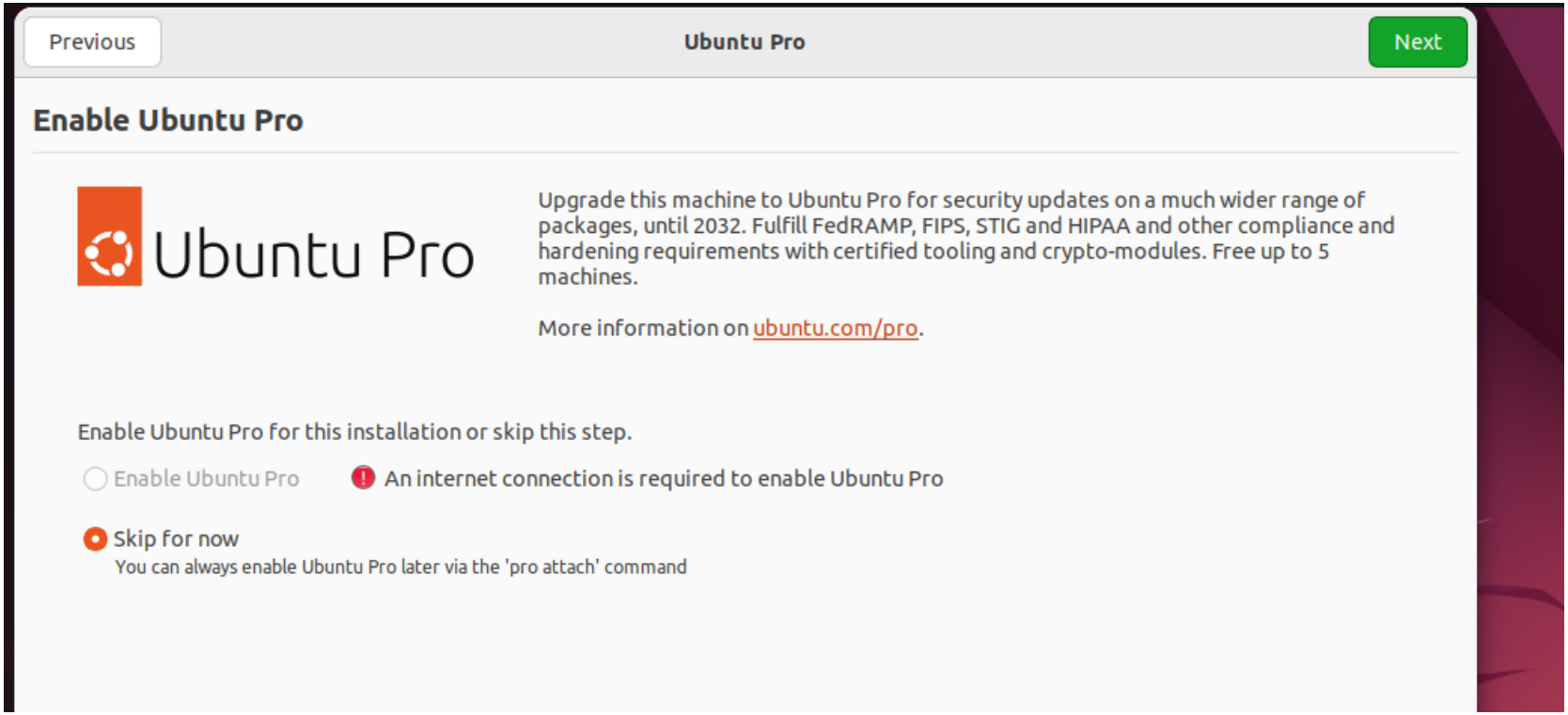
VMWare VM Setup Recommendations

Steps to Creating a VM:

12. Click NEXT



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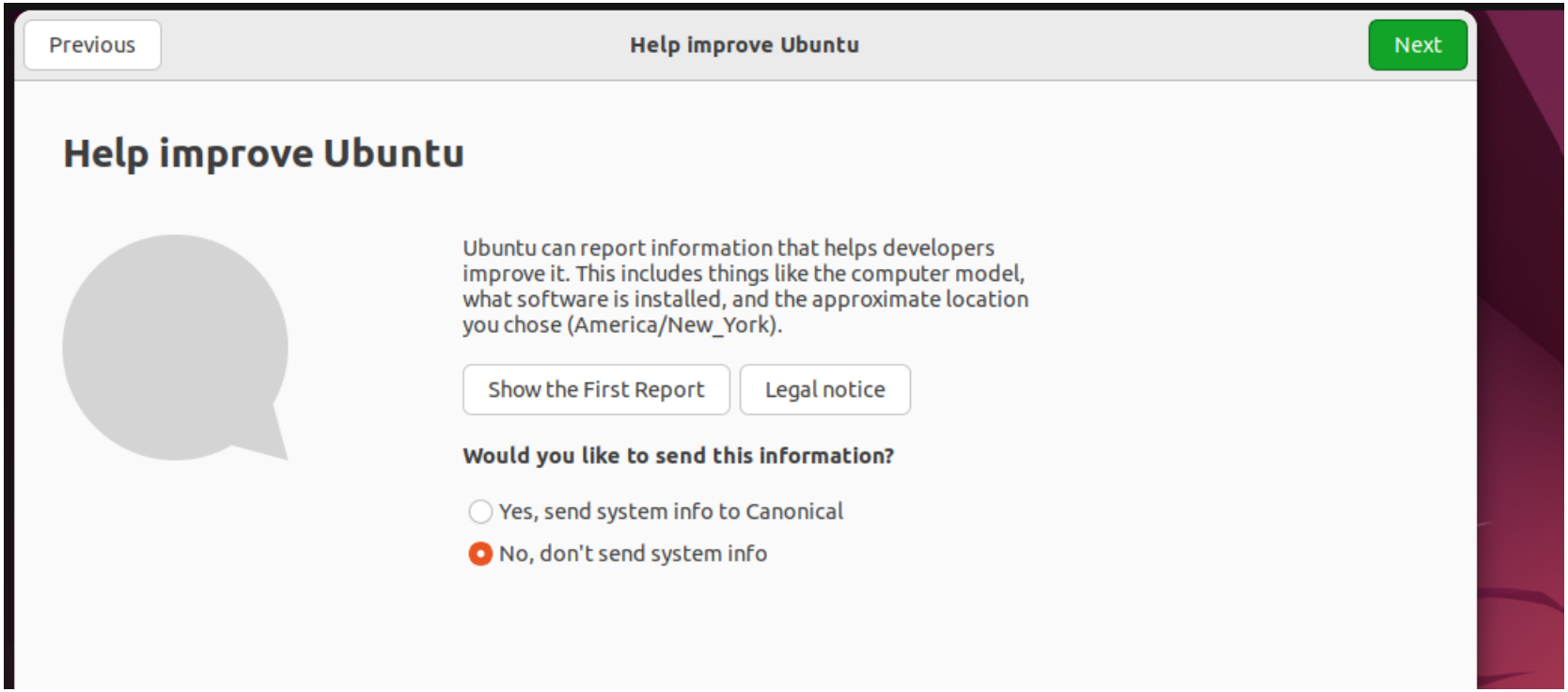
VMWare VM Setup Recommendations

Steps to Creating a VM:

13. Click NEXT



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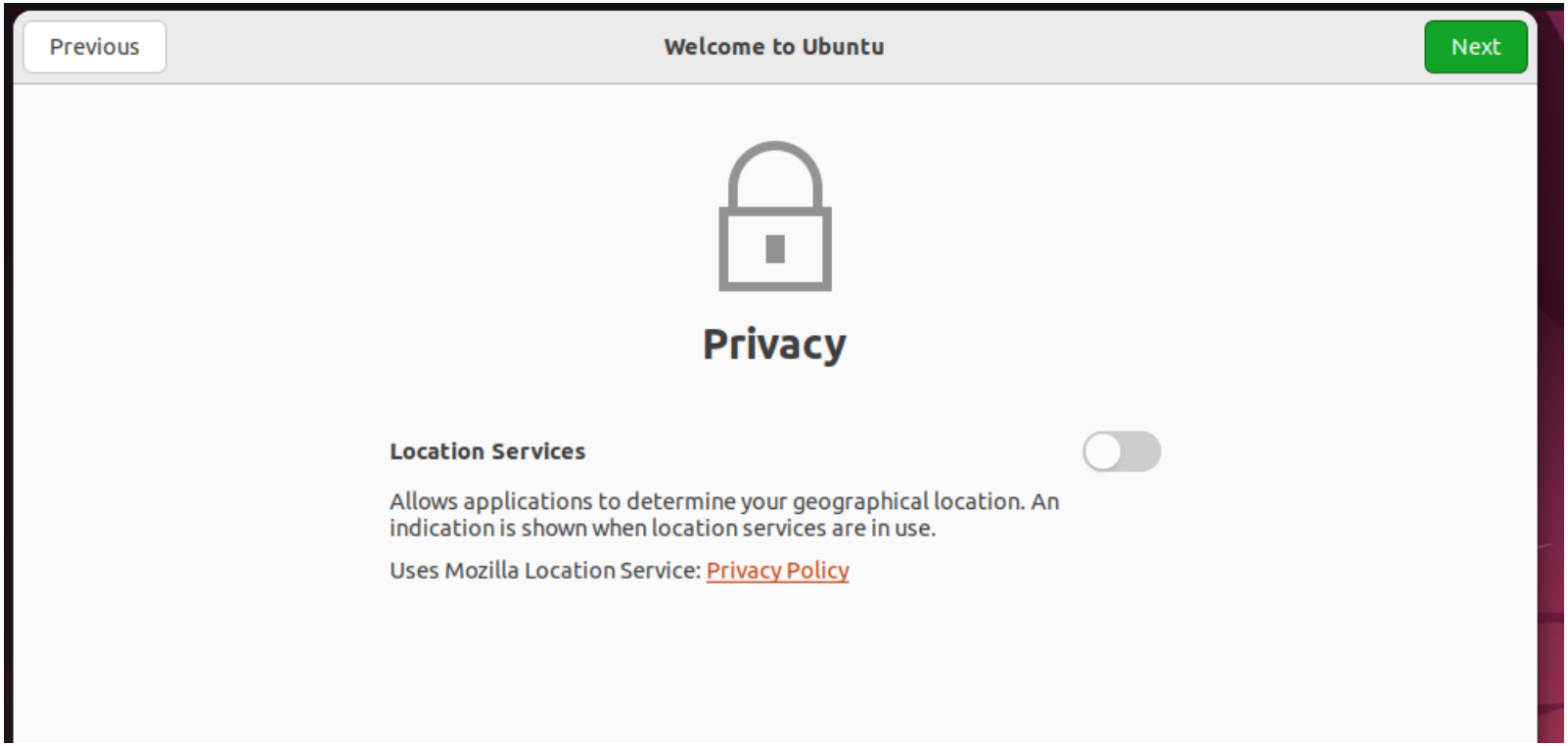
VMWare VM Setup Recommendations

Steps to Creating a VM:

14. Click NEXT



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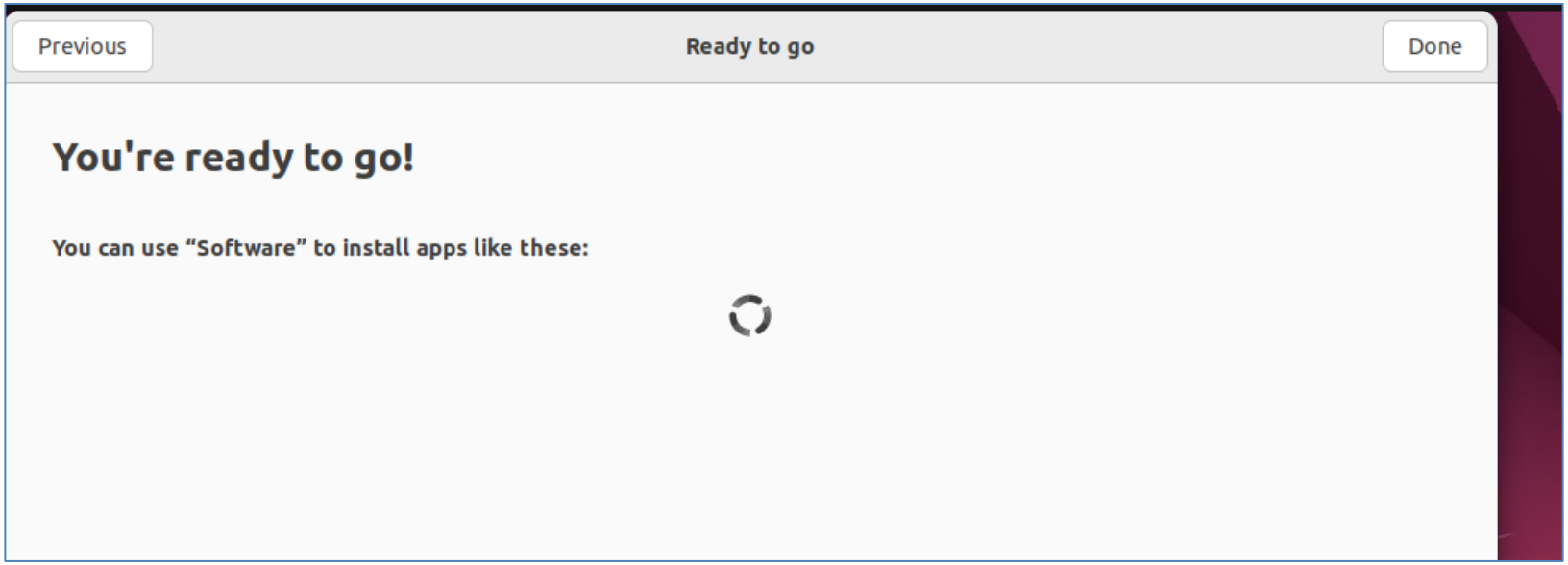
VMWare VM Setup Recommendations

Steps to Creating a VM:

15. Click **DONE!**



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APPENDIX B

Setting Up Internet on VM Ware

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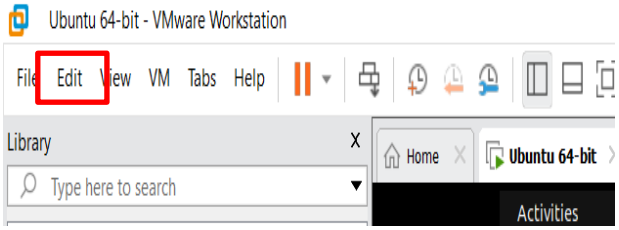
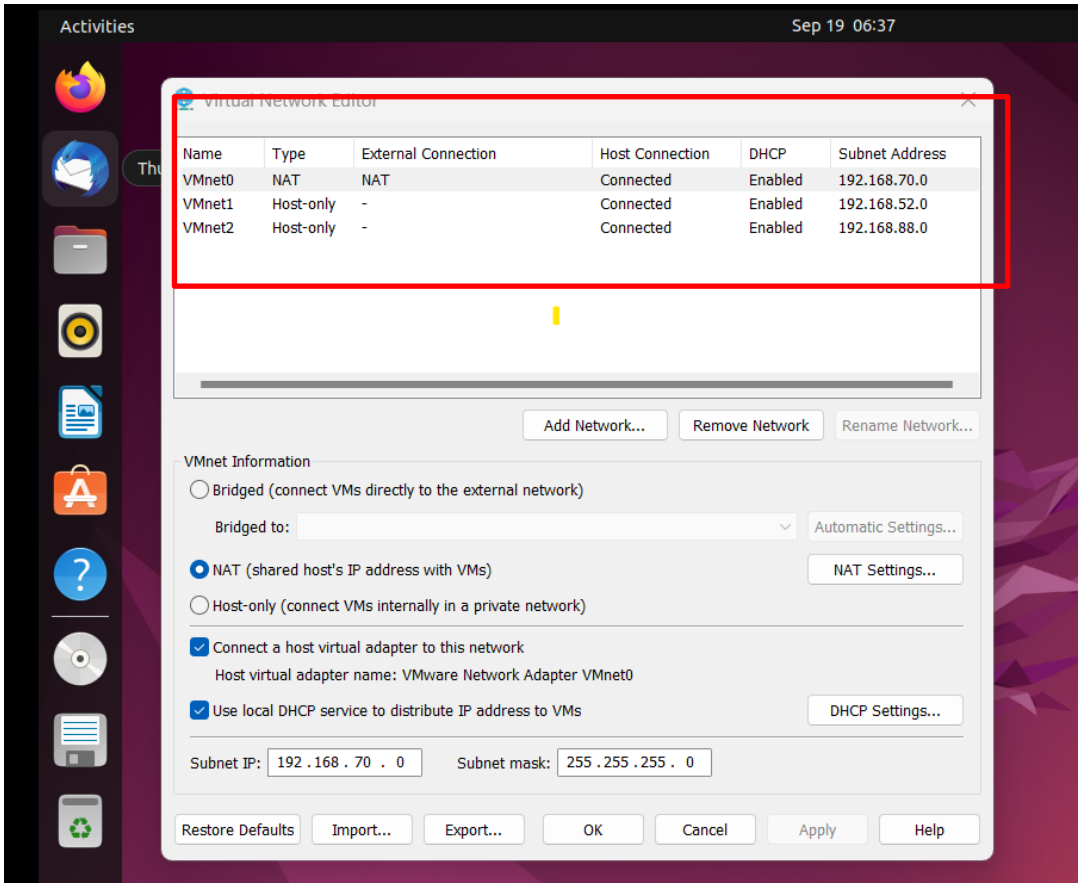
Setting Up Internet

- If you do not have internet connection in your VM then you can do the following:

Step 1: Choose **EDIT** from Main Menu then Choose Virtual Network Editor





Make sure you have:

- 3 networks:
  - VMnet0 (Set to NAT)
  - VMNet1 (set to Host Only)
  - VMNet2 (Set to Host Only)
- All should be **Connected**
- **Click Apply**

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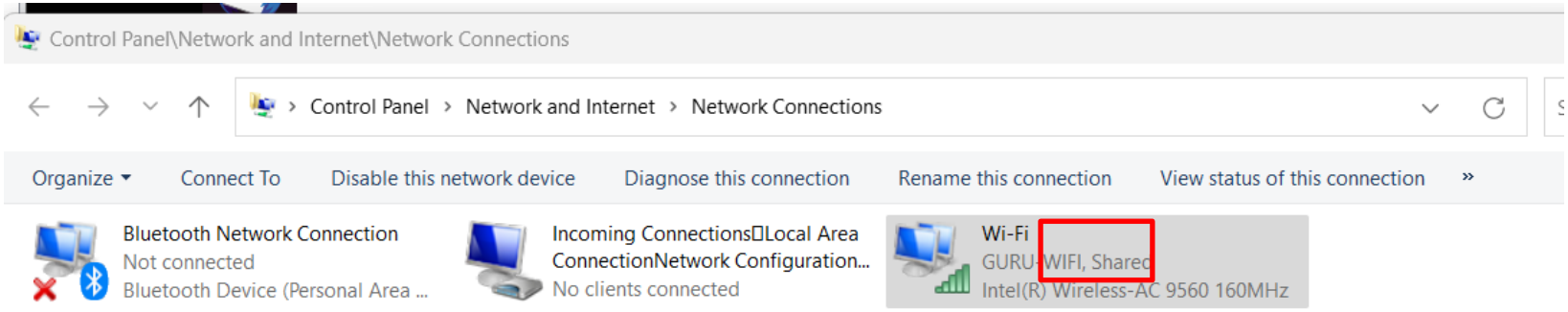
Setting Up Internet

- If you do not have internet connection in your VM then you can do the following:

