AI Platform for CTAM System

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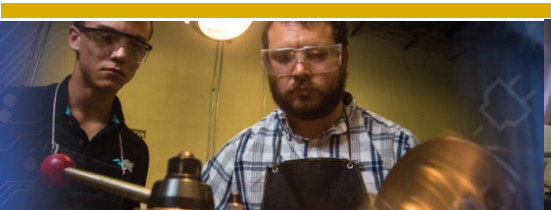
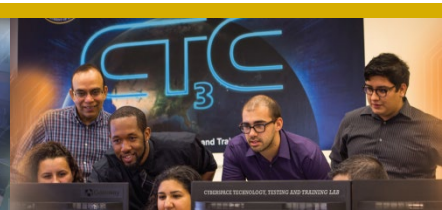
Research Funded by
OSD Test Resources Management Center
T&E S&T Program, Cyberspace Test Technology

FLORIDA INTERNATIONAL UNIVERSITY

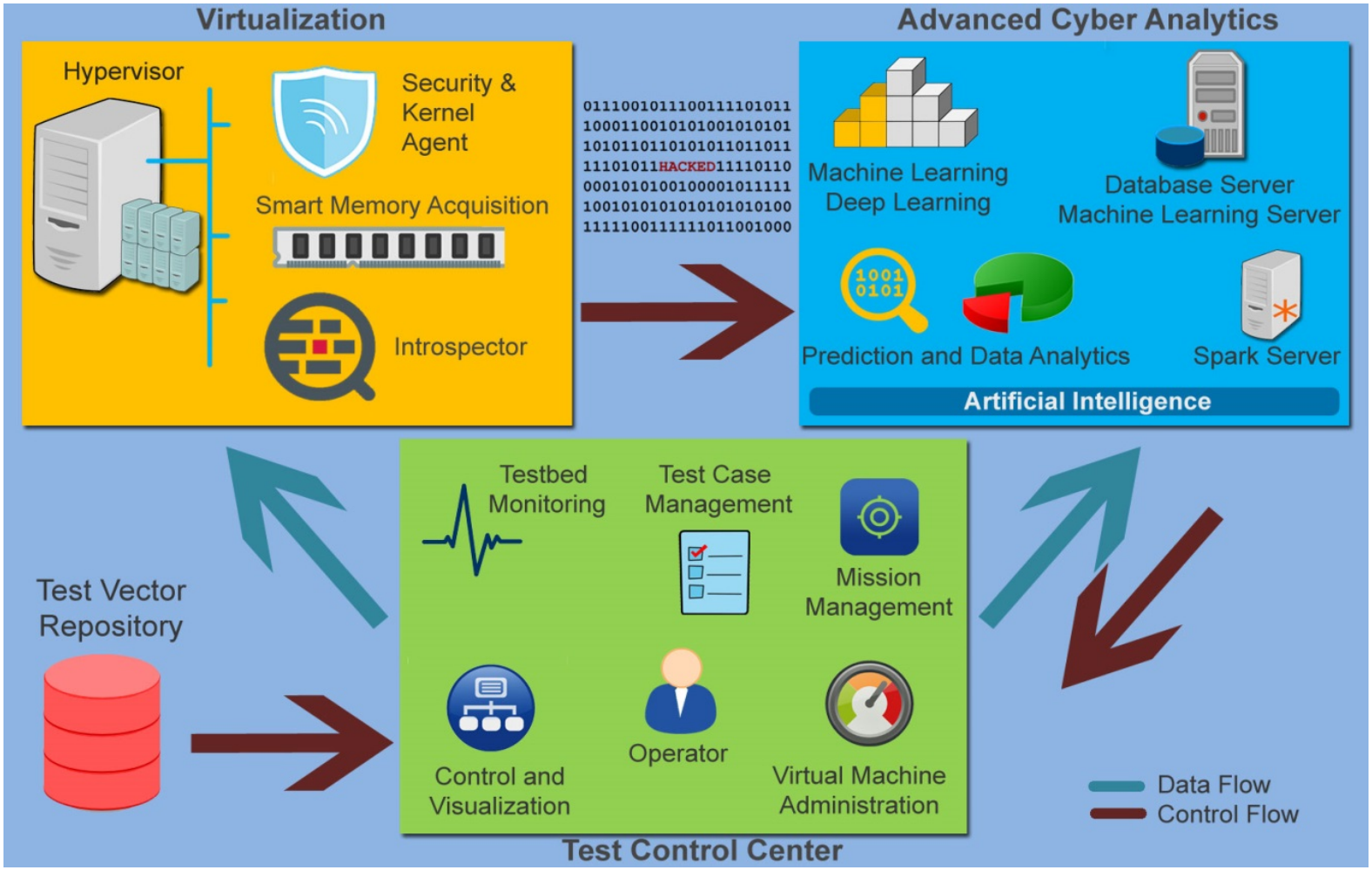




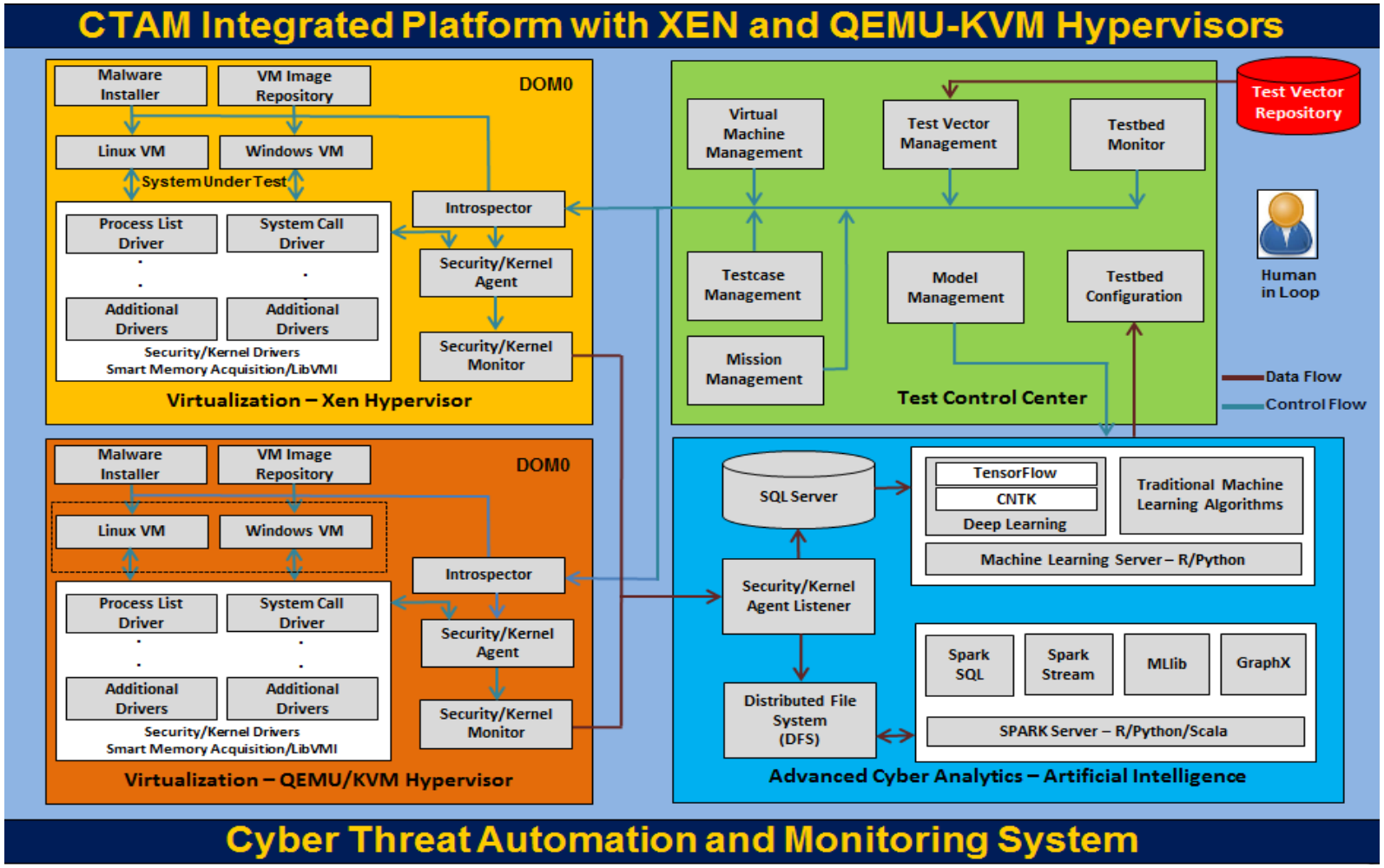
Project Description

- CTAM is a Cyberspace Test Technology for T & E purposes to monitor and analyze behavior during cyber attacks and also the impact on the current mission
- CTAM is based on fine-grained introspection of kernel data structures, data collection and advanced cyber analytics using Artificial Intelligence / Machine Learning techniques
- CTAM consists of three platforms:
  - Virtualization
  - Advanced Cyber Analytics
  - Test Control Center