Step 2: Go to Control Panel -> Network and Internet -> Network Connections

- **If using Wi-FI – make sure WI-FI is Sharing the Connection**



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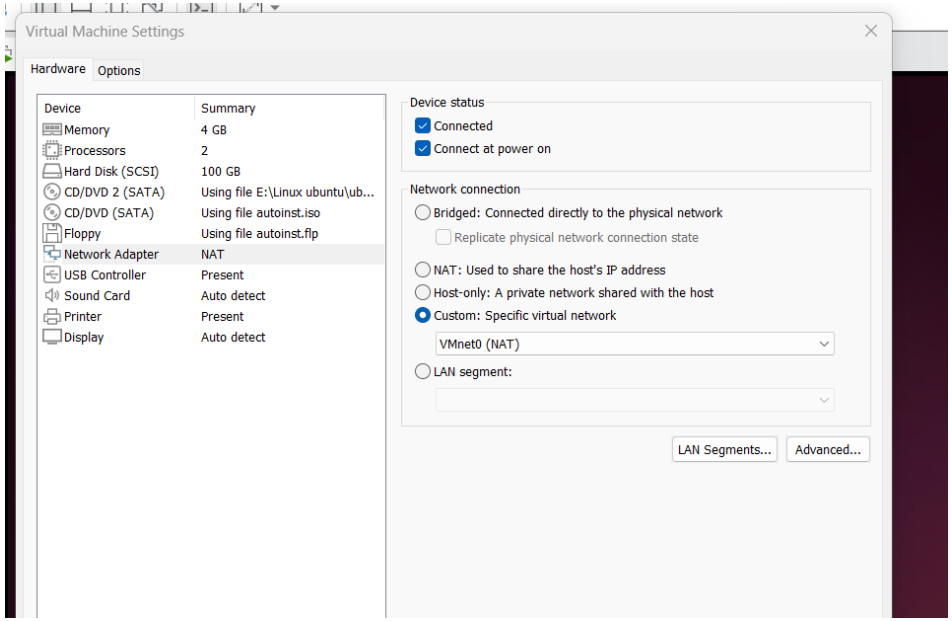
Setting Up Internet

- If you do not have internet connection in your VM then you can do the following:

Step 3: Go to VM -> Settings from Main Menu and Choose Network Adapter

- **Select Custom -> Choose VMNet0 -> Click OK**



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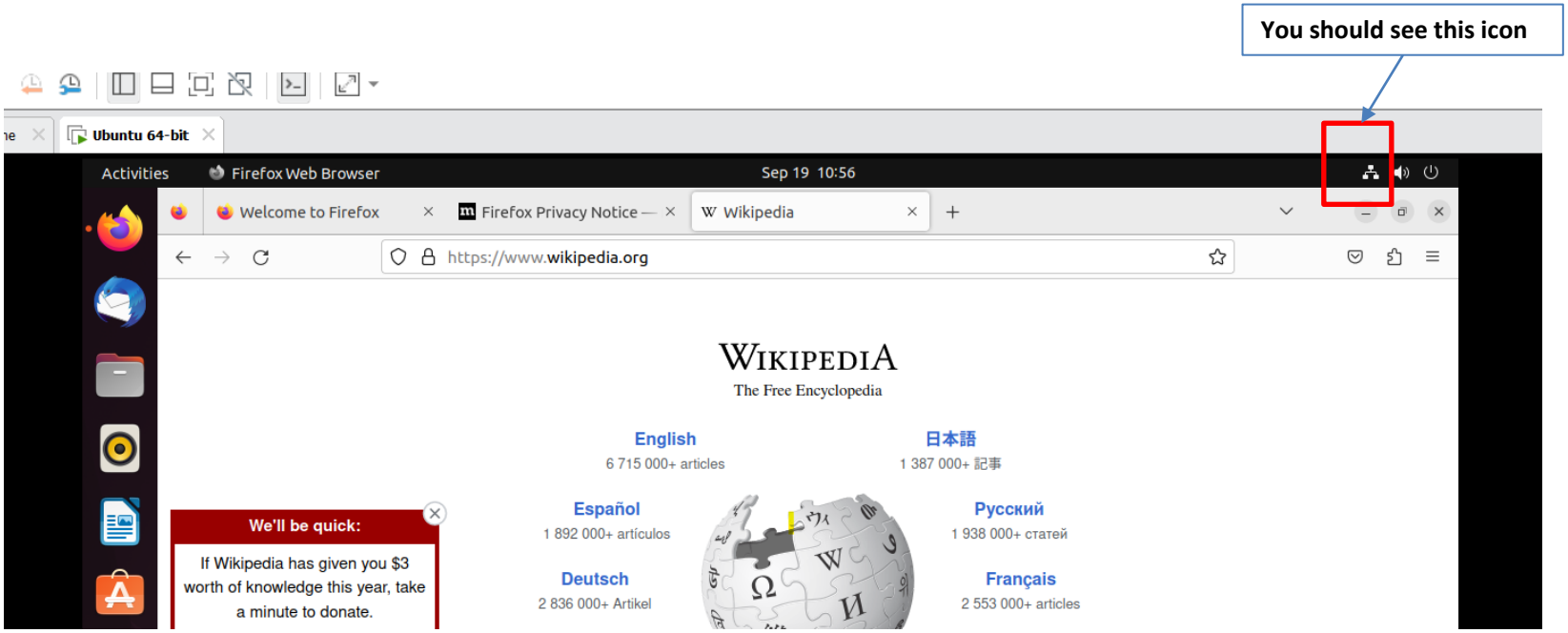
Setting Up Internet

- If you do not have internet connection in your VM then you can do the following:

Step 4: You Should Now Have Internet!



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APPENDIX C

Vmware: Pulling/Running TML Docker Container and TML Streaming Dashboard

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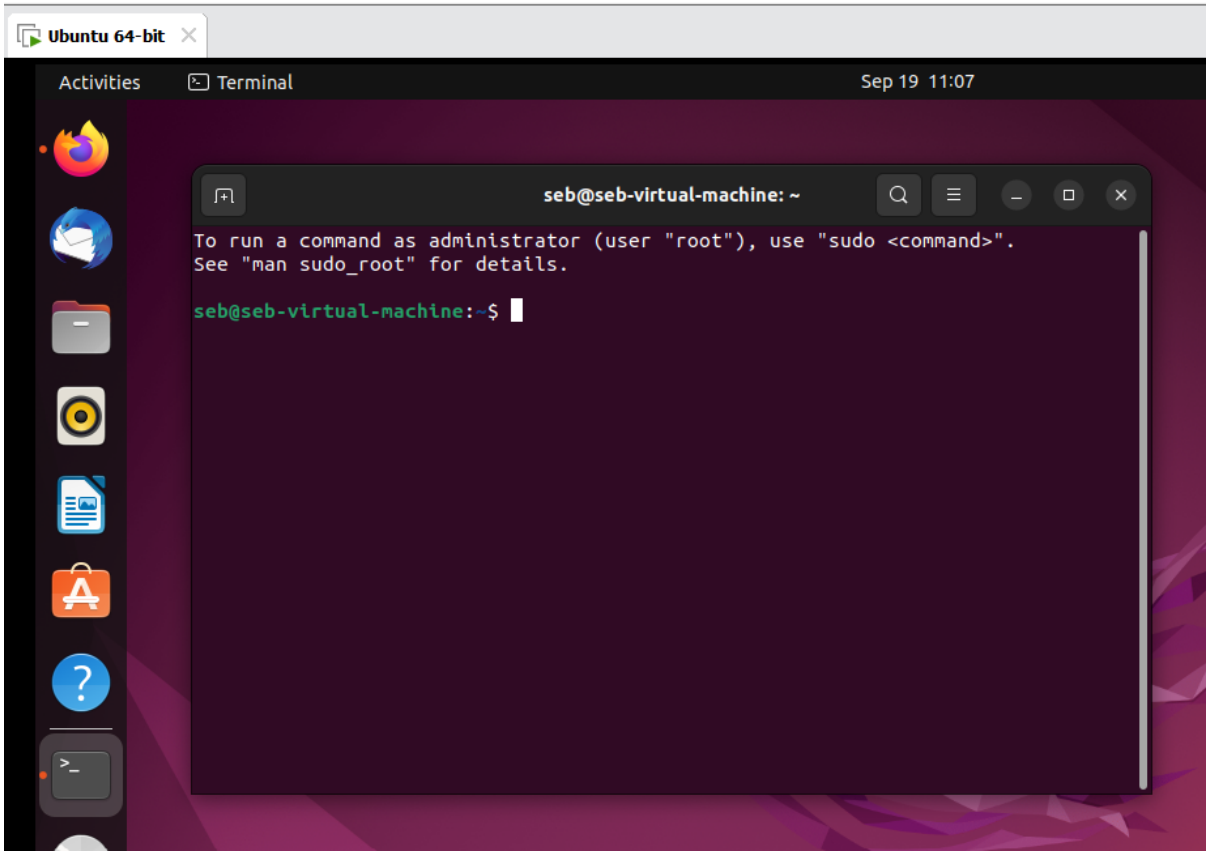
Running TML Docker Container and Streaming Dashboard

Step 1: Start Terminal in your VM



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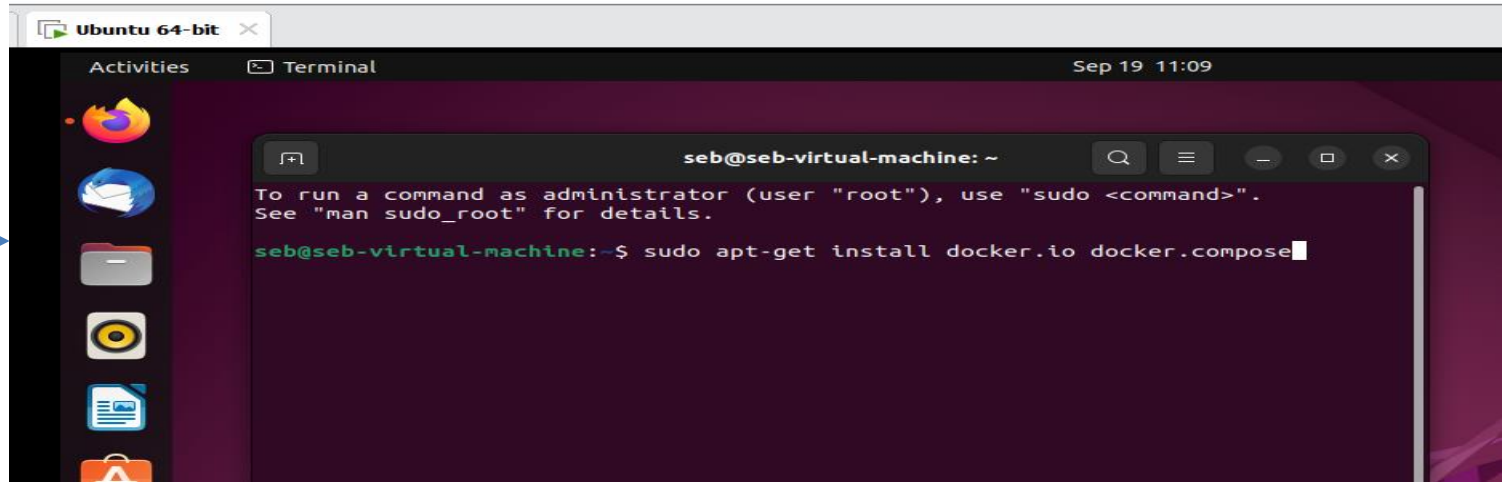
Running TML Docker Container and Streaming Dashboard

Step 2: Install docker

- **FIRST RUN**: sudo apt-get update
- **THEN RUN**: sudo apt-get install docker.io docker.compose

```
seb@seb-virtual-machine:~$ sudo apt-get update
Get:1 http://security.ubuntu.com/ubuntu jammy-security InRelease [110 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu jammy InRelease [270 kB]
Get:3 http://us.archive.ubuntu.com/ubuntu jammy-updates InRelease [119 kB]
Get:4 http://us.archive.ubuntu.com/ubuntu jammy-backports InRelease [109 kB]
Get:5 http://security.ubuntu.com/ubuntu jammy-security/main amd64 Packages [802
kB]
Get:6 http://security.ubuntu.com/ubuntu jammy-security/main i386 Packages [327 k
B]
Get:7 http://security.ubuntu.com/ubuntu jammy-security/main Translation-en [168
```



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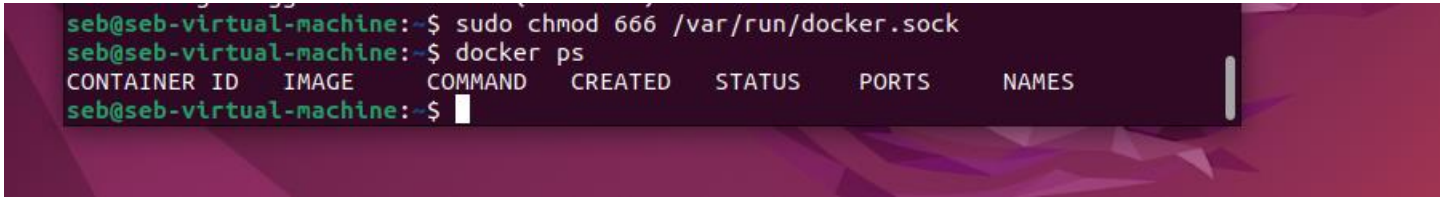
Running TML Docker Container and Streaming Dashboard

Step 3: Change permissions on docker.sock

- **RUN**: sudo chmod 666 /var/run/docker.sock
- **THEN RUN**: docker ps



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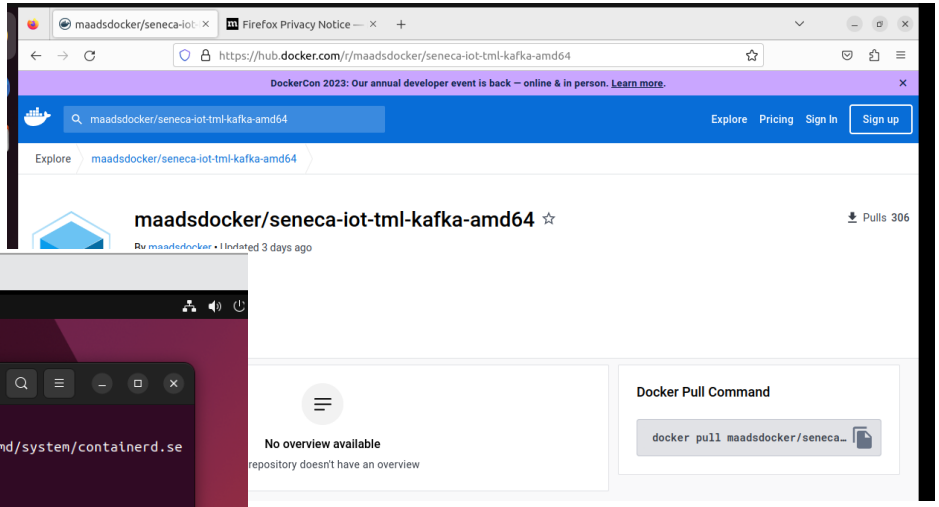
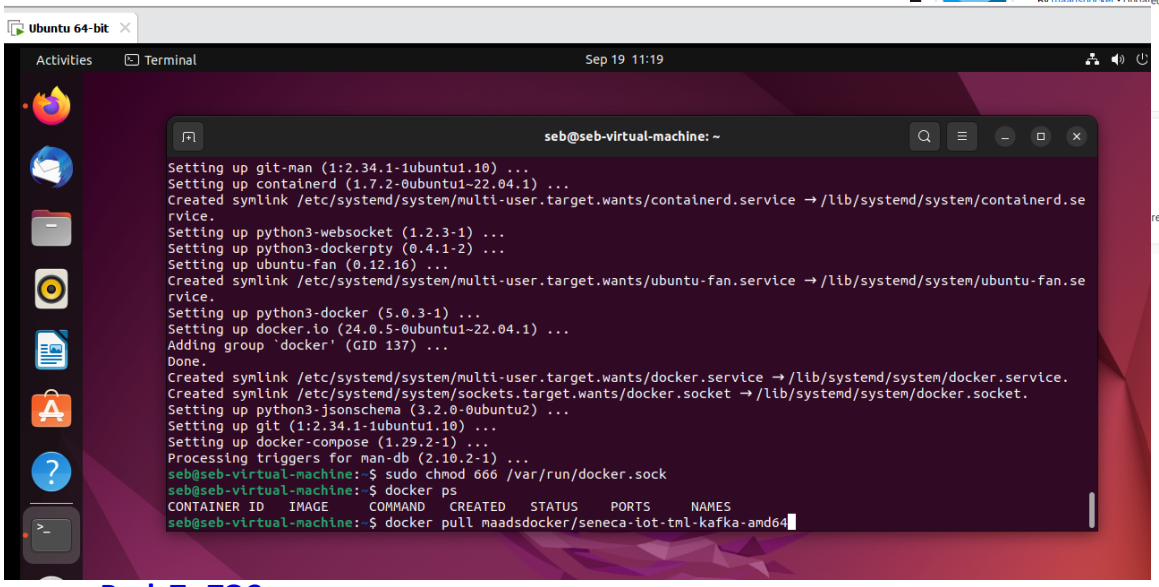
Running TML Docker Container and Streaming Dashboard

Step 4: You can now pull the TML Container on Docker Hub:

https://hub.docker.com/maadsdocker/seneca-iot-tml-kafka-amd64

- **RUN**: docker pull maadsdocker/seneca-iot-tml-kafka-amd64





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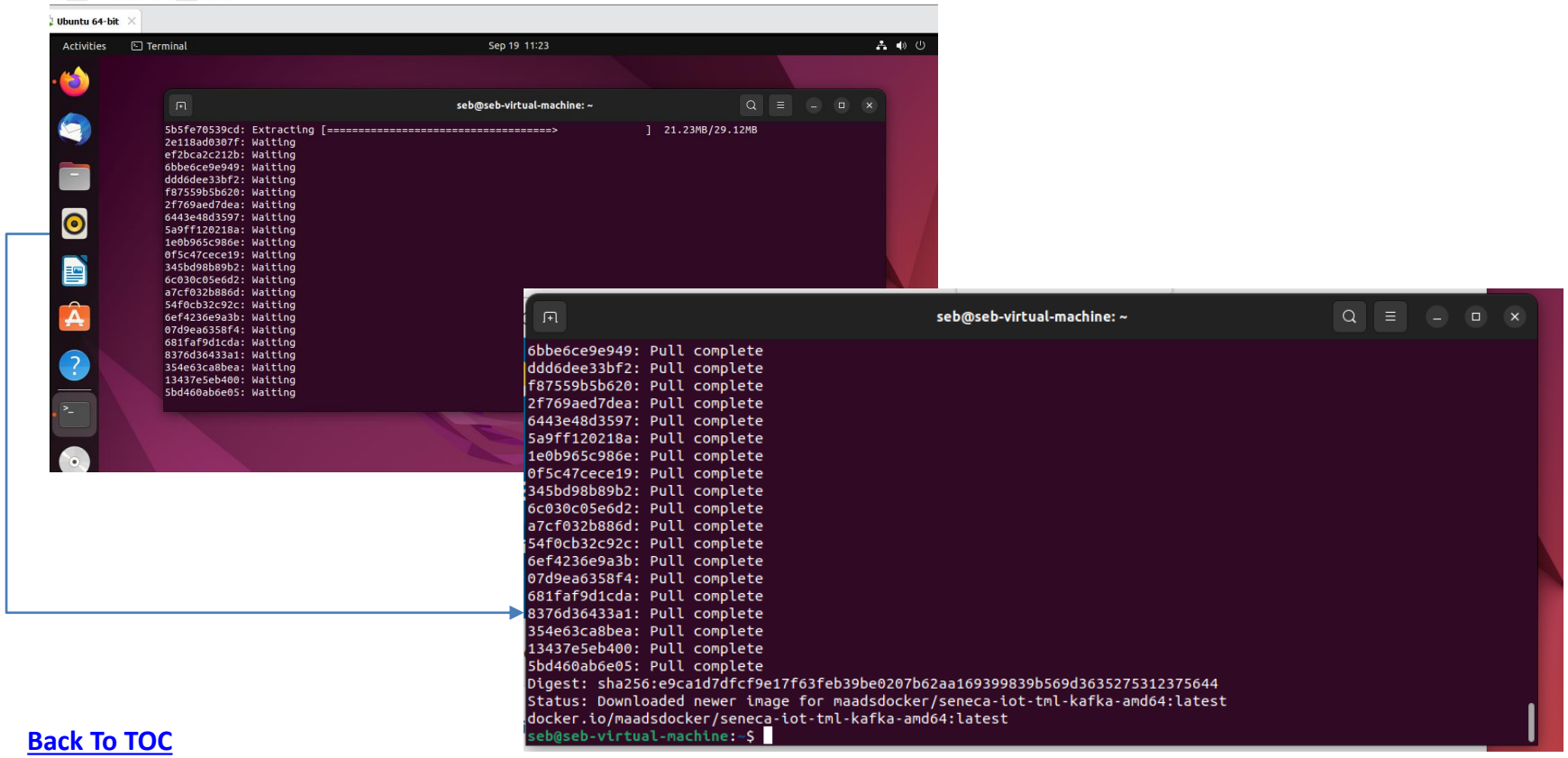
Running TML Docker Container and Streaming Dashboard

Step 4: You can now pull the TML Container on Docker Hub:

https://hub.docker.com/maadsdocker/seneca-iot-tml-kafka-amd64

You are now pulling the container (this can take about ~10 minutes):



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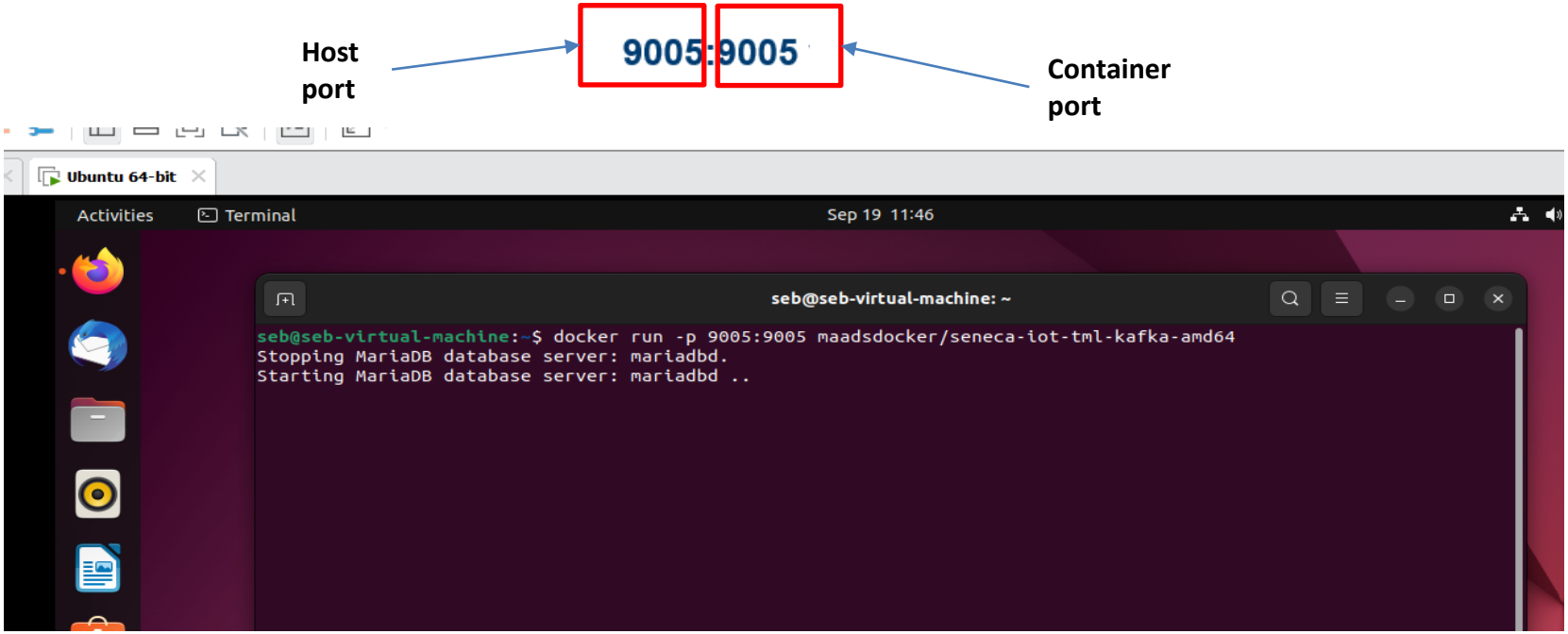
Running TML Docker Container

Step 5: **You can now Run the container**

RUN: docker run -p 9005:9005 maadsdocker/seneca-iot-tml-kafka-amd64

NOTE: -p is needed for port forwarding: **-p 9005:9005 will tell Docker that connections on the host port 9005 will be forwarded to the Container port 9005.**

- **MAADS-Viperviz is listening on Port 9005 inside the container**



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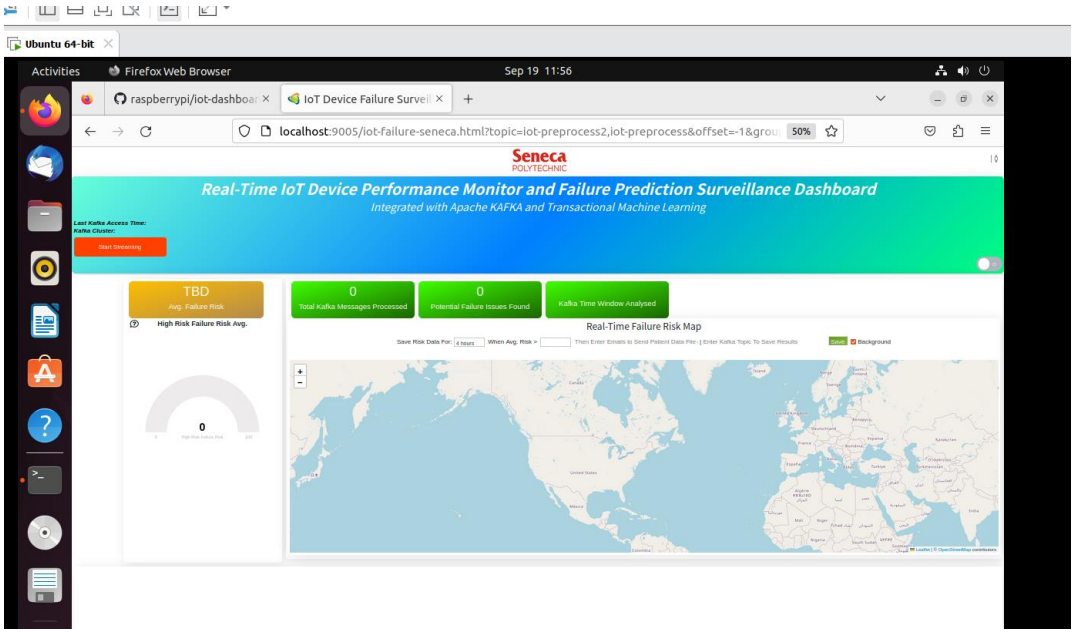
Running TML Streaming Dashboard

Step 6: **You can now Run the Dashboard**

- **Open Firefox Browser and Enter the URL: *http://localhost:9005/iot-failure-seneca.html?topic=iot-preprocess2,iot-preprocess&offset=-1&groupid=&rollbackoffset=500&topictype=prediction&append=0&secure=1***
- **You should the TML streaming dashboard**



- The TML Dashboard is a live streaming dashboard running from your Docker Container
- It is analysing REAL IoT device data for failures by analysing their VOLTAGE, CURRENT and POWER data in real-time
- It shows RED, YELLOW, GREEN bubbles to indicate which devices are likely to fail (RED)
- It used Preprocessing type: AnomProb, Trend, and AVG to process streaming data from EACH device **(at the entity level)**

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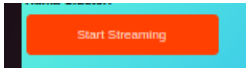
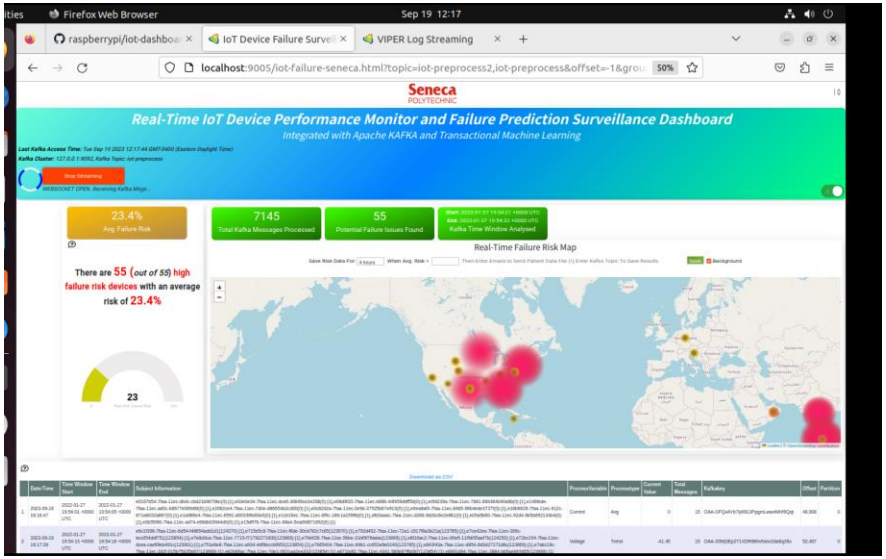
Running TML Streaming Dashboard

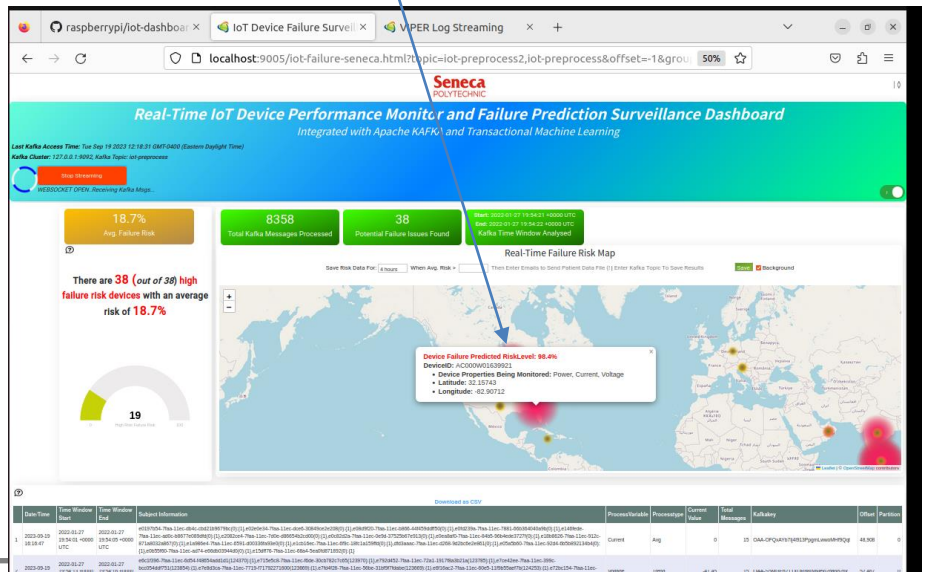
Step 7: Click the Button: START STREAMING and wait few seconds



NOTE: If you don't see enough data – just be patient – you can also Press STOP and START STREAMING the MAP will start to populate



Hover over the map



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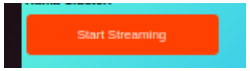
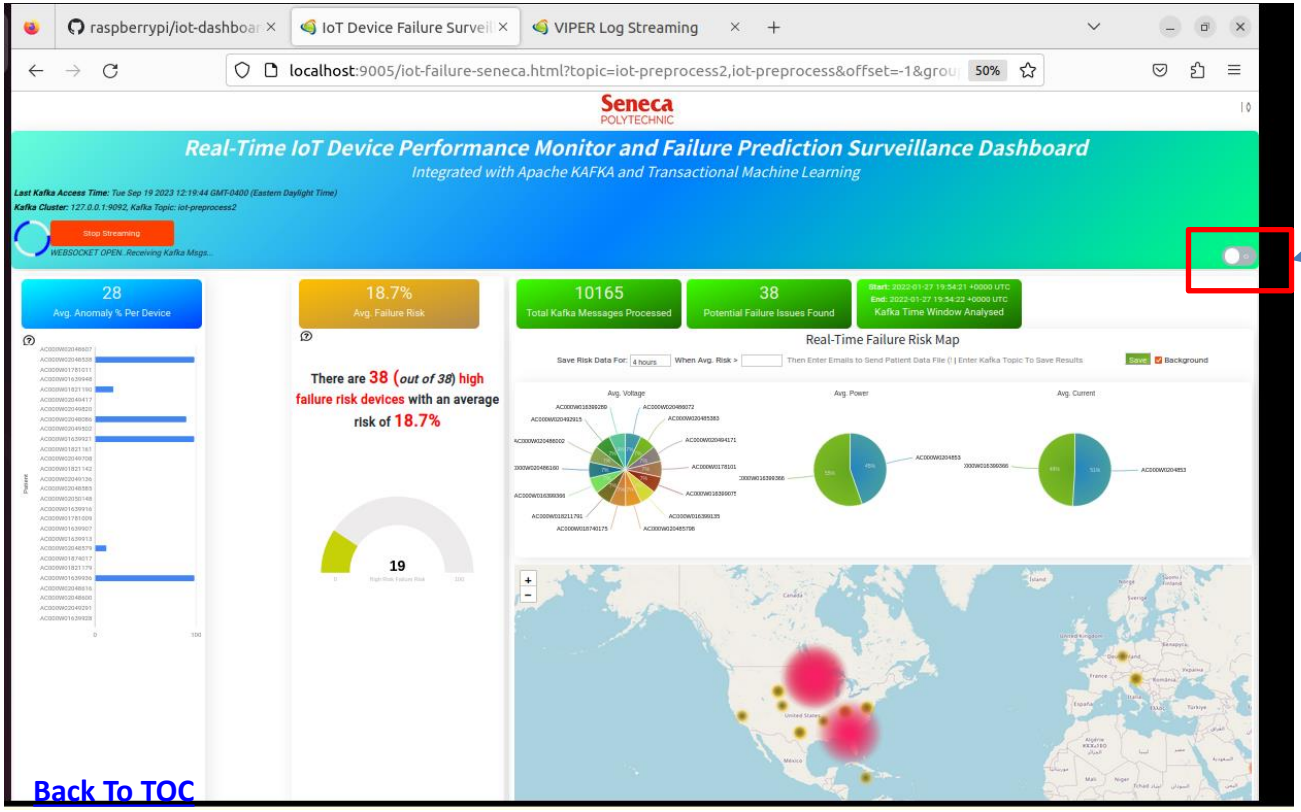
Running TML Streaming Dashboard

Step 7: Click the Button: START STREAMING and wait few seconds



NOTE: If you don't see enough data – just be patient – you can also Press STOP and START STREAMING - the MAP will start to populate

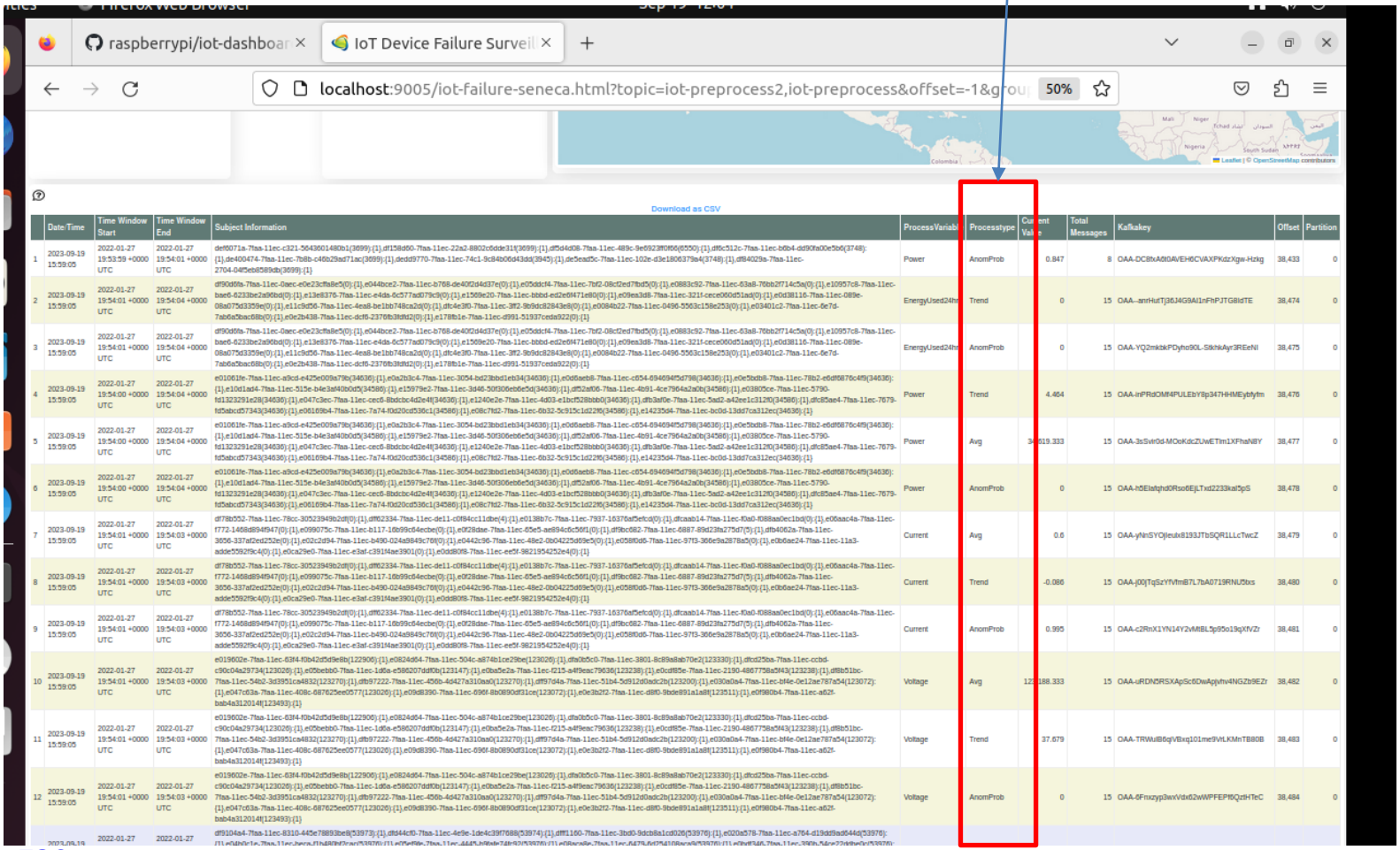


Click

Running TML Streaming Dashboard

- **Scroll down to see the table**
- **You can also DOWNLOAD the table data to CSV**

processtypes



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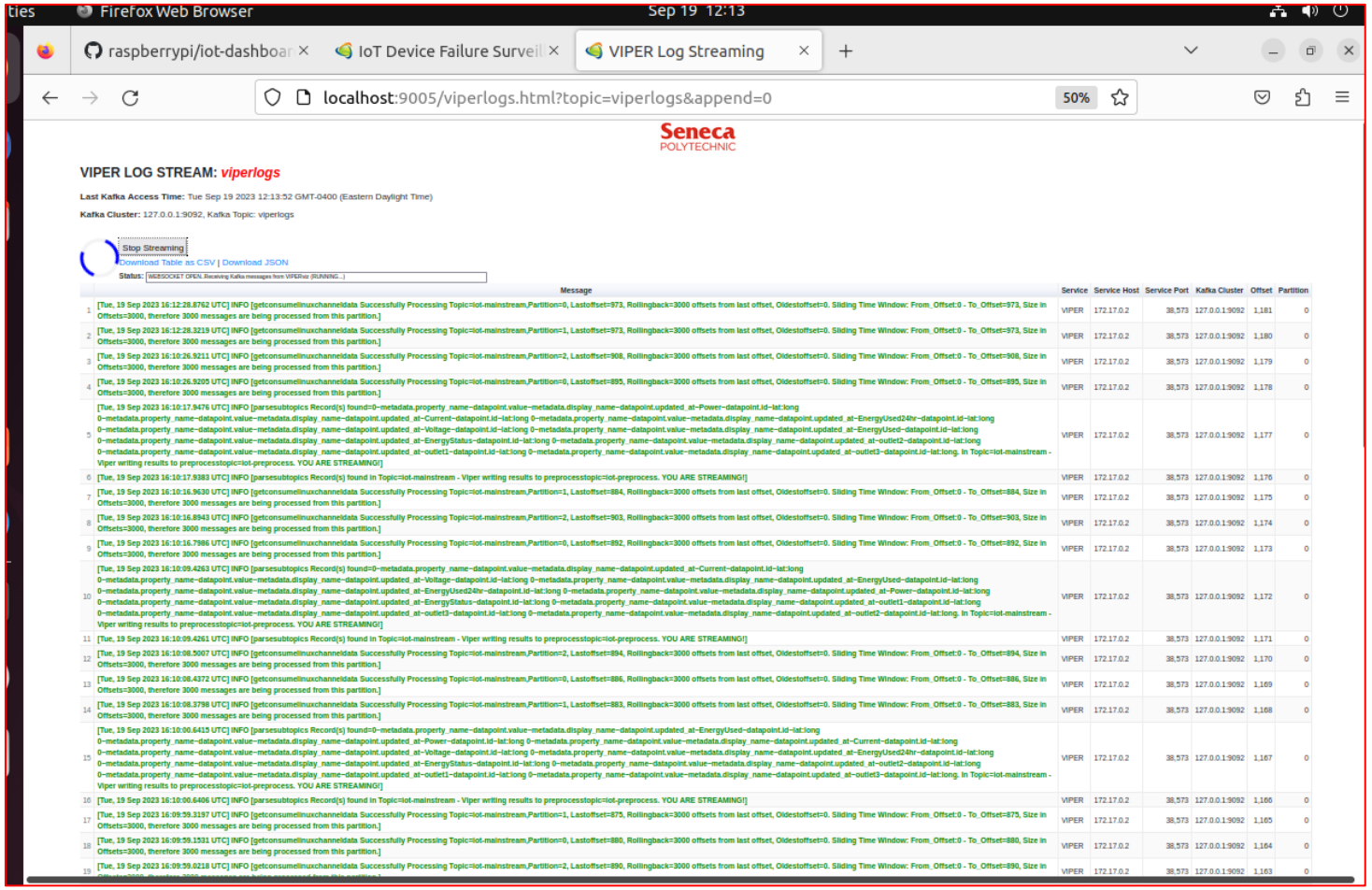
Running TML Streaming Dashboard

You also view TML Log Data – Open a New Tab in Firefox and enter:
http://localhost:9005/viperlogs.html?topic=viperlogs&append=0



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APPENDIX D

Vmware: Building Your Own Container

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Building Your Own Container

Step 1: Create Docker directory and copy Dockerfile

Create Docker folder in your VM

RUN: mkdir docker

```
seb@seb-virtual-machine:~$ mkdir docker
seb@seb-virtual-machine:~$ ls
Desktop  docker  Documents  Downloads  kubernetes  Music  Pictures  Public  snap  Templates  Videos
seb@seb-virtual-machine:~$
```

Go to: https://github.com/smaurice101/raspberrypi/blob/main/docker/Dockerfile

1. **COPY** Dockerfile contents from GitHub to your Local machine
    1. **RUN: cd docker**
    2. **RUN: nano Dockerfile**
    3. Right – click and **PASTE** contents
    4. **Press these keys in nano: Ctlr + O THEN Ctlr + X <choose YES both times>**

You should see in the Docker folder your "Dockerfile" and ready for Build:

```
seb@seb-virtual-machine:~/docker$ ls
Dockerfile
seb@seb-virtual-machine:~/docker$
```

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Building Your Own Container

Step 2: To build your own container

RUN: docker build -t <container name> --build-arg CHIP=<chip arch> --no-cache --network=host .