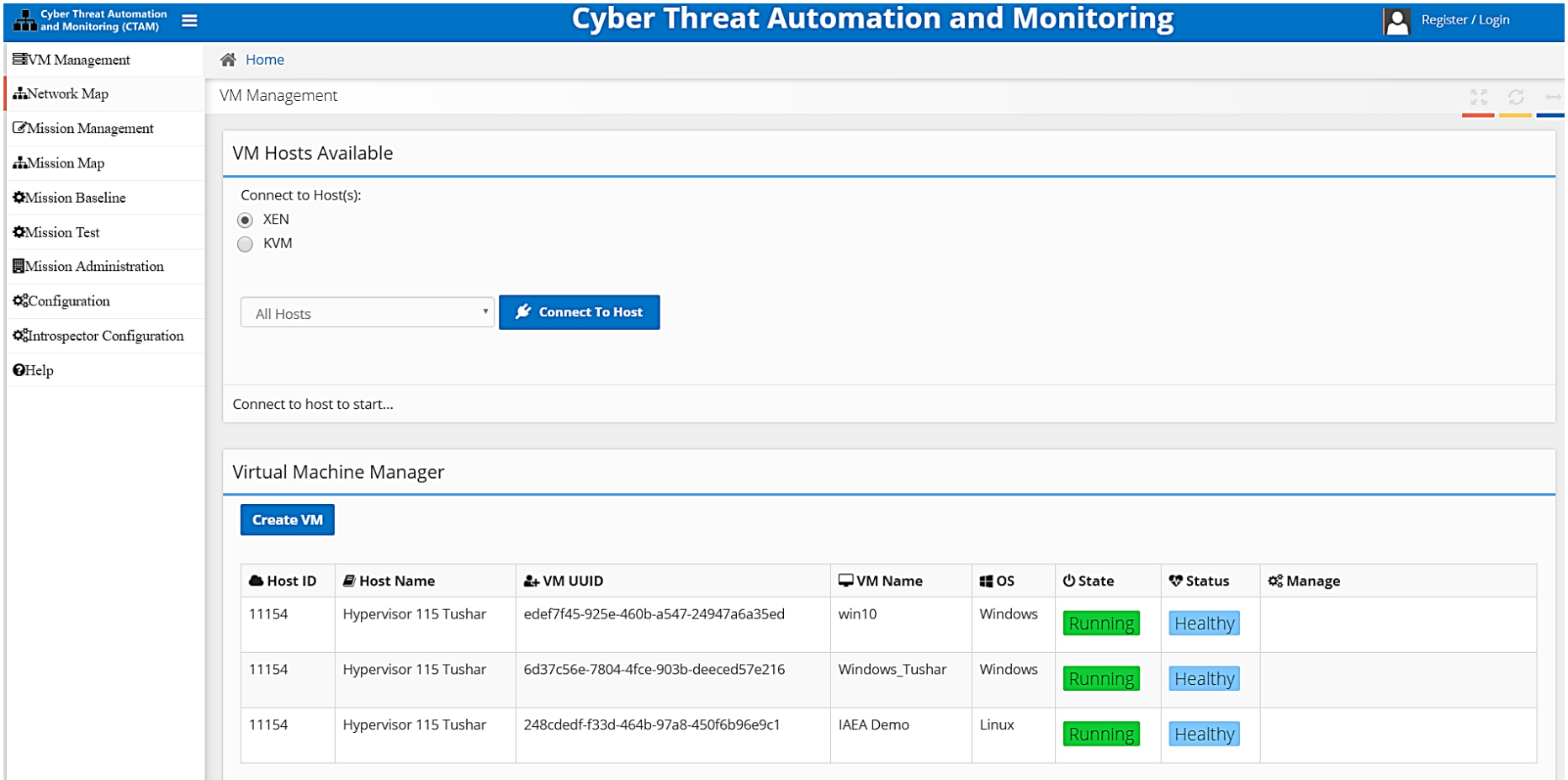
CTAM System Diagram



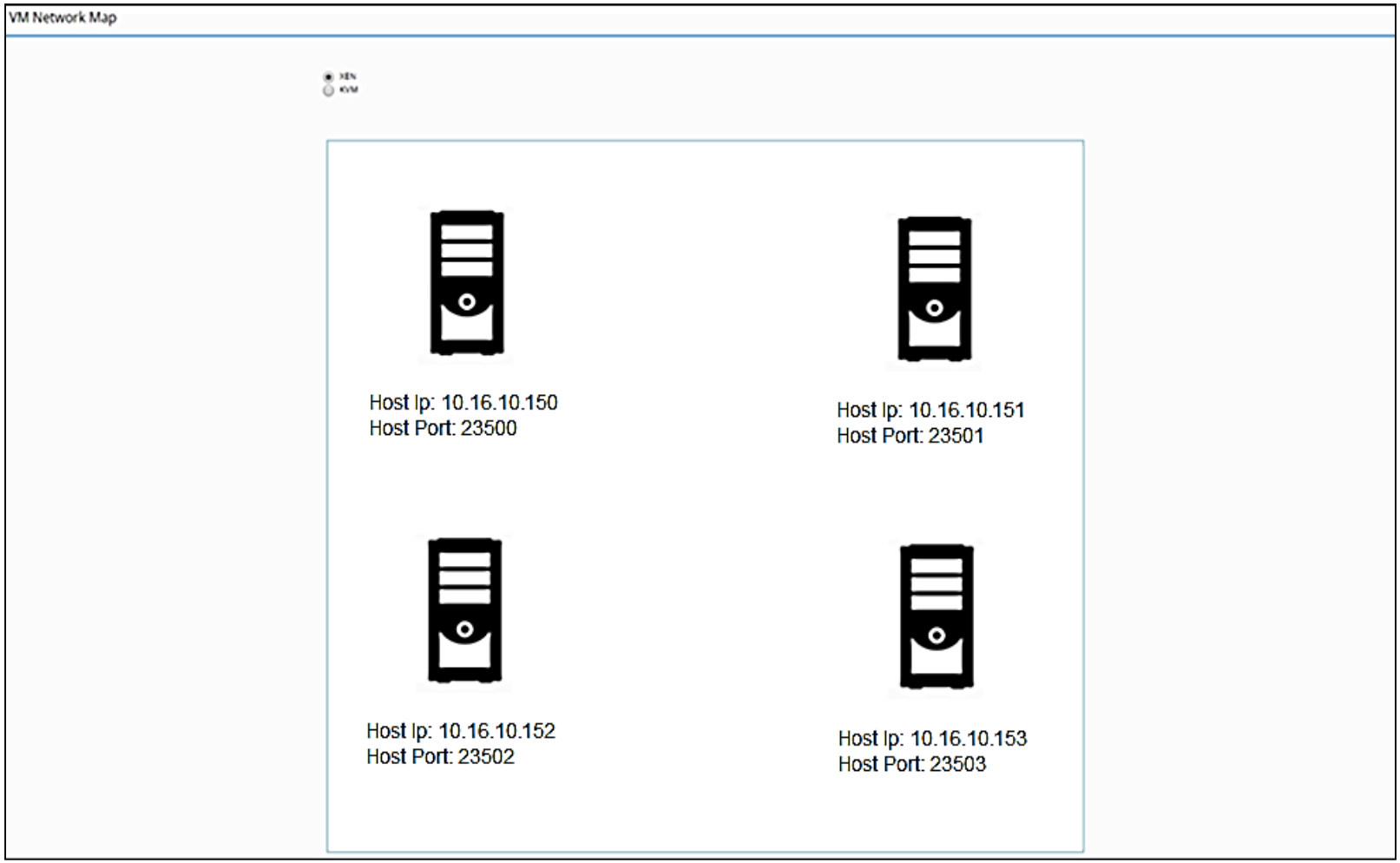
System Block Diagram



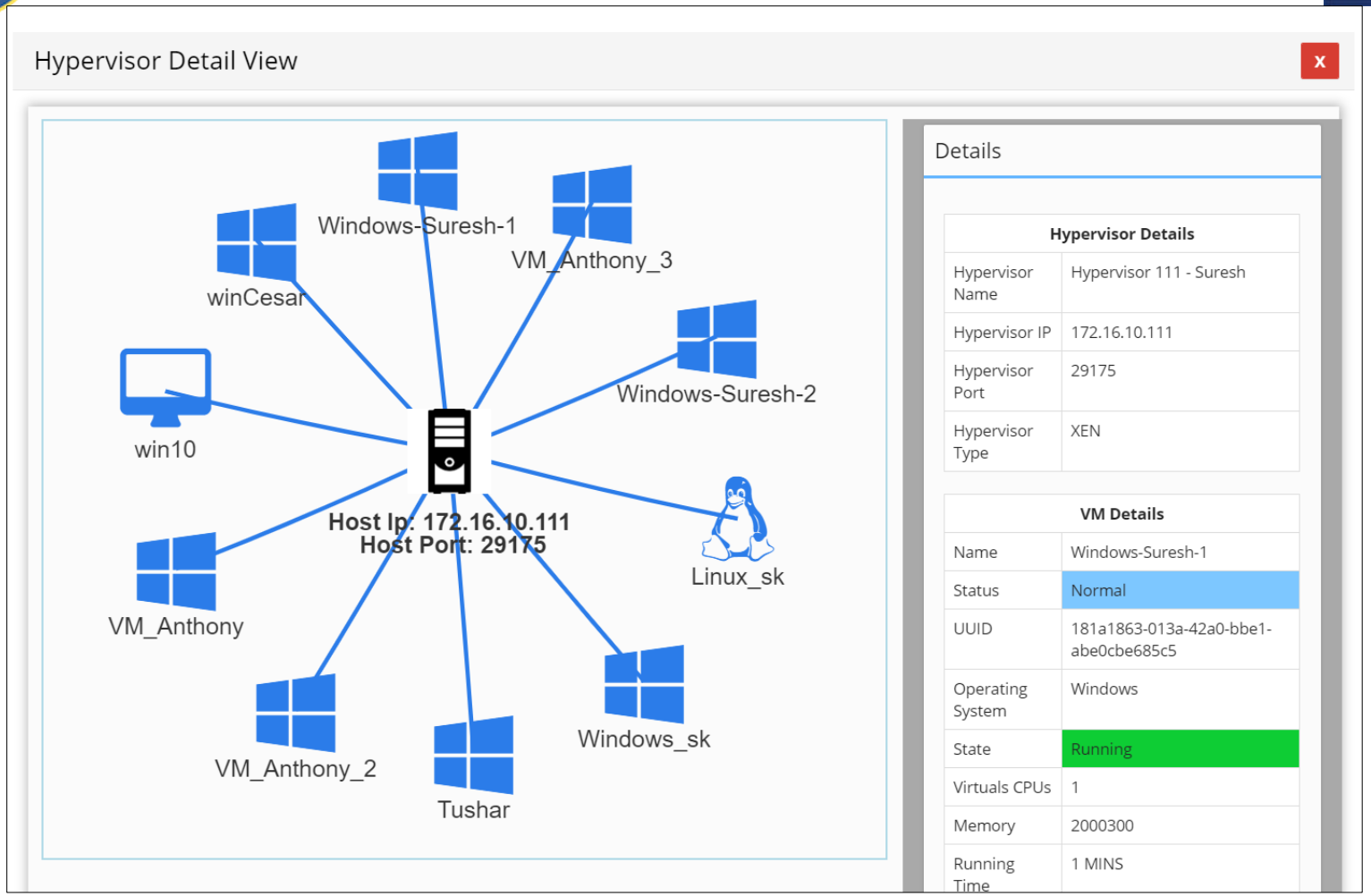
VM Management



VM Management



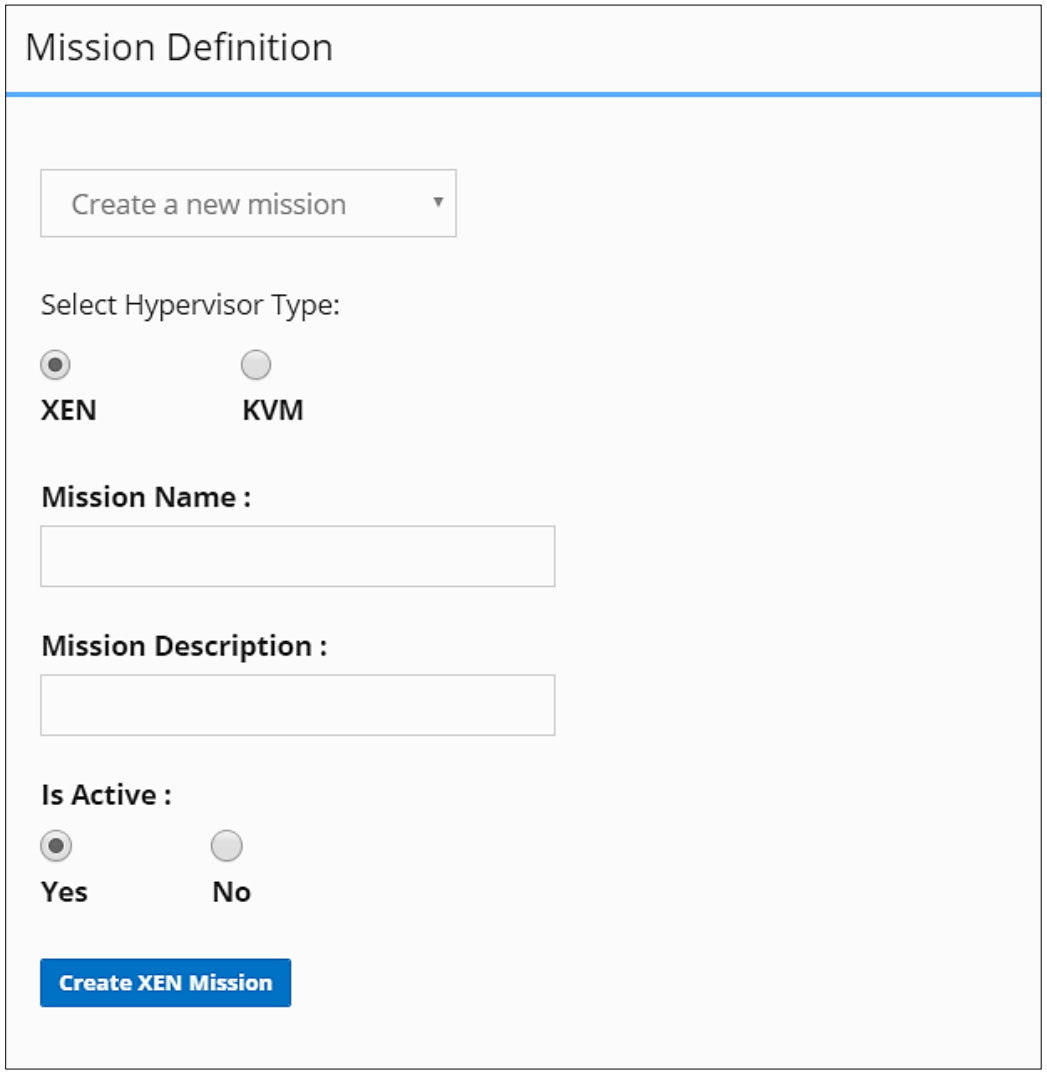
Network Map


Hypervisor Detail View
x
Windows-Suresh-1
VM_Anthony_3
winCesar
Windows-Suresh-2
win10
Host Ip: 172.16.10.111
Host Port: 29175
Linux_sk
VM_Anthony
Windows_sk
VM_Anthony_2
Tushar
Details
Hypervisor Details
Hypervisor Name
Hypervisor 111 - Suresh
Hypervisor IP
172.16.10.111
Hypervisor Port
29175
Hypervisor Type
XEN
VM Details
Name
Windows-Suresh-1
Status
Normal
UUID
181a1863-013a-42a0-bbe1-abe0cbe685c5
Operating System
Windows
State
Running
Virtuals CPUs
1
Memory
2000300
Running Time
1 MINS

SUT Mission

- **SUT Mission Management**
  - SUT Mission Definition
  - SUT Mission Subsystems
  - SUT Mission Module
- **SUT Mission Map**
  - SUT Map View
  - SUT Mission System Summary
- **SUT Mission Baseline**
- **SUT Mission Test**
- **SUT Mission Administration**

Mission Definition



Mission Subsystems

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Mission SubSystem

Add Mission SubSystem

	MissionSystemID	MissionID	MissionSystemName	MissionSystemDescription	HostID	VMStatusID	IsActive
Edit Delete	159	114	GPS	GPS	11155	806	1
Edit Delete	161	114	Application Server	Application Server	11155	807	1
Edit Delete	162	114	DBS	DBS	11155	808	1
Edit Delete	157	114	Flight Path Generator - SUT	Flight Path Generator - SUT	11155	809	1
Edit Delete	158	114	Weather	Weather	11155	810	1

Mission Modules

Mission Module

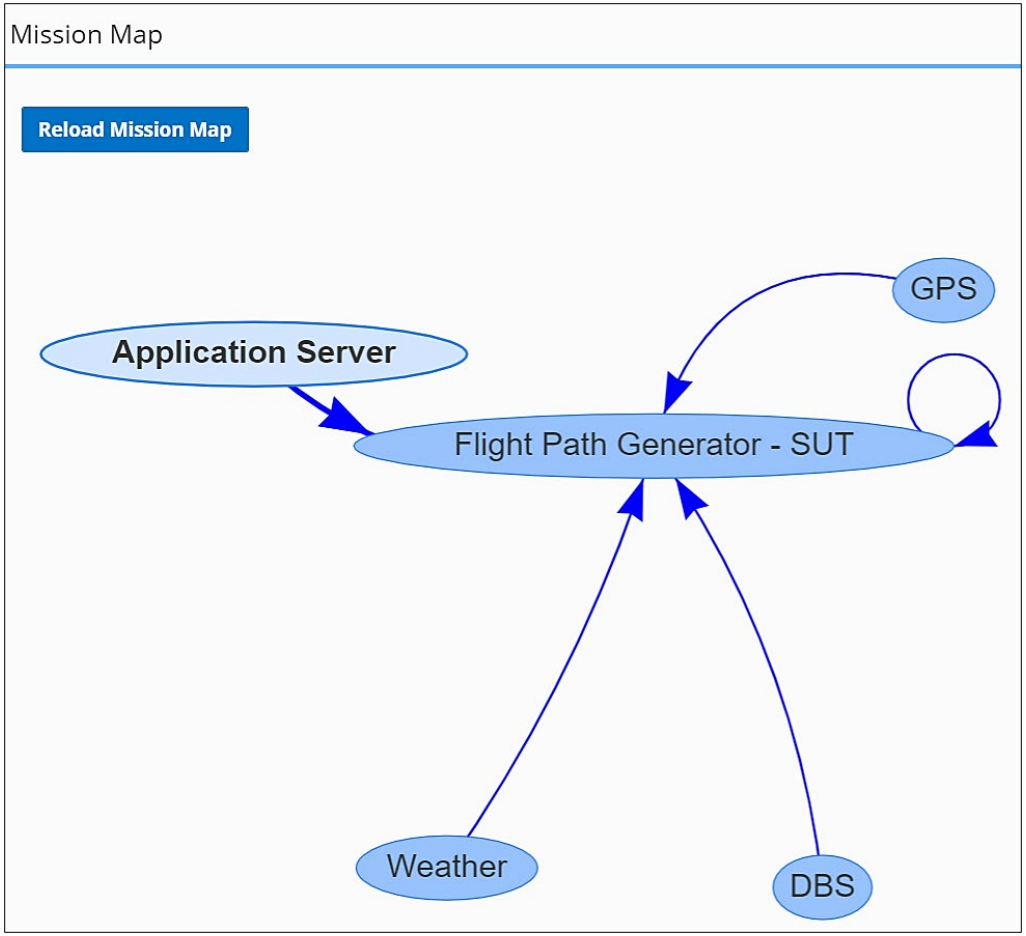
Select Mission Subsystem:

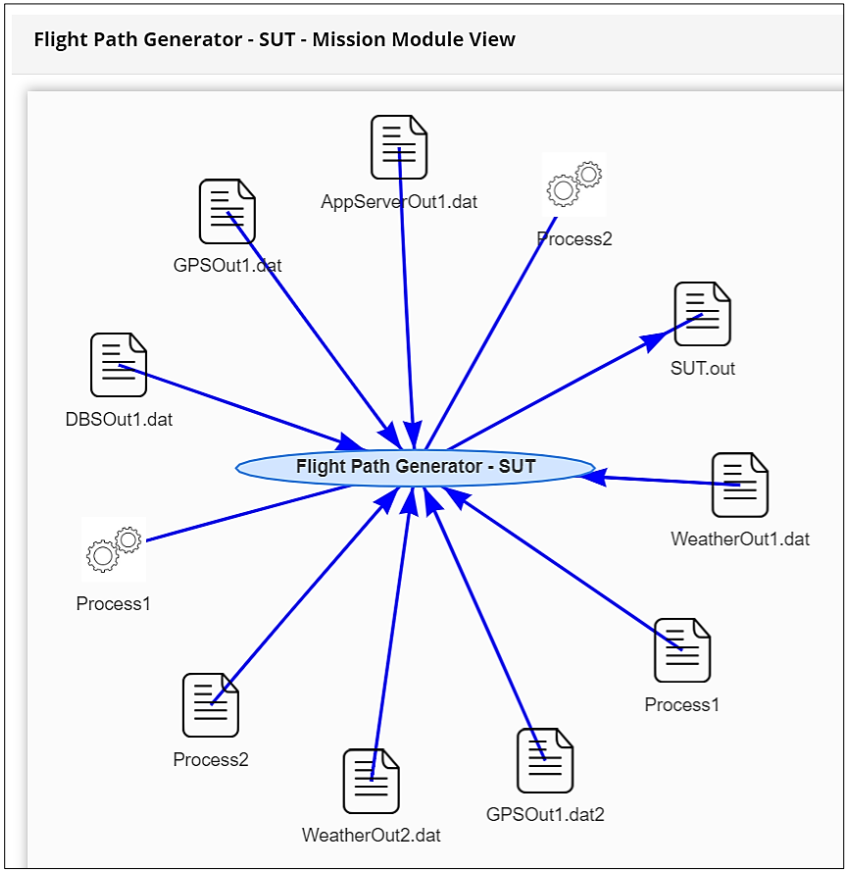
Flight Path Generator - SUT

Add Mission Module

	MissionModuleID	MissionSystemID	ModuleName	ModuleDescription	FileName	FilePath	ModuleTy
Edit Delete	169	157	Input	Input	GPSOut1.dat		1
Edit Delete	170	157	Input	Input	GPSOut1.dat2		1
Edit Delete	171	157	Input	Input	WeatherOut1.dat		1
Edit Delete	172	157	Input	Input	WeatherOut2.dat		1
Edit Delete	173	157	Input	Input	DBSOut1.dat		1
Edit Delete	174	157	Input	Input	AppServerOut1.dat		1

Mission Map


Mission Map
Reload Mission Map
GPS
Application Server
Flight Path Generator - SUT
Weather
DBS


Flight Path Generator - SUT - Mission Module View
AppServerOut1.dat
Process2
GPSOut1.dat
SUT.out
DBSOut1.dat
Flight Path Generator - SUT
WeatherOut1.dat
Process1
Process1
Process2
GPSOut1.dat2
WeatherOut2.dat

Mission Systems Summary

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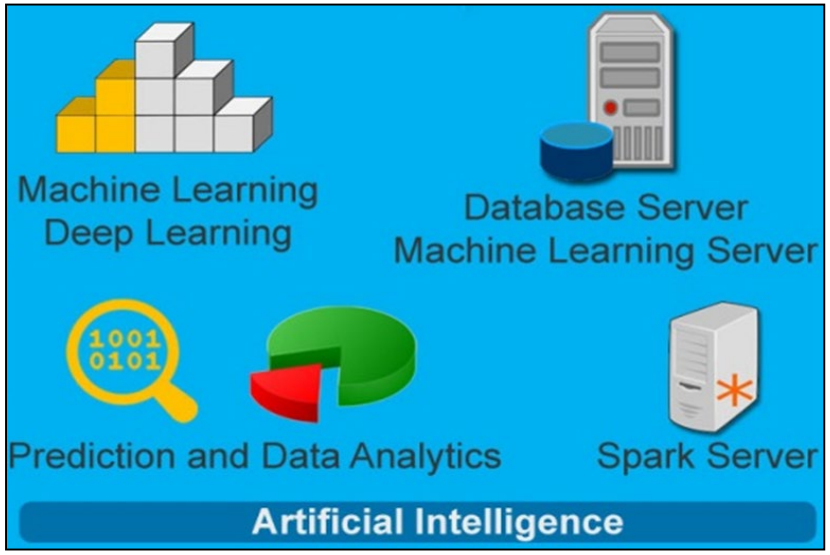
Mission Systems Summary