For example RUN: docker build -t maadsdocker/seneca-iot-tml-test --build-arg CHIP=AMD64 --no-cache --network=host .

MAC USERS: docker build -t maadsdocker/seneca-iot-tml-test --build-arg CHIP=MAC --no-cache --network=host .

```
seb@seb-virtual-machine:~/docker$ docker build -t maadsdocker/seneca-iot-tml-test --build-arg CHIP=AMD64 --no-cache
--network=host .
```

- **maadsdocker is my Dockerhub username (replace it with your Docker hub username)**
- **seneca-iot-tml-test is the name of my container – you can choose any name like:**
  - **docker build -t maadsdocker/daffyduck --build-arg CHIP=AMD64 --no-cache --network=host .**

```
seb@seb-virtual-machine:~/docker$ docker build -t maadsdocker/seneca-iot-tml-test --build-arg CHIP=AMD64 --no-cache
--network=host .
DEPRECATED: The legacy builder is deprecated and will be removed in a future release.
            Install the buildx component to build images with BuildKit:
            https://docs.docker.com/go/buildx/

Sending build context to Docker daemon  10.24kB
Step 1/119 : FROM python:3.9-slim
3.9-slim: Pulling from library/python
a803e7c4b030: Extracting [>                                                  ]  294.9kB/29.12MB
bf3336e84c8e: Download complete
3614ca5053cf: Download complete
7f93433c11f3: Download complete
2fd2c896255c: Download complete
```

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Building Your Own Container

Step 3: To build your own container faster

AFTER You Build your container you can use a FASTER build – this is useful if you are making frequent changes to your container. Fast builds will take ~5 minutes.

RUN: docker build -t <container name> --build-arg CHIP=<chip arch> --build-arg CACHEBUST=$(date +%s) --network=host .

Form example: docker build -t maadsdocker/seneca-iot-tml-test --build-arg CHIP=AMD64 --build-arg CACHEBUST=$(date +%s) --network=host .

FOR MAC USERS: docker build -t maadsdocker/seneca-iot-tml-test --build-arg CHIP=MAC --build-arg CACHEBUST=$(date +%s) --network=host .

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Building Your Own Container

Step 4: Push Your Container to Docker Hub

FIRST LOGIN TO YOUR DOCKERHUB ACCOUNT FROM YOUR VM:

RUN: docker login

```
seb@seb-virtual-machine:~/docker$ docker login
Login with your Docker ID to push and pull images from Docker Hub. If you don't have a Docker ID, head over to https
://hub.docker.com to create one.
Username: maadsdocker
Password:
WARNING! Your password will be stored unencrypted in /home/seb/.docker/config.json.
Configure a credential helper to remove this warning. See
https://docs.docker.com/engine/reference/commandline/login/#credentials-store

Login Succeeded
```

NOW RUN: docker push <container name>

For example: docker push maadsdocker/seneca-iot-tml-test:latest

(Note: Do NOT use sudo)

```
Successfully built aad47e5f7ec8
Successfully tagged maadsdocker/seneca-iot-tml-test:latest
seb@seb-virtual-machine:~/docker$
seb@seb-virtual-machine:~/docker$ docker push maadsdocker/seneca-iot-tml-test:latest
```

```
seb@seb-virtual-machine: ~/docker
7522013e3863: Pushing [==================================>                ]  25.52MB/36.28MB
bc78a03b550f: Waiting
```

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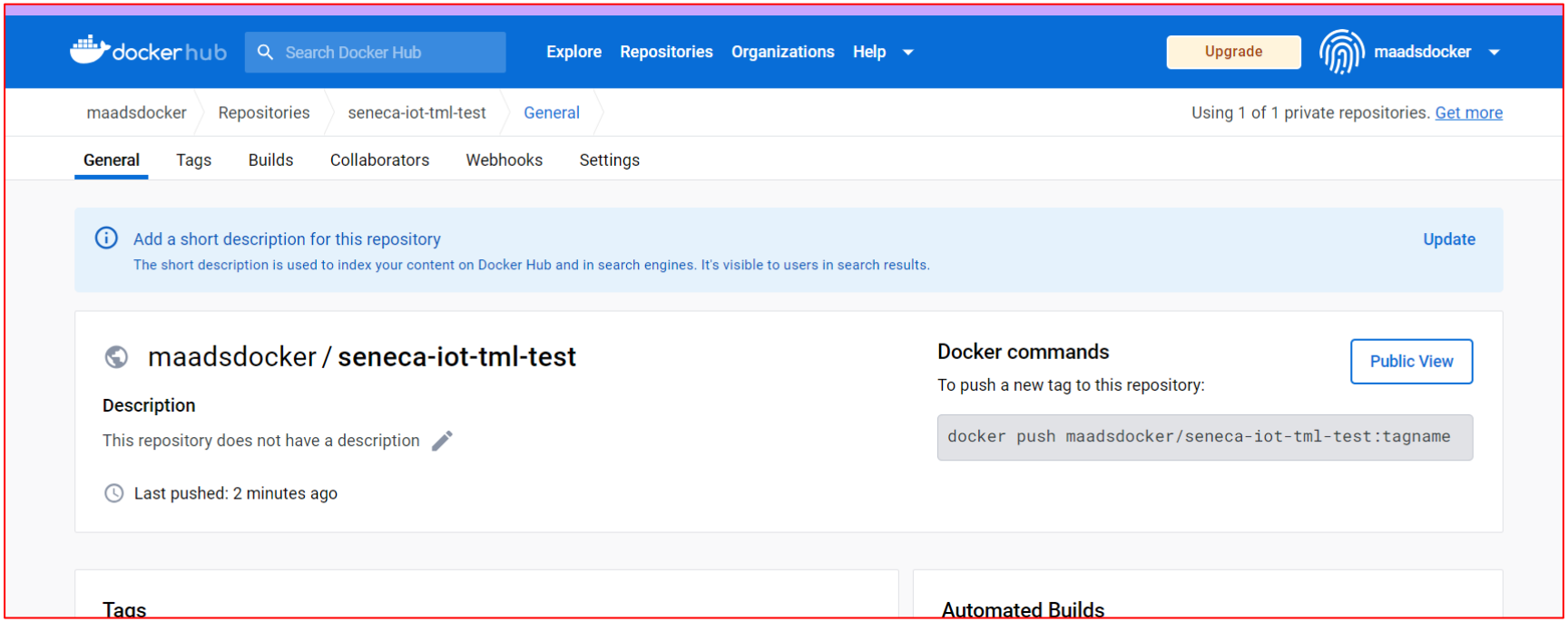
Building Your Own Container

Step 4b: View Your Container in Docker Hub



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Building Your Own Container

Step 5: Run Your Container

CONGRATULATIONS! You just built your OWN Docker Container!

Follow Steps in APPENDIX C using your NEW container name!

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APPENDIX E

- Going Inside the Container

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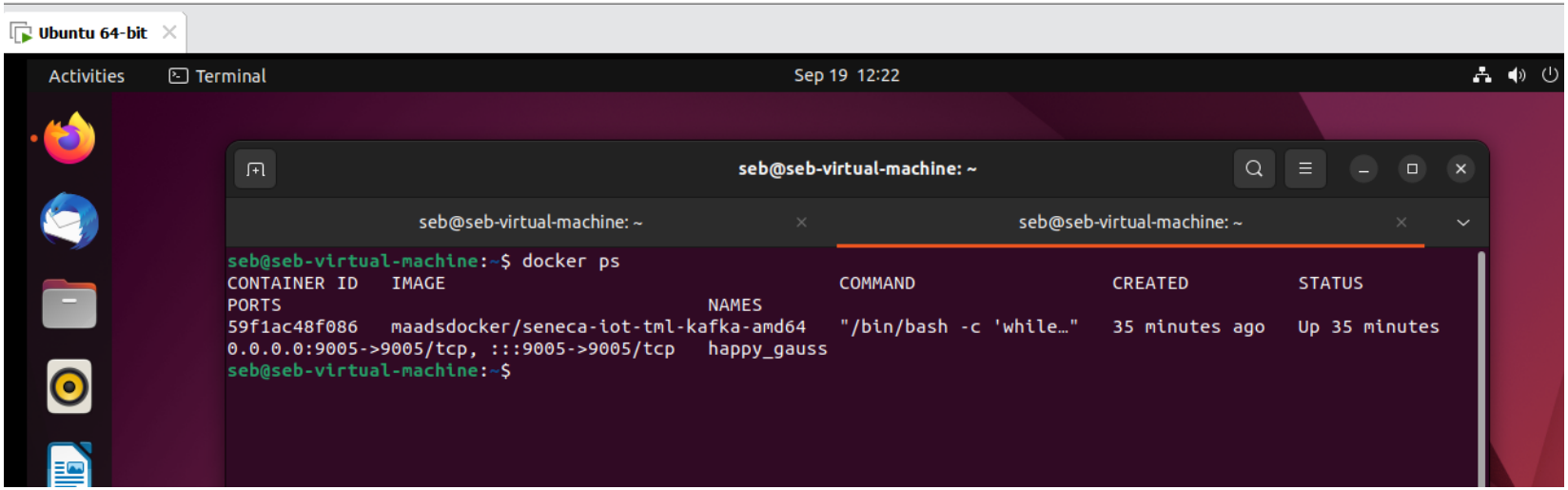
Go Inside the Container

STEP 1: Open a new terminal window

RUN: docker ps



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Go Inside the Container

STEP 2: Go inside the container

RUN: docker exec -it <enter CONTAINER ID>

- **For example: docker exec -it 59f1ac48f086 bash**
- **You are now inside the container!**
- **RUN: ls** (to see folders inside the container)

```
seb@seb-virtual-machine:~$ docker exec -it 59f1ac48f086 bash
root@59f1ac48f086:/#
```

```
root@59f1ac48f086:/# ls
Hpde          Viper-preprocess   Viperviz  deploy  home   lib64   mnt   root  srv  tmux
IotSolution   Viper-preprocess2  bin       dev     lib    libx32  opt   run   sys  usr
Kafka         Viper-produce      boot      etc     lib32  media   proc  sbin  tmp  var
root@59f1ac48f086:/#
```

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Go Inside the Container

STEP 3: List TMUX windows inside the container

RUN: tmux ls

- **These windows are your TML Solution running in real-time!**

```
root@59f1ac48f086:/# tmux ls
kafka: 1 windows (created Tue Sep 19 15:46:24 2023)
preprocess-data-python-8001: 1 windows (created Tue Sep 19 15:46:41 2023)
preprocess-data-viper-8001: 1 windows (created Tue Sep 19 15:46:34 2023)
preprocess2-data-python-8002: 1 windows (created Tue Sep 19 15:46:41 2023)
preprocess2-data-viper-8002: 1 windows (created Tue Sep 19 15:46:34 2023)
produce-iot-data-python-8000: 1 windows (created Tue Sep 19 15:46:41 2023)
produce-iot-data-viper-8000: 1 windows (created Tue Sep 19 15:46:34 2023)
visualization-viperviz-9005: 1 windows (created Tue Sep 19 15:46:41 2023)
zookeeper: 1 windows (created Tue Sep 19 15:46:20 2023)
root@59f1ac48f086:/#
```

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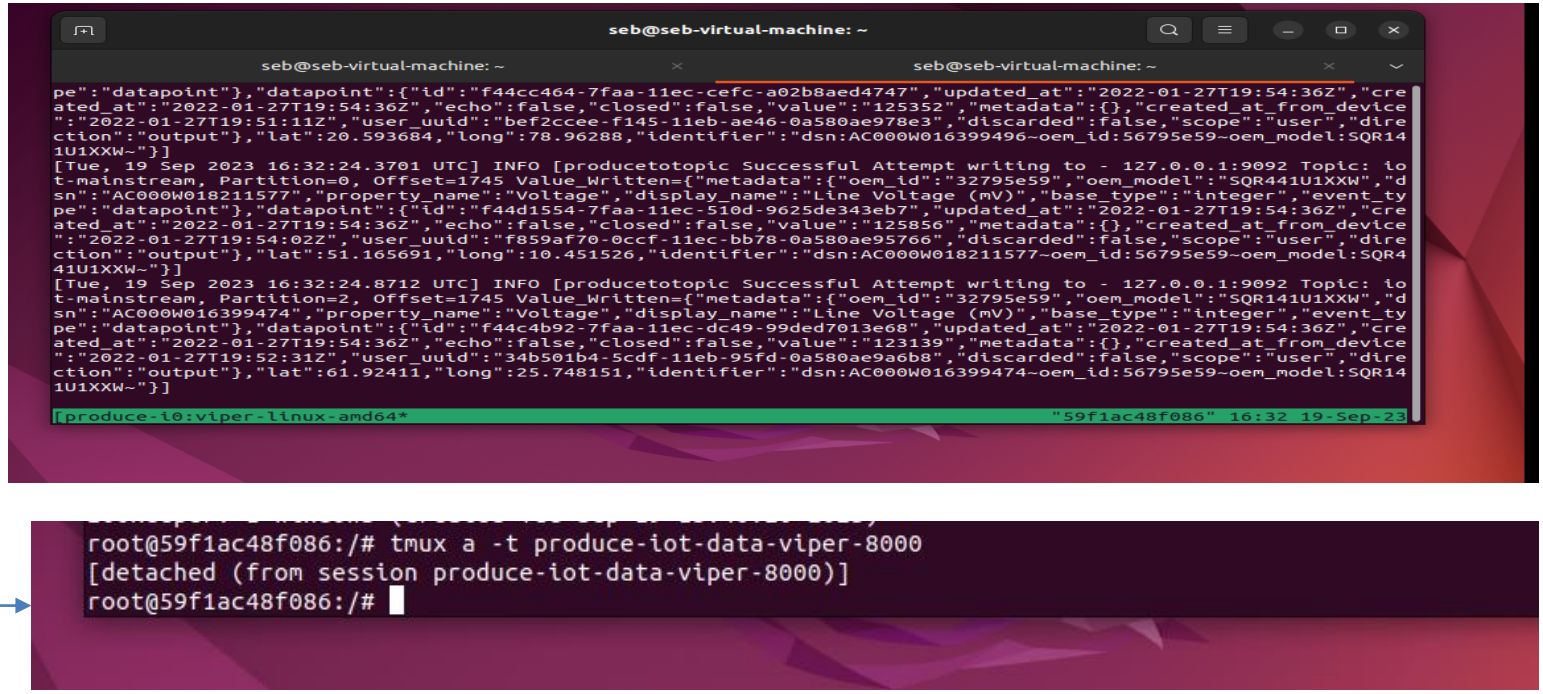
Go Inside the Container

STEP 4: Go inside a TMUX window inside the container

RUN: tmux a -t produce-iot-data-viper-8000

- **This is the RAW IoT data that is streaming to Kafka all running inside your container.**
- **To Detach from the TMUX window press at the same time: Ctrl+B (only press once and then let go of these buttons), THEN just press D**



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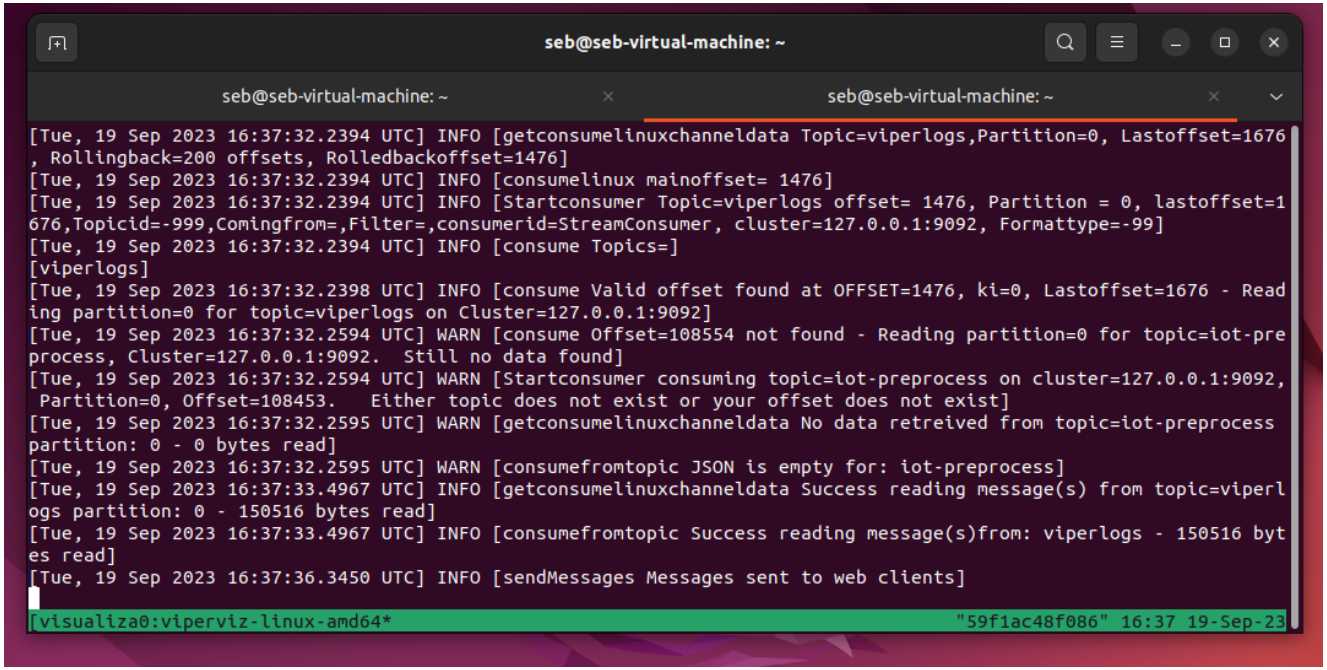
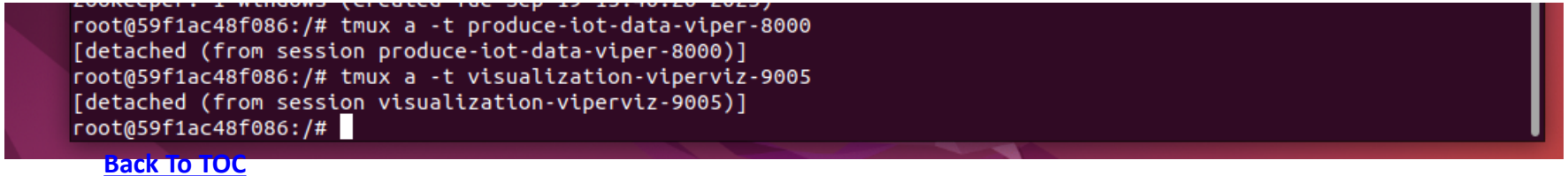
Go Inside the Container

STEP 5: Go inside another TMUX window inside the container

RUN: tmux a -t visualization-viperviz-9005

- **This is the MAADS-Viperviz binary that is powering your Dashboard.**





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Go Inside the Container

STEP 6: Exit from your container

RUN: exit

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TML - TMUX Window Explanation

- TML solution is controlled by 6 separate TMUX windows running in their own Linux instance:
- The Python windows control the Viper windows
- For example:
- **produce-iot-data-python-8000 uses REST API to control produce-iot-data-viper-8000**
- **preprocess-data-python-8001 uses REST API to control preprocess-data-viper-8001**
- **preprocess2-data-python-8002 uses REST API to control preprocess2-data-viper-8002**
- **The Dashboard is controlled by the window:**
  - **visualization-viperviz-9005**
- **The Viper windows have the MAADS-Viper binary running**
- **The Python windows have the TML python scripts running**

```
root@59f1ac48f086:/# tmux ls
kafka: 1 windows (created Tue Sep 19 15:46:24 2023)
preprocess-data-python-8001: 1 windows (created Tue Sep 19 15:46:41 2023)
preprocess-data-viper-8001: 1 windows (created Tue Sep 19 15:46:34 2023)
preprocess2-data-python-8002: 1 windows (created Tue Sep 19 15:46:41 2023)
preprocess2-data-viper-8002: 1 windows (created Tue Sep 19 15:46:34 2023)
produce-iot-data-python-8000: 1 windows (created Tue Sep 19 15:46:41 2023)
produce-iot-data-viper-8000: 1 windows (created Tue Sep 19 15:46:34 2023)
visualization-viperviz-9005: 1 windows (created Tue Sep 19 15:46:41 2023)
zookeeper: 1 windows (created Tue Sep 19 15:46:20 2023)
```

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APPENDIX F

- Kubernetes setup with Docker Container

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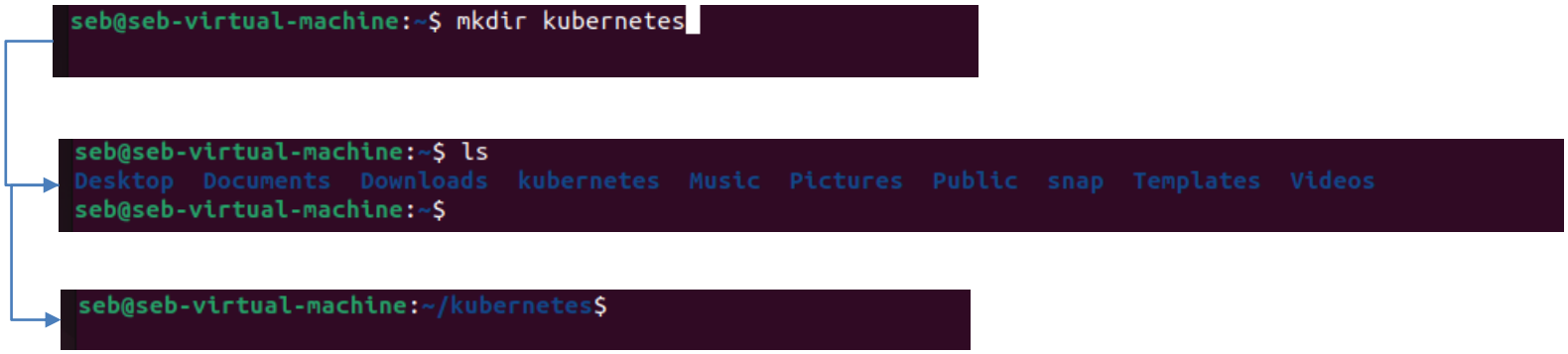
Kubernetes Setup

STEP 1: Create kubernetes directory

First RUN: mkdir kubernetes

Then RUN: ls

Then RUN: cd kubernetes



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Kubernetes Setup

STEP 2: install Kubernetes (minikube)

Note: minikube is a One node Kubernetes cluster – it is meant for development and testing – it is the SAME as a production grade Kubernetes clusters with the same functionality.

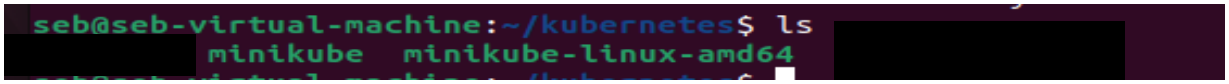
DOWNLOAD MINIKUBE in Kubernetes folder:

RUN: wget https://storage.googleapis.com/minikube/releases/latest/minikube-linux-amd64

Install minikube:

RUN: sudo install minikube-linux-amd64 minikube

You should now see:



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Kubernetes Setup

STEP 3: install kubectl

Note: kubectl is a command line tool that is very popular and controls all functionalilty of Kubernetes (minikube)

DOWNLOAD Kubectl in Kubernetes folder:

RUN: curl -LO https://storage.googleapis.com/kubernetes-release/release/`curl -s https://storage.googleapis.com/kubernetes-release/release/stable.txt`/bin/linux/amd64/kubectl

NOTE IF YOU DO NOT HAVE curl you can install it like this:

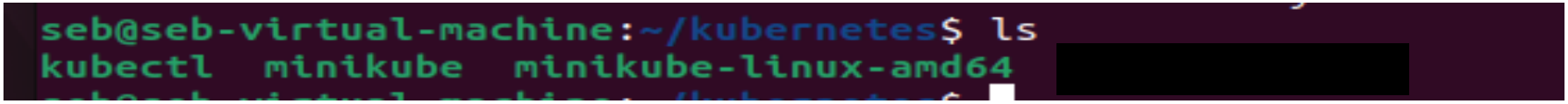
a. sudo apt update && sudo apt upgrade

b. sudo apt install curl

RUN: chmod +x kubectl

RUN: sudo install -o root -g root -m 0755 kubectl /usr/local/bin/kubectl

You should now see:



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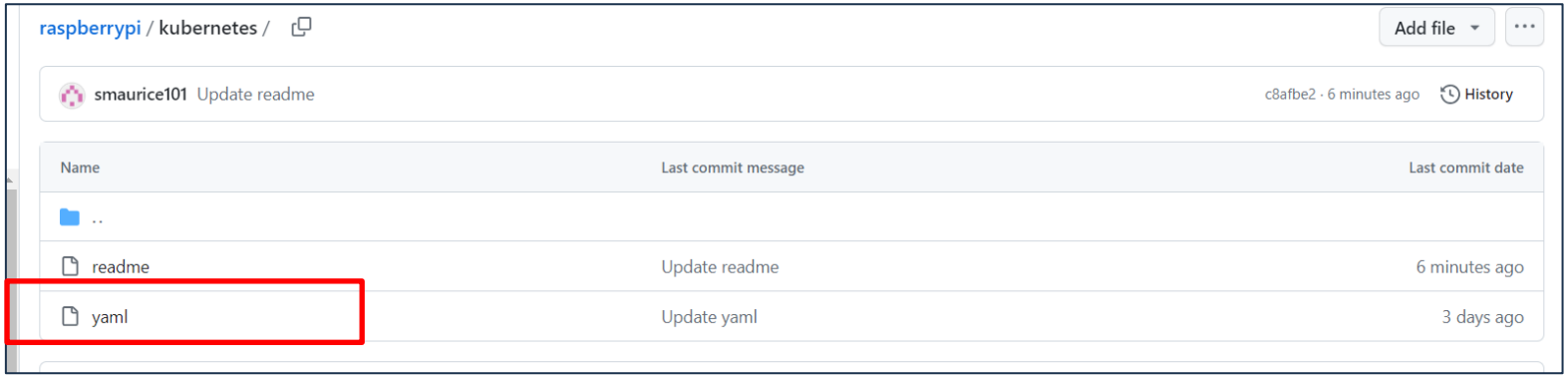
Kubernetes Setup

STEP 4: Download YAML file – Kubernetes (minikube) script

- **Go to: https://github.com/smaurice101/raspberrypi/tree/main/kubernetes**



- Click “yaml”
- Download yaml file to your local kubernetes folder
  - **RENAME** this file: yaml → **senecaiot.yml**

You should now see:

```
seb@seb-virtual-machine:~/kubernetes$ ls
kubectl  minikube  minikube-linux-amd64  senecaiot.yml
```

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Kubernetes Setup

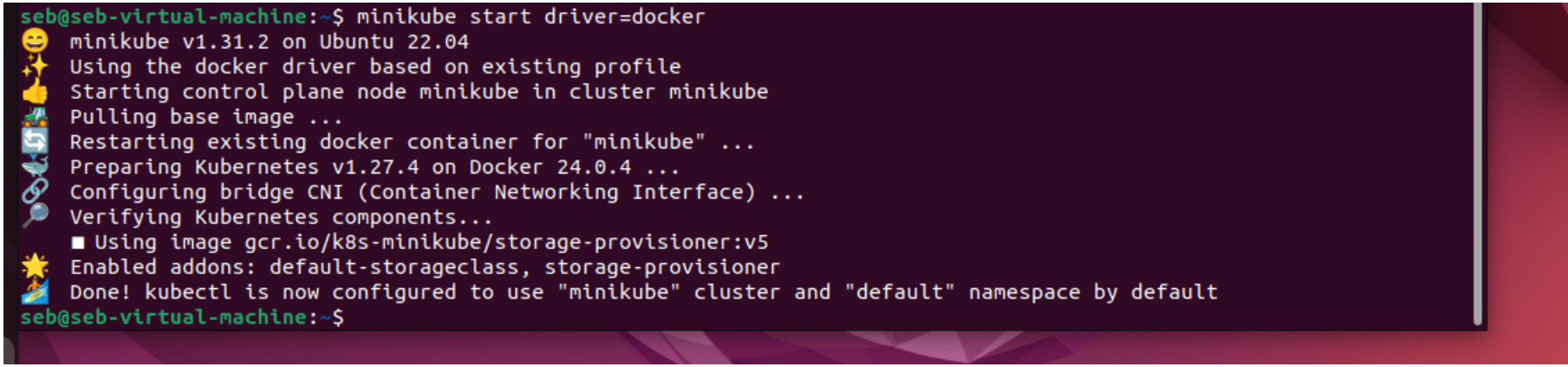
STEP 5: Start Kubernetes (minikube)

RUN: minikube start --driver=docker

(make sure you are in your Kubernetes folder)

Note: You must have docker installed – if not go to APPENDIX C and follow those instructions.

You should see this:



RUN: minikube status

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Kubernetes Setup

STEP 6: Create Kubernetes POD (this is your docker container)

Note: Kubernetes will PULL your docker image and run it. If you open the senecaiot.yml file, the Docker image path is located in the "image" field.

RUN: kubectl apply -f senecaiot.yml

(make sure you are in your kubernetes folder)

RUN: kubectl get pods

You should see this (your Docker container is now running in Kubernetes):

```
seb@seb-virtual-machine:~/kubernetes$ kubectl get pods
NAME                                    READY   STATUS    RESTARTS       AGE
seneca-iot-deployment-78757d978d-czht5   1/1     Running   3 (6m9s ago)   2d20h
seb@seb-virtual-machine:~/kubernetes$
```

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Kubernetes Setup

STEP 7: Port Forwarding to Run Dashboard

Open a new terminal window

RUN: kubectl get pods

Note: the pod NAME in the example it is: seneca-iot-deployment-78757d978d-czhts – your pod NAME will be different

RUN: kubectl port-forward seneca-iot-deployment-78757d978d-czhts 9005:9005

You should see this:

```
seb@seb-virtual-machine:~/kubernetes$ kubectl port-forward seneca-iot-deployment-78757d978d-czht5 9005:9005
Forwarding from 127.0.0.1:9005 -> 9005
Forwarding from [::1]:9005 -> 9005
```

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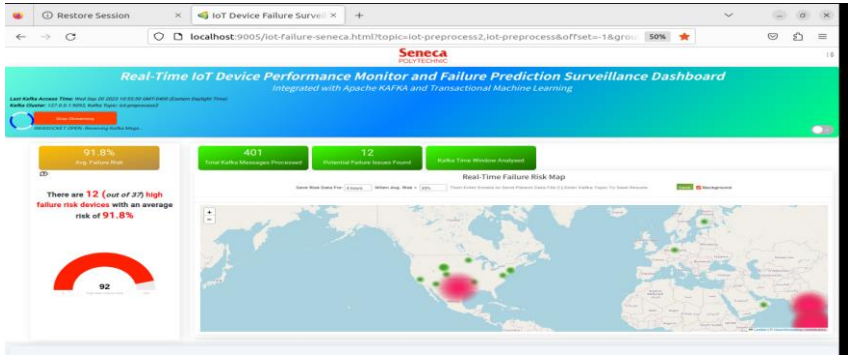
Kubernetes Setup

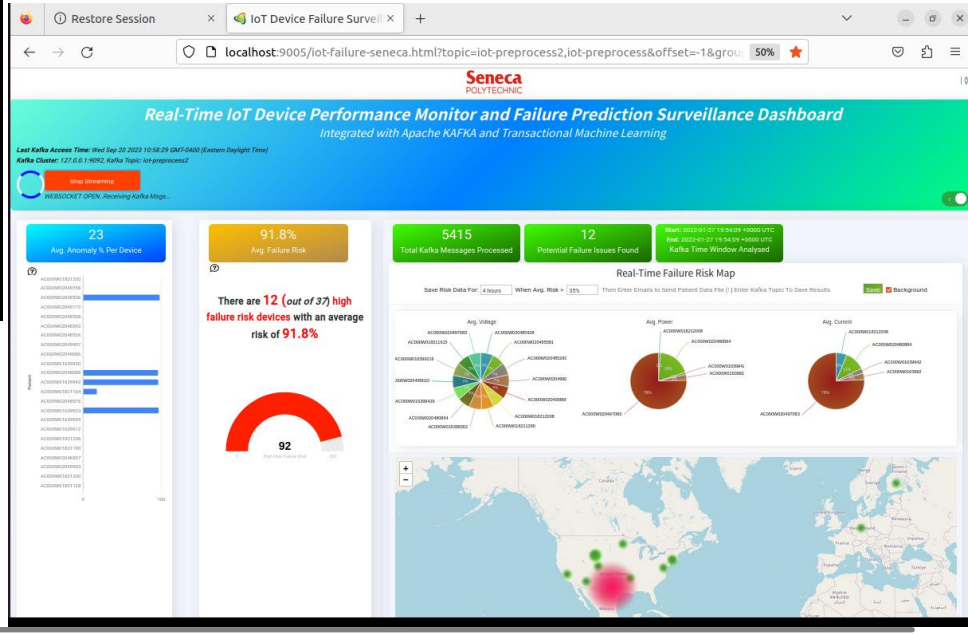
STEP 8: Start Your TML Dashboard

Open a Web Browser in your VM (i.e. Firefox)

ENTER URL: *http://localhost:9005/iot-failure-seneca.html?topic=iot-preprocess2,iot-preprocess&offset=-1&groupid=&rollbackoffset=500&topictype=prediction&append=0&secure=1*

You should see this: (As shown in APPENDIX C)





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Kubernetes Setup

STEP 9: Go inside Kubernetes Pod

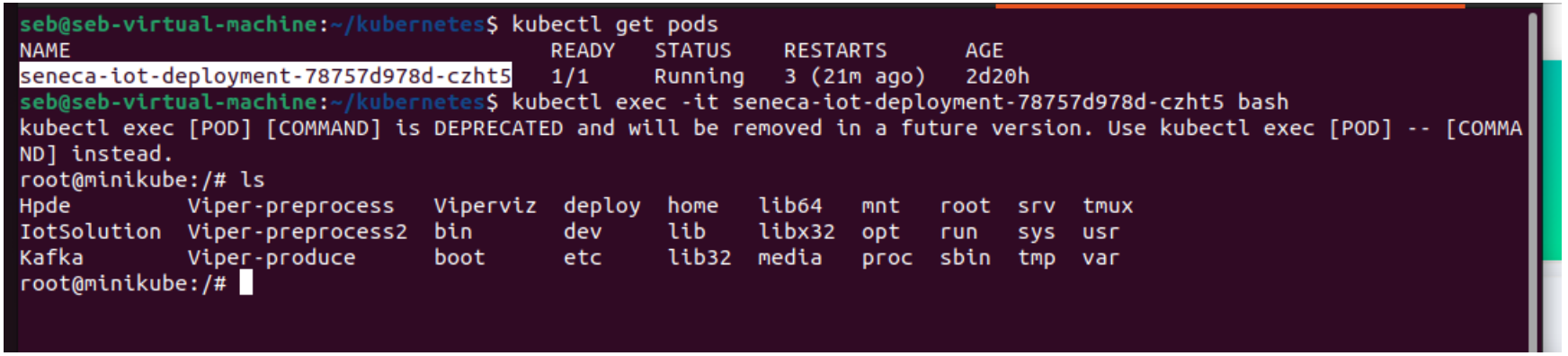
Open a new terminal window

RUN: kubectl get pods

Note: the pod NAME in the example it is: seneca-iot-deployment-78757d978d-czhts – your pod NAME will be different

RUN: kubectl exec -it seneca-iot-deployment-78757d978d-czhts bash

You should see this: (You are now inside the container running in Kubernetes)



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Kubernetes Setup

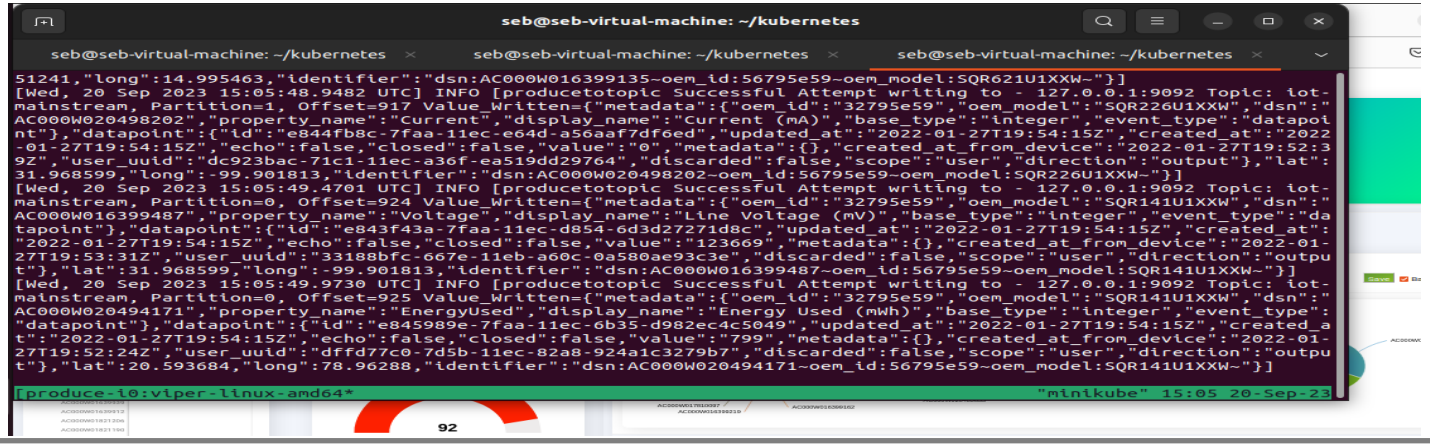
STEP 10: TMUX into windows (See APPENDIX D and run those same commands)

RUN: tmux ls

RUN: tmux a –t produce-iot-data-viper-8000

You should see this: (You are now inside the container running in Kubernetes)

```
root@minikube:/# tmux ls
kafka: 1 windows (created Wed Sep 20 14:40:21 2023)
preprocess-data-python-8001: 1 windows (created Wed Sep 20 14:40:39 2023)
preprocess-data-viper-8001: 1 windows (created Wed Sep 20 14:40:31 2023)
preprocess2-data-python-8002: 1 windows (created Wed Sep 20 14:40:39 2023)
preprocess2-data-viper-8002: 1 windows (created Wed Sep 20 14:40:32 2023)
produce-iot-data-python-8000: 1 windows (created Wed Sep 20 14:40:39 2023)
produce-iot-data-viper-8000: 1 windows (created Wed Sep 20 14:40:31 2023)
visualization-viperviz-9005: 1 windows (created Wed Sep 20 14:40:39 2023)
zookeeper: 1 windows (created Wed Sep 20 14:40:17 2023)
root@minikube:/#
```



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Kubernetes Setup

STEP 11: Exit

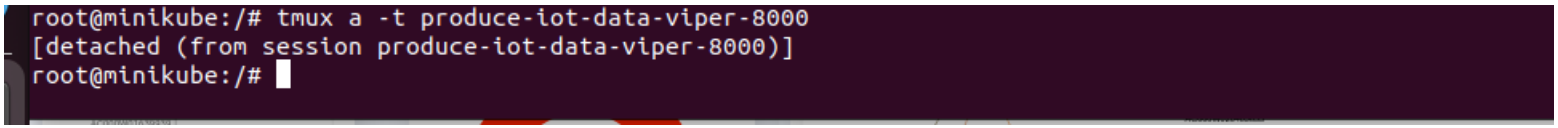
EXIT OUT OF TMUX

RUN: Ctlr+B, D

EXIT OUT OF Container

RUN: exit

You should see this: (You are now inside the container running in Kubernetes)



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Kubernetes Setup

STEP 12: Enable Kubernetes Dashboard

RUN: minikube addons enable dashboard

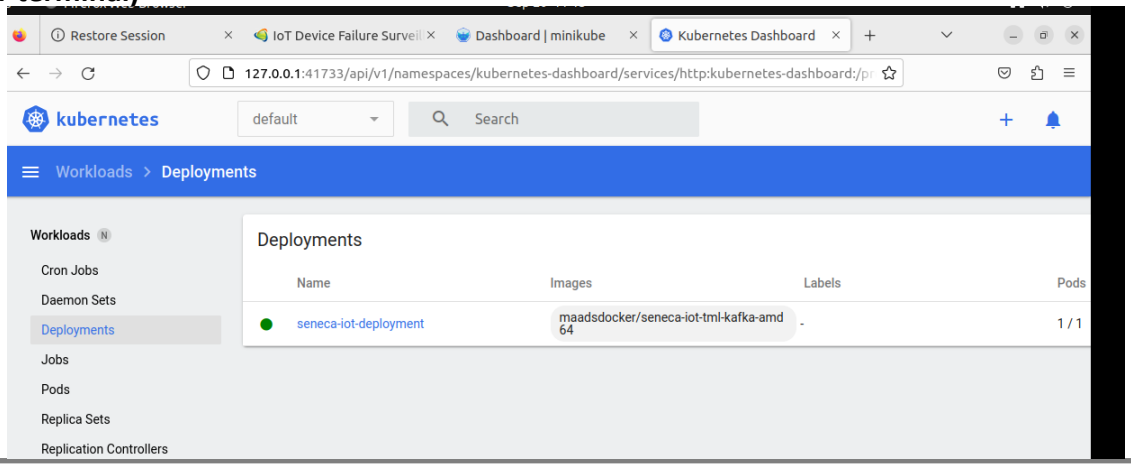
You should see this:

```
seb@seb-virtual-machine:~/kubernetes$ minikube addons enable dashboard
💡  dashboard is an addon maintained by Kubernetes. For any concerns contact minikube on GitHub.
You can view the list of minikube maintainers at: https://github.com/kubernetes/minikube/blob/master/OWNERS
    ▪ Using image docker.io/kubernetesui/metrics-scraper:v1.0.8
    ▪ Using image docker.io/kubernetesui/dashboard:v2.7.0
💡  Some dashboard features require the metrics-server addon. To enable all features please run:

        minikube addons enable metrics-server


🌟  The 'dashboard' addon is enabled
```

Run the Kubernetes Dashboard:

RUN: minikube dashboard

(to exit dashboard press Ctlr + C in your terminal)



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Kubernetes (minikube) Popular Commands

Dashboard:

- enable dashboard: minikube addons enable dashboard
- run dashboard: minikube dashboard

COMMAND kubectl commands:

- 1. create pod: kubectl apply -f senecaiot.yml
- 2. kubectl delete pods seneca-iot-pod
- 3. kubectl get pods
- 4. kubectl exec -it container_name bash
- 5. kubectl describe pods pod_name
- 6. kubectl delete all --all --all-namespaces
- 7. kubectl expose deployment seneca-iot-deployment --port=9005 --target-port=9005 --name=seneca-iot --type=LoadBalancer
- 8. kubectl port-forward <pod name> 9005:9005

- ERRORS:
- if error or kubelet and aopiserver is STOPPED run:
- a. minikube stop
- b. minikube delete
- c. minikube start
- d. minikube status

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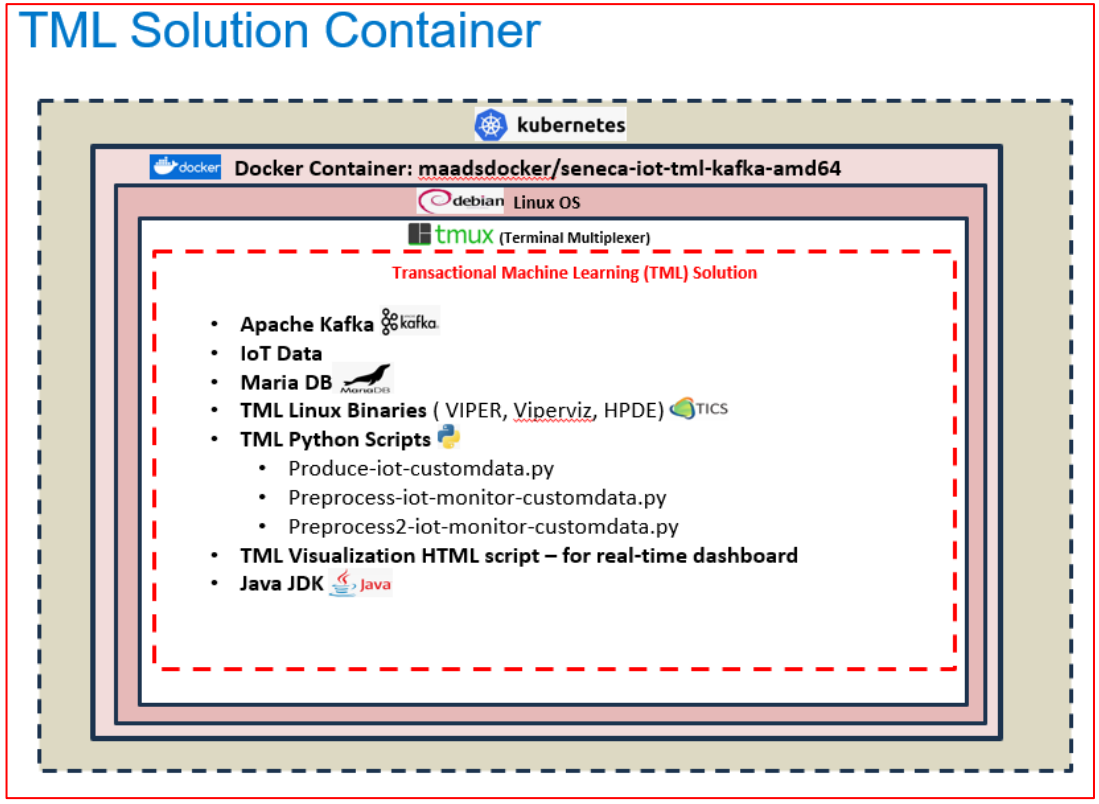
CONGRATULATIONS!

You just built, pulled, ran, streamed, and analysed a TML Solution Docker container in Kubernetes and completed the deployment of the ENTIRE TML SOLUTION CONTAINER!



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APPENDIX G

- TML Folder Structure in Container

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TML Solution Folder Structure in Container

- There are 6 parts to the TML solution that run in the Docker Container:

1. Producing data to Kafka
2. Preprocess data that is streaming to Kafka
3. Preprocess2 data to determine the probability of anomalies in the data
4. Visualization to stream preprocess and preprocess2 to dashboard
5. TMUX – Runs all the TML solution windows
6. Kafka – storage for the RAW data

The TML Solution Container Structure is as follows: (Note your docker container id will be different from the id: effa956fa33a in the example below – simple RUN: docker ps to get your CONTAINER ID)

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TML Solution Folder Structure in Container

1. **Producing data to Kafka: this produces Raw data to Apache Kafka that is running inside the container – this RAW data is used for the entire solution**

a) The name of the RAW Data file called **IotData.txt** it's location in the **IotSolution** folder

```
seb@seb-virtual-machine:~$ docker exec -it effa956fa33a bash
root@effa956fa33a:/# ls
Hpde         Kafka            Viper-preprocess2  Viperviz  boot    dev  home  lib32  libx32  mnt  proc  run   srv  tmp   usr
IotSolution  Viper-preprocess  Viper-produce      bin       deploy  etc  lib   lib64  media   opt  root  sbin  sys  tmux  var
root@effa956fa33a:/#
```

```
root@effa956fa33a:/IotSolution# ls
IoTData.txt       iot-ml-predictions_topicid_logistics.py  preprocess-iot-monitor-customdata.py  produce-iot-customdata.py
dsntmlidmain.csv  iot-ml-training_topicid_logistics.py     preprocess2-iot-monitor-customdata.py  readme
```

b) The Python Script: **produce-iot-customdata.py** reads each line of IoTData.txt and streams the data to Kafka.

- the script calls the MAADS-Viper binary called **viper-linux-amd64** that is running in the **Viper-produce** folder which produces the Raw data to **Kafka topic: iot-mainstream**

```
root@effa956fa33a:/Viper-produce# ls
'MAADS-Viper Installation Guide.pdf'   admin.tok       client.key.pem   token.tok          viper.db    viper.env.bak   viperlogs
'MAADS-Viper-Product Brief.pdf'        client.cer.pem   server.cer.pem   viper-linux-amd64  viper.env   viper.txt
```

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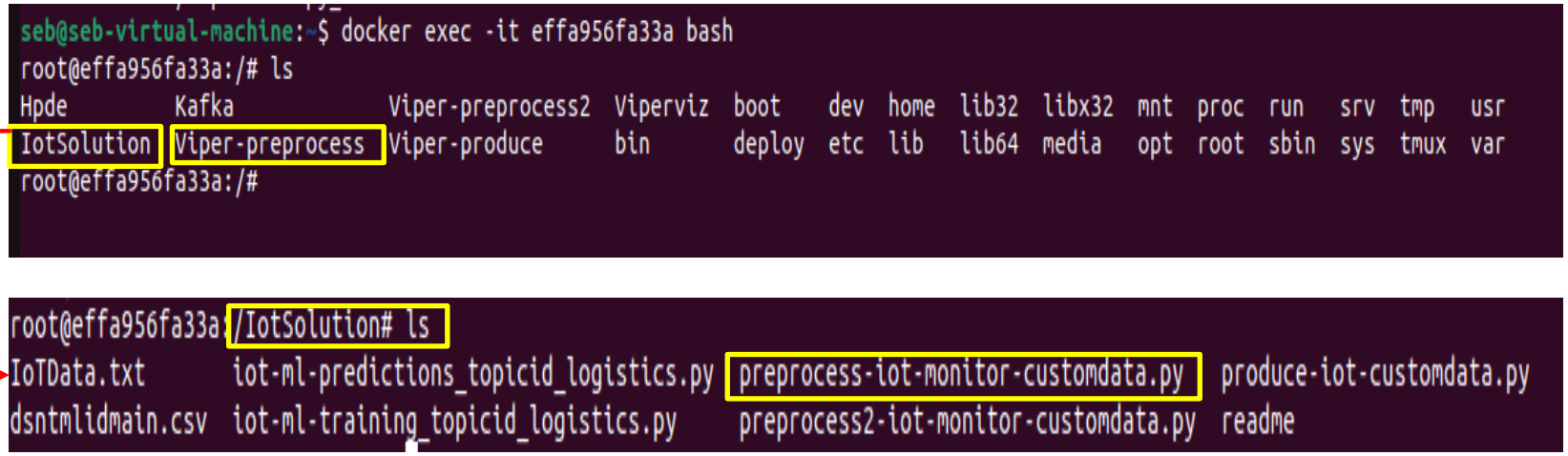
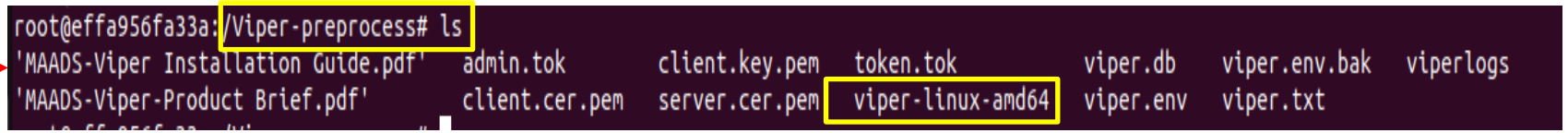
TML Solution Folder Structure in Container

1. **Preprocess data to Kafka: this preprocesses the Raw data by reading a Kafka Topic: iot-mainstream, and writes the output to another Kafka topic: iot-preprocess**



a) The Python Script: **preprocess-iot-monitor-customdata.py** consumes (reads) from the Kafka Topic: **iot-mainstream and produces (writes) it to another Kafka topic: iot-preprocess**

- this python script calls the MAADS-Viper binary called **viper-linux-amd64** that is running in the **Viper-preprocess** folder and does all the reading/writing to Kafka topics.



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TML Solution Folder Structure in Container

1. **Preprocess2 data to Kafka: this preprocesses2 the Raw data by reading a Kafka Topic: preprocess, and writes the output to another Kafka topic: iot-preprocess2**

```
seb@seb-virtual-machine:~$ docker exec -it effa956fa33a bash
root@effa956fa33a:/# ls
Hpde        Kafka           Viper-preprocess2  Viperviz  boot   dev  home  lib32  libx32  mnt  proc  run   srv  tmp   usr
IotSolution Viper-preprocess Viper-produce     bin       deploy etc  lib   lib64  media   opt  root  sbin  sys  tmux  var
root@effa956fa33a:/#
```

```
root@effa956fa33a:/IotSolution# ls
IoTData.txt       iot-ml-predictions_topicid_logistics.py  preprocess-iot-monitor-customdata.py   produce-iot-customdata.py
dsntmlidmain.csv  iot-ml-training_topicid_logistics.py     preprocess2-iot-monitor-customdata.py  readme
```

a) The Python Script: **preprocess2-iot-monitor-customdata.py** consumes (reads) from the Kafka Topic: **iot-preprocess and produces (writes) it to another Kafka topic: iot-preprocess2**

- this python script calls the MAADS-Viper binary called **viper-linux-amd64** that is running in the **Viper-preprocess2** folder and does all the reading/writing to Kafka topics.

```
root@effa956fa33a:/Viper-preprocess2# ls
'MAADS-Viper Installation Guide.pdf'   admin.tok       client.key.pem   token.tok          viper.db    viper.env.bak   viperlogs
'MAADS-Viper-Product Brief.pdf'        client.cer.pem   server.cer.pem   viper-linux-amd64  viper.env   viper.txt
```

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TML Solution Folder Structure in Container

1. **Visualization Folder is in Viperviz**

```
seb@seb-virtual-machine:~$ docker exec -it effa956fa33a bash
root@effa956fa33a:/# ls
Hpde         Kafka            Viper-preprocess2  Viperviz  boot  dev  home  lib32  libx32  mnt  proc  run   srv  tmp  usr
IotSolution  Viper-preprocess  Viper-produce      bin       deploy  etc  lib   lib64  media   opt  root  sbin  sys  tmux  var
root@effa956fa33a:/#
```

2. The TML binary that streams data from Kafka topics: iot-preprocess and iot-preprocess2 to the client browser is **viperviz-linux-amd64**

```
root@7d125f62d0b1:/Viperviz# ls
'MAADS-Viper Installation Guide.pdf'   client.key.pem   viper.db    viperviz-linux-amd64
 admin.tok                             server.cer.pem   viper.env   viperviz.txt
 client.cer.pem                        token.tok        viperviz    viperviz.zip
```

3. The TML IoT Dashboard is in the folder: Viperviz -> viperviz -> views called: **iot-failure-seneca.html**

```
root@7d125f62d0b1:/Viperviz/viperviz/views# ls
OTICS-New-Logo-Black.png            externaldashboardpasswords_for_nginx  medication-fraud.html
aims.html                           fg_fhir_landing.html                  medicationfrauddash.png
anomaly.html                        fhirhealthmonitor-json                nft-priceprediction-Blockchain.html
apex                                fhirpopulationhealth.html             optimization.html
backgroundscripts                   fhirpopulationhealthmap-chatgpt.html  oticsico.png
banner.png                          fhirpopulationhealthmap.html          prediction.html
cluster.jpg                         firstgenesislogo.png                  preprocess.html
cluster.png                         genericTopics.html                    searchanomalies.html
clusteranalysis.html                help.png                              senecalogo.png
clusteranalysisotics.html           img                                   smilelogo.png
crypto-marketrisk-Blockchain.html   iot-failure-Blockchain.html           testheatmap.html
crypto1.png                         iot-failure-Machinelearning.html      testheatmap2.html
crypto2.png                         iot-failure-seneca.html               testheatmap3.html
```

This **iot-failure-seneca.html makes a websocket connection to viperviz-linux-amd64, which directly reads Kafka topics: iot-preprocess and iot-preprocess2: viperviz-linux-amd64 is listening on port 9005.**

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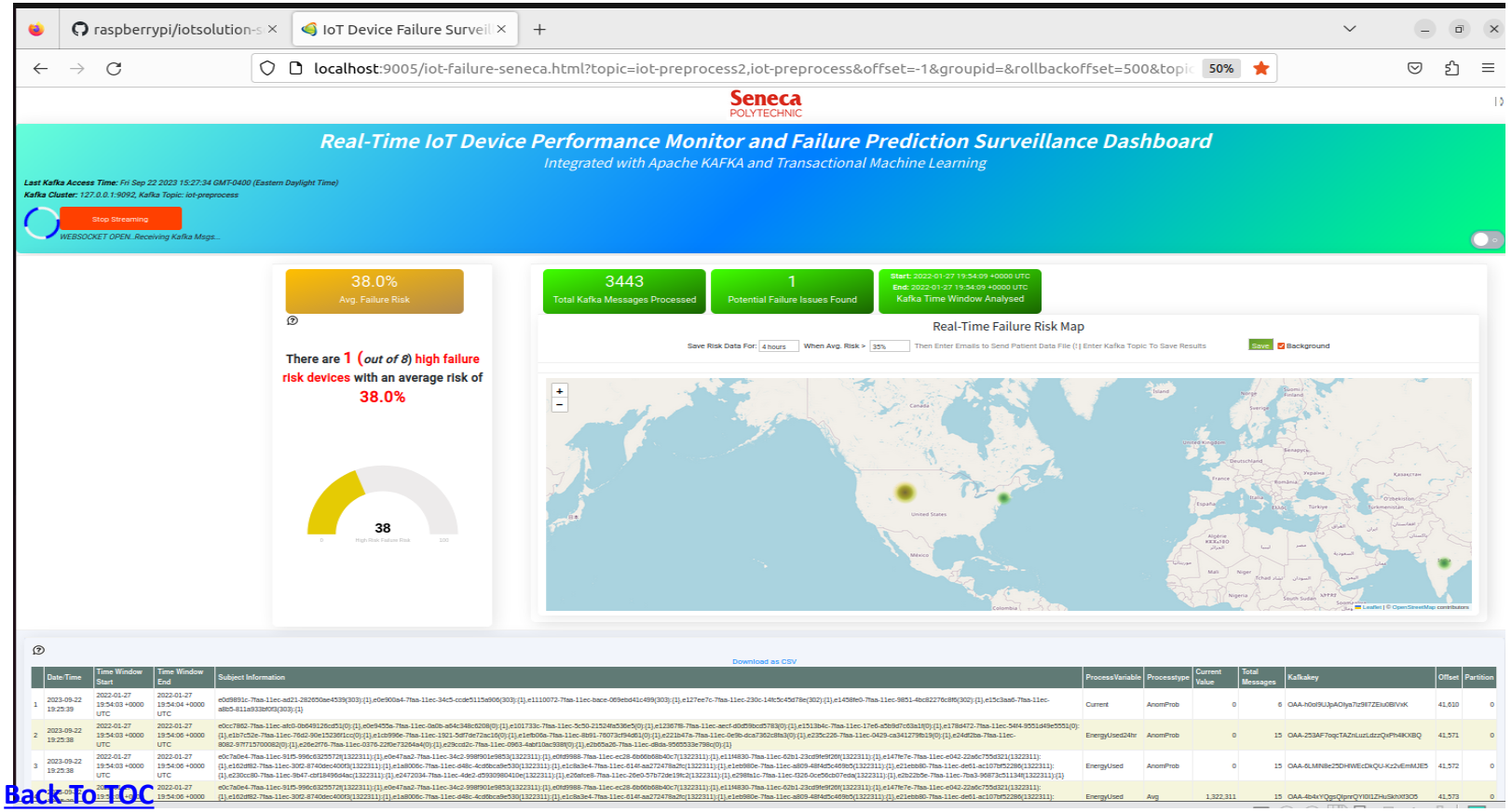
TML Dashboard

The TML Dashboard runs by entering this URL in the browser:
http://localhost:9005/iot-failure-seneca.html?topic=iot-preprocess2,iot-preprocess&offset=-1&groupid=&rollbackoffset=500&topictype=prediction&append=0&secure=1

NOTE: The URL topic=iot-preprocess2,iot-preprocess – these are precisely the topics where the preprocessed data are being produced in Kafka.



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TMUX: Terminal Multiplexer

- When Docker starts up – it runs a **tmux-docker.sh** at the **ENTRYPOINT INSIDE Dockerfile:**

```
325     RUN rm -rf raspberrypi
326
327     ENTRYPOINT ["/bin/bash","-c","while true; do sleep 1; done | ./tmux/tmux-docker.sh"]
```

- This file is located in **tmux** folder:

```
seb@seb-virtual-machine:~$ docker exec -it effa956fa33a bash
root@effa956fa33a:/# ls
Hpde         Kafka             Viper-preprocess2  Viperviz  boot   dev  home  lib32  libx32  mnt  proc  run   srv  tmp  usr
IotSolution  Viper-preprocess  Viper-produce      bin       deploy etc  lib   lib64  media   opt  root  sbin  sys  tmux var
root@effa956fa33a:/#
```

```
root@7d125f62d0b1:/tmux# ls
tmux-docker.sh
```

- **tmux-docker.sh** automatically creates and runs all the TML solution files and applications running in their own Linux instances.

```
root@7d125f62d0b1:/# tmux ls
kafka: 1 windows (created Fri Sep 22 19:09:24 2023)
preprocess-data-python-8001: 1 windows (created Fri Sep 22 19:09:41 2023)
preprocess-data-viper-8001: 1 windows (created Fri Sep 22 19:09:34 2023)
preprocess2-data-python-8002: 1 windows (created Fri Sep 22 19:09:41 2023)
preprocess2-data-viper-8002: 1 windows (created Fri Sep 22 19:09:34 2023)
produce-iot-data-python-8000: 1 windows (created Fri Sep 22 19:09:41 2023)
produce-iot-data-viper-8000: 1 windows (created Fri Sep 22 19:09:34 2023)
visualization-viperviz-9005: 1 windows (created Fri Sep 22 19:09:41 2023)
zookeeper: 1 windows (created Fri Sep 22 19:09:19 2023)
```

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APPENDIX H

- TML-CISCO Cybersecurity and Network Monitoring Solution

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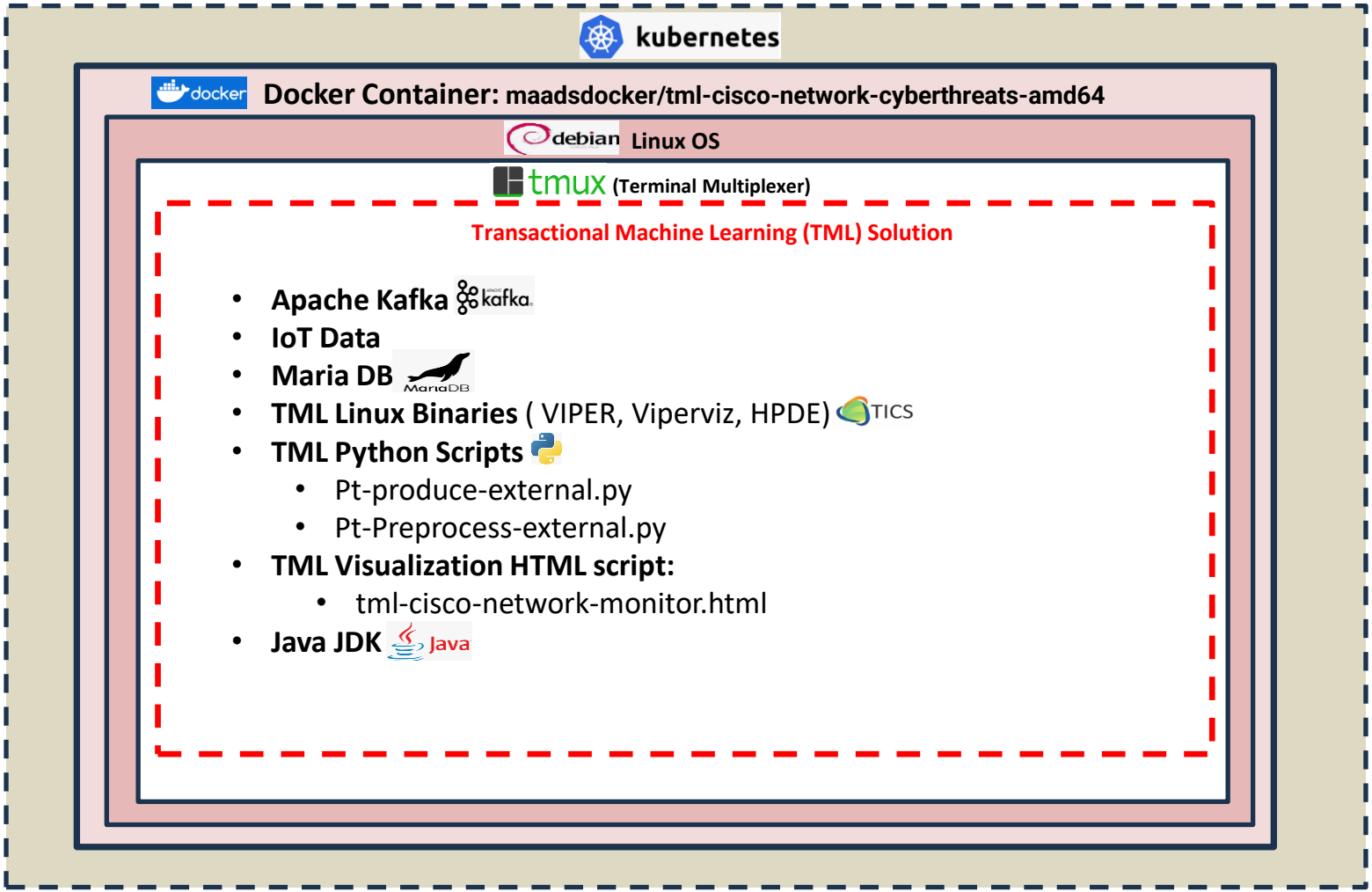
TML – Cisco Solution Container (Linux/Mac)



Mac user: **maadsdocker/tml-cisco-network-cyberthreats-mac**

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TML-CISCO Cybersecurity and Network Monitoring Solution

- This solution is an interactive solution between Students and Instructor
- **The goal of this solution is the real-time detection of network anomalies and teaching students how data is analysed and interpreted for Real-Time data driven decision-making**
- The Instructor plays the role of a hacker – who tries to hack into one of the end devices connected to a Cisco Switch
- The students TML solution should, in real-time, be able to detect which machine(s) the instructor is hacking into
- In addition – the instructor can also take a machine offline – this should also be detected by the TML solution
- ***STUDENTS WILL BUILD THEIR OWN TML Solution using the scripts provided – this solution is similar to the one shown here in the container and dashboard***

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Setting Up Confluent Kafka Cloud

- Instructors will need to setup a FREE 30 day Confluent Kafka Cloud Account – for instructions see:

  - How to setup Kafka Cloud with TML Binary can be found in the video here:
  - https://github.com/smaurice101/raspberrypi/tree/main/TML%20Crash%20course/Videos
  - Kafka Cloud accounts are FREE for 30 days on Confluent.io ***(no credit card needed)***

TML-CISCO: Container RUN Command

- In Dockerhub instructors and students can find:
  - Linux Container: maadsdocker/tml-cisco-network-cyberthreats-amd64
  - MAC Container: maadsdocker/tml-cisco-network-cyberthreats-mac
  - These containers can be pulled using: ***docker pull maadsdocker/tml-cisco-network-cyberthreats-amd64*** *(MAC users use the MAC container)*
- These containers can be run in several ways using **docker run** by changing the value of the **RUNTYPE variable:**

EXAMPLE: docker run -d --net="host" --env RUNTYPE=-1 --env BROKERHOSTPORT=pkc-lzvrd.us-west4.gcp.confluent.cloud:9092 --env KAFKAPRODUCETOPIC=cisco-network-mainstream --env HACKEDHOSTS=5.100-i,6.18-i,5.18-i --env CLOUDUSERNAME=Z6ZIK7OALQZXYYC2 --env CLOUDPASSWORD=*uBGl02SFiZ69BBJhjE7vjE7mfd5S8XqaMTpAv93doab5Gvn6szZ+Vbue4saX8CGo* maadsdocker/tml-cisco-network-cyberthreats-amd64

NOTE: Give data 30 – 60 seconds to populate and preprocessed on Dashboard.

- The next slide defines the RUNTYPE and other parameter settings in Docker Run.

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TML-CISCO: Docker Parameter Settings

Scenario	RUNTYPE	BROKERHOSTPORT	KAFKAPRODUCETOPIC	HACKEDHOSTS	CLOUDUSERNAME	CLOUDPASSWORD
1*	**-1** (instructors enter this)	This is the Confluent Kafka Cloud Broker Host and Port. **it will be provided by the Instructor.** It will look similar to this: **pkc-lzvrd.us-west4.gcp.confluent.cloud:9092** https://www.confluent.io/ **30 Day FREE Kafka Cloud accounts can be setup without credit card.**	**Instructors will set this to a string value for example: cisco-network-mainstream.** This is the topic that raw data will be streamed to**. Instructors can specify any topic name.**	Instructors specific which hosts they want to hack into, the format is: [subnet].[hostid]-[i or d], where i=increasing packets, d=decreasing packets. For example:**5.100-i,6.18-i,5.18-I – means hosts: 5.100, 6.18 and 5.18 are being hacked with increasing packets.** ***SOLUTION IS SIMULATING PACKETS.***	Instructor downloads the API Key from Confluent Kafka Cloud. ***This is the KEY.***	Instructor downloads the API Key from Confluent Kafka Cloud. ***This is the SECRET.***
2*	**-2** (students)	Students will enter the Kafka Cloud Broker in 1*: ***This will be given to them by instructor.***	Student enter the same topic name in 1*. ***This will be given to them by instructor.***	***STUDENTS' TML SOLUTION MUST IDENTIFY THE HACKED HOSTS***	Students receive this from their Instructor.	Students receive this from their instructor.
3	0	**STUDENT TESTING:** Using CLOUD Kafka **Enter kafka cloud broker host/port. Student MUST have Cisco Packet Tracer file running. See 1* below.**	Students specify any Kafka topic. Or leave blank – then default topic will be used: **cisco-network-mainstream**	Students specify any hacked hosts.	Student downloads the API Key from Confluent Kafka Cloud. ***This is the KEY.***	Student downloads the API Key from Confluent Kafka Cloud. ***This is the SECRET.***
4	1	**STUDENT TESTING:** Using LOCAL Kafka running in the container. **Enter: 127.0.0.1:9092. Cisco data is read from a LOCAL FILE: *cisco_network_data.txt***	Students specify any Kafka topic. Or leave blank – then default topic will be used: **cisco-network-mainstream**	Students specify any hacked hosts.	n/a – leave empty	n/a – leave empty
5	2	**STUDENT TESTING:** Using CLOUD Kafka **Enter Kafka Cloud broker host and port. LOCAL FILE: *cisco_network_data.txt is read and streamed to Kafka cloud***	Students specify any Kafka topic. Or leave blank – then default topic will be used: **cisco-network-mainstream**	Students specify any hacked hosts.	Student downloads the API Key from Confluent Kafka Cloud. ***This is the KEY.***	Student downloads the API Key from Confluent Kafka Cloud. ***This is the SECRET.***
6	3	**VISUALIZATION ONLY:** Using CLOUD Kafka or **On-prem use: 127.0.0.1:9092**	n/a	n/a	***For Cloud: key or leave empty for on-prem***	***For Cloud: secret or leave empty for on-prem***

- **Scenarios 1* and 2* are the MAIN Instructor and Student Presentation scenarios:**
  1* - Instructors MUST run the Docker container with RUNTYPE = -1Instructors MUST have Cisco Packet Tracer running : **tml-hacker-networksecurity-setup v3.pkt – this file can be downloaded from: https://github.com/smaurice101/raspberrypi/tree/main/tml-cisco-pt/ptfile**
  2* Students MUST run their Docker container with RUNTYPE = -2

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Valid Hosts to Hack

- **This is based on the Cisco Packer Tracer file: tml-hacker-networksecurity-setup v3.pkt**
- **Found here:** https://github.com/smaurice101/raspberrypi/tree/main/tml-cisco-pt/ptfile
- **Cisco Packer Tracer can be installed from MyApps**

- **Valid hosts on interface: 192.168.5.1**
- 5.100
- 5.101
- 5.10
- 5.11
- 5.12
- 5.13
- 5.14
- 5.15
- 5.16
- 5.17
- 5.18
- 5.19
- 5.21
- 5.22
- 5.23
- 5.24
- 5.25
- 5.26
- 5.27
- 5.28
- 5.29
- 5.30
- 5.31

- **Valid hosts on interface: 192.168.6.1**
- 6.100
- 6.101
- 6.10
- 6.11
- 6.12
- 6.13
- 6.14
- 6.15
- 6.16
- 6.17
- 6.18
- 6.19
- 6.20
- 6.21
- 6.22
- 6.23
- 6.24
- 6.25
- 6.26

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Docker Run Commands For Instructor and Students

A. INSTRUCTOR Docker Run Command Must be:

docker run -d --net="host" --env RUNTYPE=-1 --env BROKERHOSTPORT=<replace> --env KAFKAPRODUCETOPIC=<replace> --env HACKEDHOSTS=<replace> --env CLOUDUSERNAME=<replace> --env CLOUDPASSWORD=<replace> *maadsdocker/tml-cisco-network-cyberthreats-amd64*

- instructor MUST enter values for **<replace>** *and NOTIFY STUDENTS*

B. STUDENTS Docker Run Command Must be:

docker run -p VIPERVIZPORT : VIPERVIZPORT --env RUNTYPE=-2 --env VIPERVIZPORT=<student chosen> --env BROKERHOSTPORT=<replace> --env KAFKAPRODUCETOPIC=<replace> --env CLOUDUSERNAME=<replace> --env CLOUDPASSWORD=<replace> *maadsdocker/tml-cisco-network-cyberthreats-amd64*

- Students MUST enter values for **<replace>** *RECEIVED FROM instructor values*

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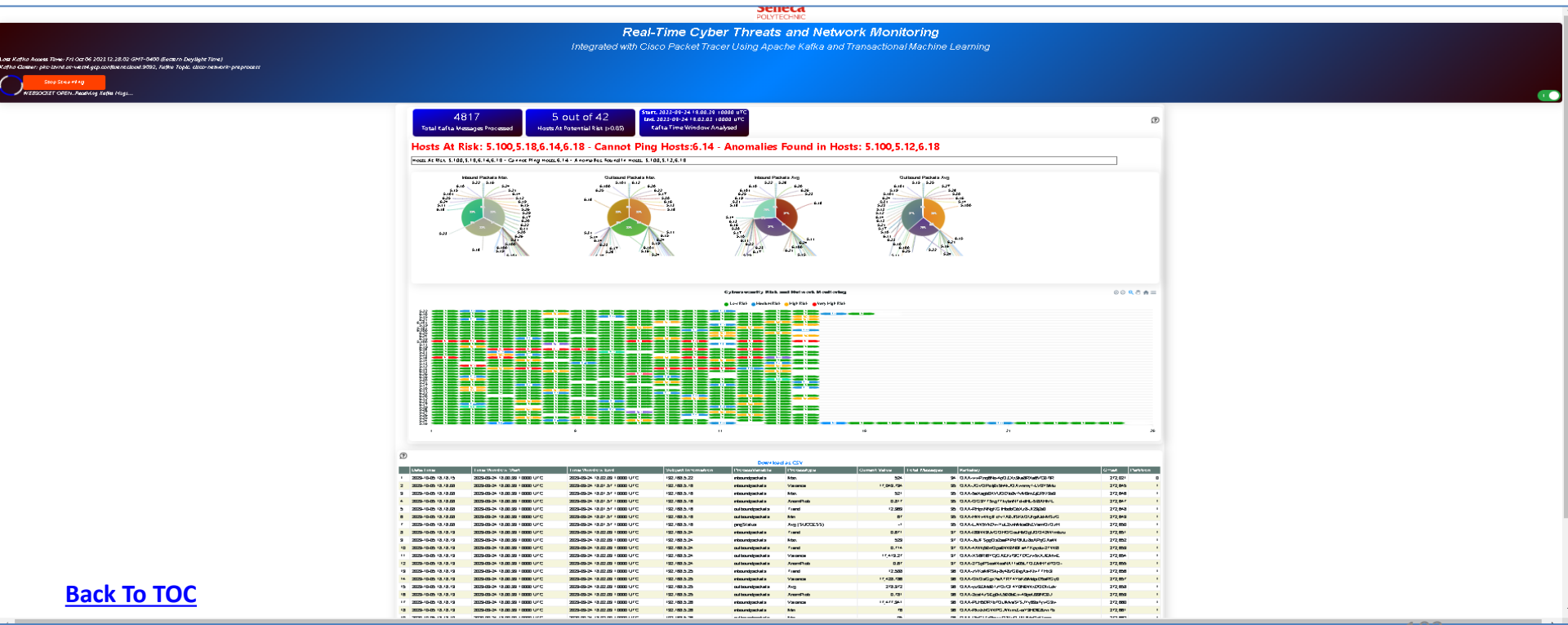
Cyber Threats/Network Monitoring Dashboard

- Once you have properly run the docker container you can visualize the dashboard by entering this URL in the browser:
- **STUDENTS USE: (IF VIPERVIZPORT=9000)**
  - http://localhost:9000/tml-cisco-network-monitor.html?topic=cisco-network-preprocess&offset=-1&groupid=&rollbackoffset=200&topictype=prediction&append=0&secure=1
- **INSTRUCTORS USE: (IF VIPERVIZPORT=10000)**
  - http://localhost:10000/tml-cisco-network-monitor.html?topic=cisco-network-preprocess&offset=-1&groupid=&rollbackoffset=200&topictype=prediction&append=0&secure=1
- **Press Start Streaming Button: You will see**

NOTE: Visualization requires –p (port-forwarding) – DO NOT use –net="host" in your Docker Run command, Visualization can be run as a standalone container using RUNTYPE=3



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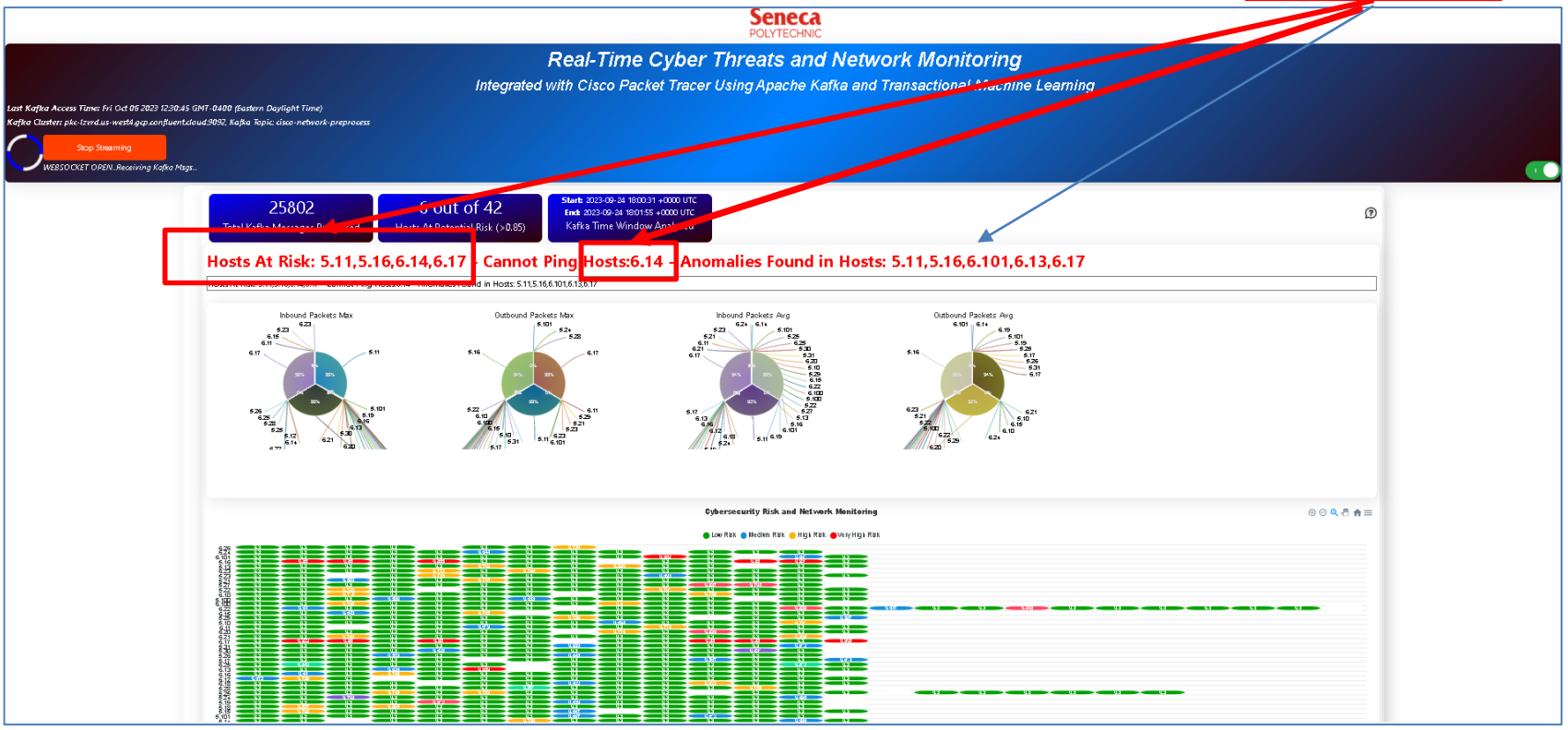
Explaining The Dashboard: EXAMPLE

Using this Docker Run Command: ***docker run -p 9000:9000 --env VIPERVIZPORT=9000 --env RUNTYPE=2 --env BROKERHOSTPORT=pkc-lzvrd.us-west4.gcp.confluent.cloud:9092 --env KAFKAPRODUCETOPIC=cisco-network-mainstream --env HACKEDHOSTS=5.11-i,5.16-i,6.17-i --env CLOUDUSERNAME=Z6ZIK7OALQZXYYC2 --env CLOUDPASSWORD=uBGl02SFiZ69BBJhjE7vjE7mfd5S8XqaMTpAv93doab5Gvn6szZ+Vbue4saX8CGo maadsdocker/tml-cisco-network-cyberthreats-amd64***

- ***The solution first simulates the hacking into 3 machines: 5.11, 5.16 and 6.17 (as specified by instructor)***
- ***Web Browser connects to Container Port for VIPERVIZ on Port 9000***
- ***The STUDENT DASHBOARD CORRECTLY identified these 3 machines as "HOSTS AT RISK" in REAL-TIME!***
- ***Note: Machine 6.14 was taken offline – the Dashboard again CORRECTLY identified that 6.14 cannot be pinged***
- ***Solution also performs further algorithmic checks for anomalies on all hosts***
- **STUDENTS HOSTS AT RISK MUST CORRECTLY IDENTIFY HOSTS THE INSTRUCTOR HACKED INTO or TAKEN OFFLINE**
  - **STUDENTS ARE GRADED ON THE HOSTS AT RISK machines and answering questions in next slide**



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Student Will Process Real-Time Data with TML and Answer the Following Questions in the Dashboard

Note: Student will receive a template Dashboard to Work from.

1. Which machines are HOSTS AT RISK?
2. Which HOSTS AT RISK cannot be pinged?
3. What is the avg outbound packets for HOSTS AT RISK?
4. What is the avg inbound packets for HOSTS AT RISK?
5. What is the maximum outbound packets for HOSTS AT RISK?
6. What is the maximum inbound packets for HOSTS AT RISK?
7. Which HOSTS AT RISK have increasing outbound packets in bytes?
8. Which HOSTS AT RISK have decreasing outbound packets in bytes?
9. Which HOSTS AT RISK have increasing inbound packets in bytes?
10. Which HOSTS AT RISK have decreasing inbound packets?
11. Which machines are down? on switch 1.
12. Which machines are down? on switch 2.
13. Which machine has the highest variance in inbound packets?
14. Which machine has the highest variance in outbound packets?
15. Which machine has an anomaly probability in outbound packets above 80%
16. Which machine has an anomaly probability in inbound packets above 80%

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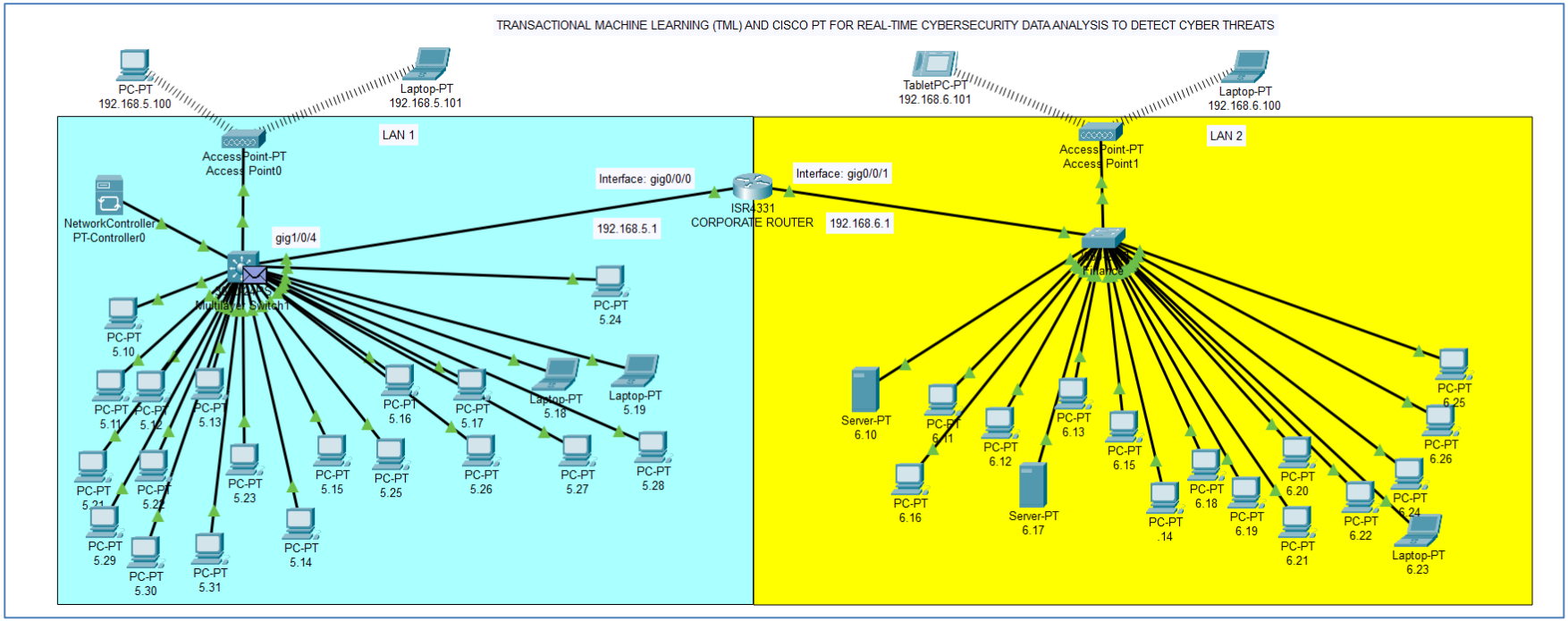
Solution: Cisco Network in Packet Tracer

Below diagram shows a network in Packet Tracer which will be used as part of the solution:
(Packet Tracer file can be downloaded from here: https://github.com/smaurice101/raspberrypi/tree/main/tml-cisco-pt/ptfile)

1. One Router
2. Two Switches connected to the Router
3. 2 WIFI devices connected to the access points

This network can be simulated and packet data can be extracted for analysis using REST API



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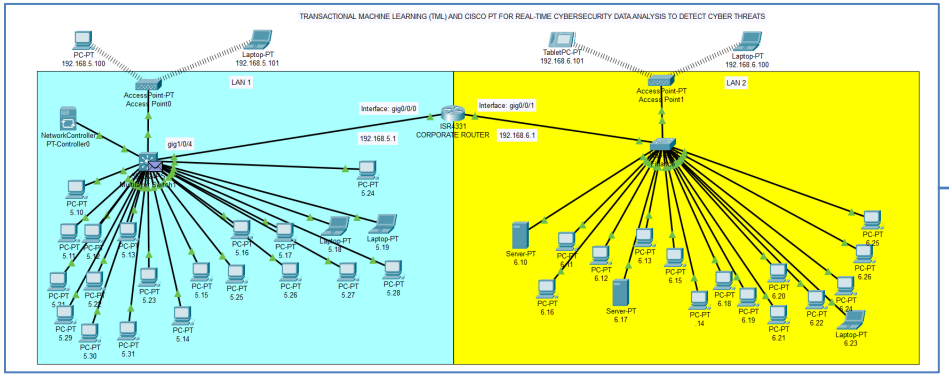
Solution Architecture

Instructors will receive a VM containing the entire solution

Instructor VM

Instructor Tells The TML Solution Container at Run Time Which Machine They are hacking into



Cisco Packet Tracer .pkt file

SDN Running in PT on Port 58000

Network data is pulled From PT using REST API

TML Solution Container

A Free Confluent Kafka Cloud account will be needed – it is valid for 30 days.

CONFLUENT

Kafka Cloud FREE

Student VM

- Student teams build their TML solution container using a Template provided to them by instructor
- Student teams present their dashboard to class
- Team must answer any of the 16 questions in **real-time from instructor**
- **For each team Instructor can in real-time change the machine he is hacking into**

STUDENT: TML Solution Container

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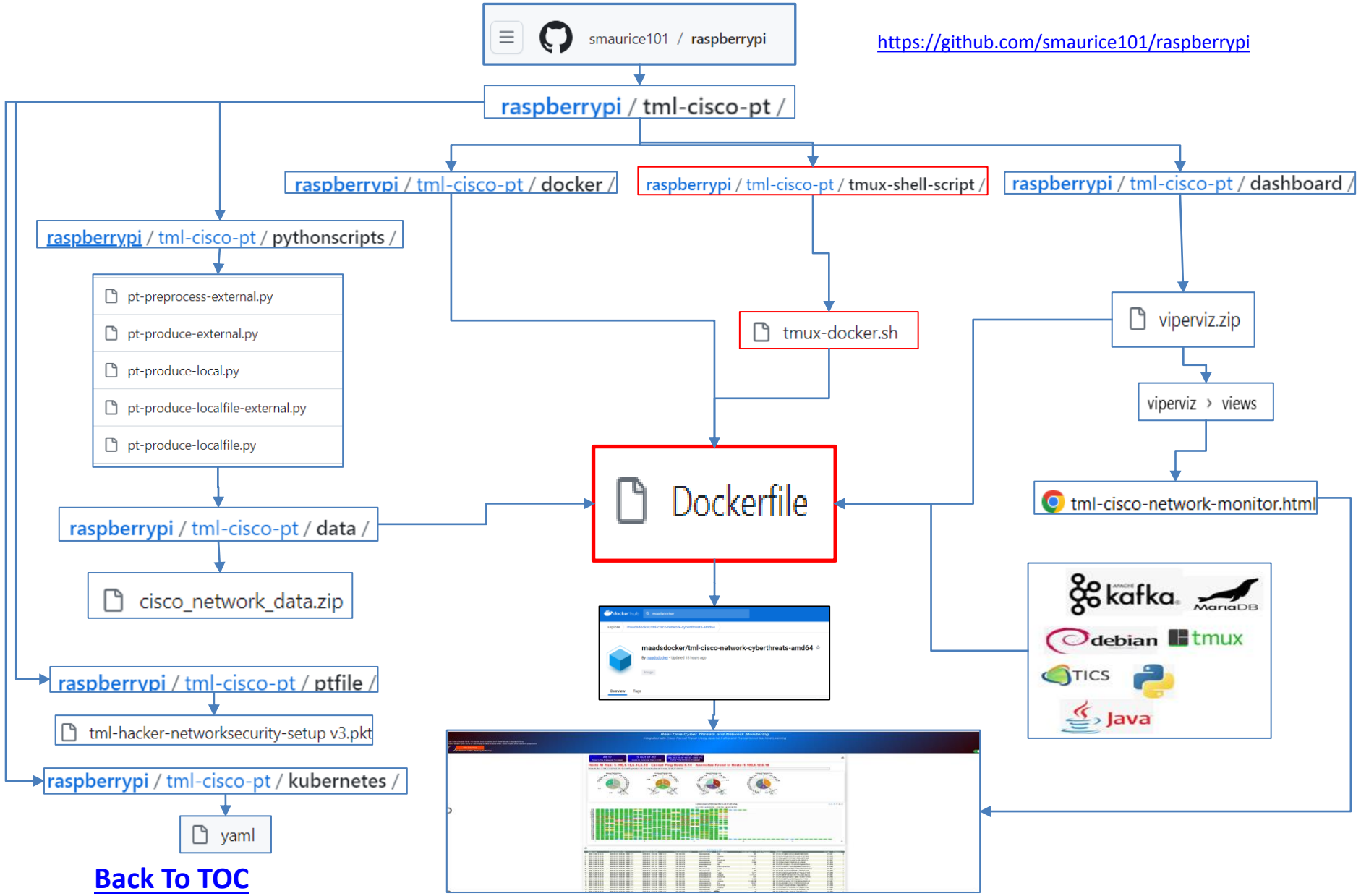
TML –CISCO SOLUTION COMPONENTS



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Technologies

- Cisco packet tracer is part of myApps
- Docker
- Students run their solution in VMWare VM using Docker Container
- TML technologies are downloaded from GitHub
- TML is already part of CSP 450 and CYT 160 and was taught in CSP 400 in the summer and very successful with students wanting to learn more TML

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APPENDIX I

- Additional sources

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Additional TML Resources:

1. **TML Crash Course Videos:**
   https://github.com/smaurice101/raspberrypi/tree/main/TML%20Crash%20course/Videos
   •

1. **TML Binaries:**
   a) https://github.com/smaurice101/transactionalmachinelearning
      •

1. **MAADSTML Python Library:**
   a) **https://pypi.org/project/maadstml/**
      •

1. **TML Blogs:**
   a) **Stream Processing/Analytics Tools Like Apache Flink is NOT Transactional Machine Learning**
   b) **Data Quality Checking in Data Streams**
   c) **A Fast and Simple Way To Migrate Data Streams Between Kafka Clusters: An Alternative to MirrorMaker2**
   d) **NFT (Ethereum) Price Prediction with Transactional Machine Learning, Kafka (or Redpanda) and Blockchain**
   e) **Detecting Medication Fraud at Scale with Transactional Machine Learning and Blockchain**
   f) **TML and Cybersecurity**
   g) **Contextualizing ChatGPT with Healthcare Data Streams**

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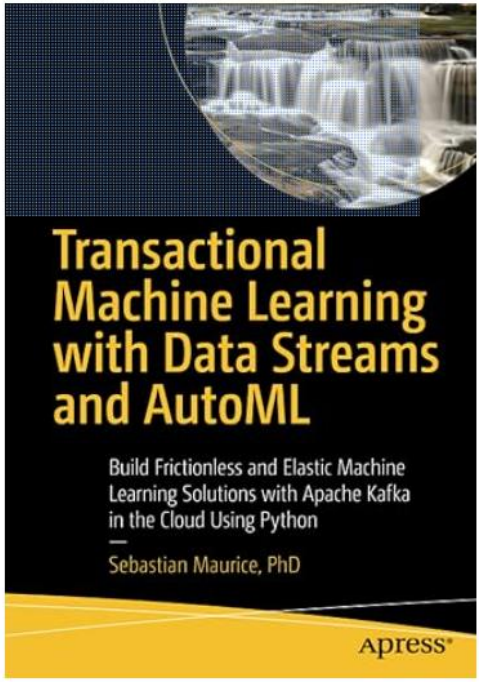
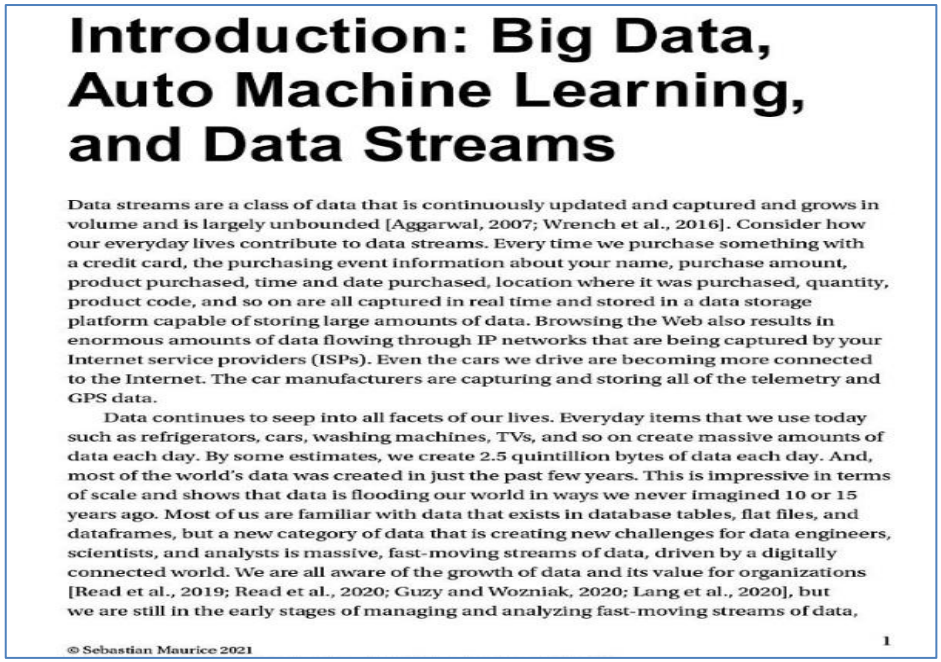
APPENDIX J

- Transactional Machine Learning Book
- Amazon.ca





Introduction: Big Data, Auto Machine Learning, and Data Streams

Data streams are a class of data that is continuously updated and captured and grows in volume and is largely unbounded [Aggarwal, 2007; Wrench et al., 2016]. Consider how our everyday lives contribute to data streams. Every time we purchase something with a credit card, the purchasing event information about your name, purchase amount, product purchased, time and date purchased, location where it was purchased, quantity, product code, and so on are all captured in real time and stored in a data storage platform capable of storing large amounts of data. Browsing the Web also results in enormous amounts of data flowing through IP networks that are being captured by your Internet service providers (ISPs). Even the cars we drive are becoming more connected to the Internet. The car manufacturers are capturing and storing all of the telemetry and GPS data.

Data continues to seep into all facets of our lives. Everyday items that we use today such as refrigerators, cars, washing machines, TVs, and so on create massive amounts of data each day. By some estimates, we create 2.5 quintillion bytes of data each day. And, most of the world's data was created in just the past few years. This is impressive in terms of scale and shows that data is flooding our world in ways we never imagined 10 or 15 years ago. Most of us are familiar with data that exists in database tables, flat files, and dataframes, but a new category of data that is creating new challenges for data engineers, scientists, and analysts is massive, fast-moving streams of data, driven by a digitally connected world. We are all aware of the growth of data and its value for organizations [Read et al., 2019; Read et al., 2020; Guzy and Wozniak, 2020; Lang et al., 2020], but we are still in the early stages of managing and analyzing fast-moving streams of data,

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APPENDIX K

- Setting Up Confluent Kafka Cloud
- Watch Video: https://github.com/smaurice101/raspberrypi/tree/main/TML%20Crash%20course/Videos/Part%201

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HAPPY STREAMING WITH TML!

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