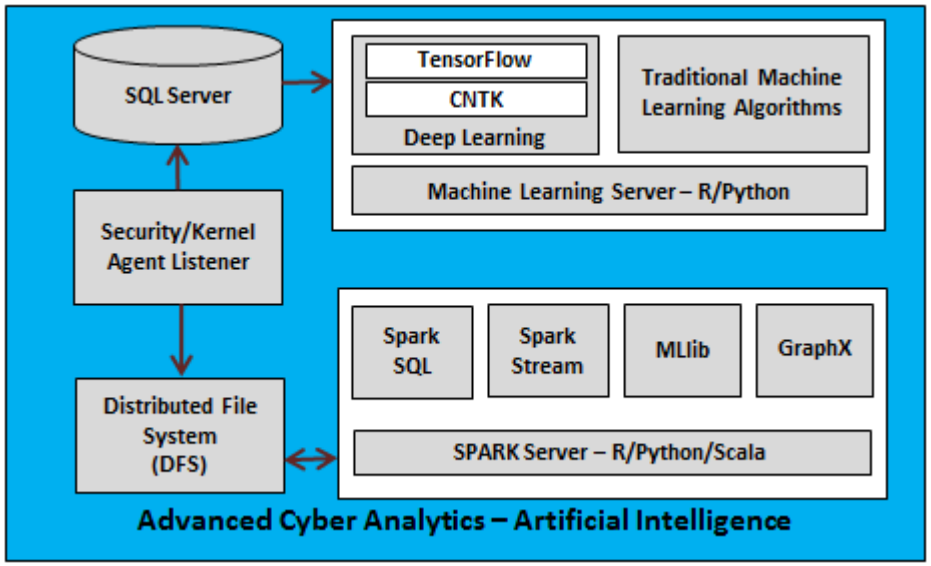
Module ID	Module Name	Module Description	Assigned VM Name	Assigned VM UUID
159	GPS	GPS	Mission_SubSystem_VM	0e74bc6b-9250-4feb-b985-270ea0ec5c2c
161	Application Server	Application Server	Mission_SubSystem_VM4	d429c12e-6a9a-4525-b731-cdeba644f4f9
162	DBS	DBS	Mission_SubSystem_VM3	616688b8-122f-41f4-86d5-7bc6f6766970
157	Flight Path Generator - SUT	Flight Path Generator - SUT	Mission_VM	ef8175c0-fe02-44ee-8d8b-2154569e1b28
158	Weather	Weather	Mission_SubSystem_VM2	7ef00d1c-c0d4-418e-b3dd-ba6ed026d460

MissionID : 114

Advanced Cyber Analytics

- Cyber Analytics module consists of Database server and Machine learning server for in-memory analytics
- Machine learning / Deep Learning models with different algorithms are built using the training data
- Models are used to predict the impact of the test vectors on a specific mission





Machine Learning / Deep Learning Algorithms

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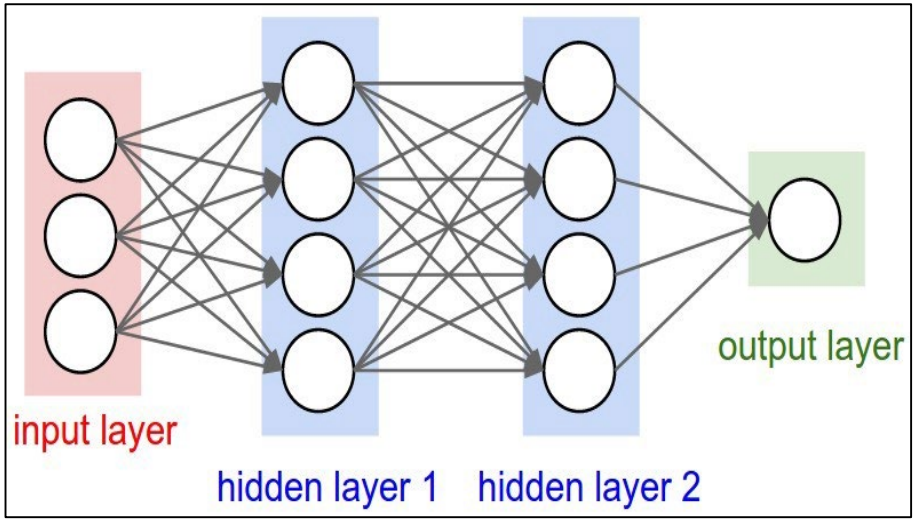
Traditional ML Algorithms	Deep Learning Algorithms
➢ Random Forest ➢ Support Vector Machine ➢ Logistic Regression ➢ Gradient Boosting ➢ Neural Network ➢ Ensemble ➢ One Class SVM ➢ Cosine Vector Similarity	➢ Recurrent Neural Networks ▪ Long Short Term Memory (LSTM) ▪ Auto-Encoders ▪ Bidirectional LSTM ▪ Generative Adversarial Network (GANs)

Deep Learning

- Weights are initialized to random values
- Data is propagated forward to produce a prediction
- The error of that prediction is propagated backwards
- The weights are corrected



Types of Deep Neural Network

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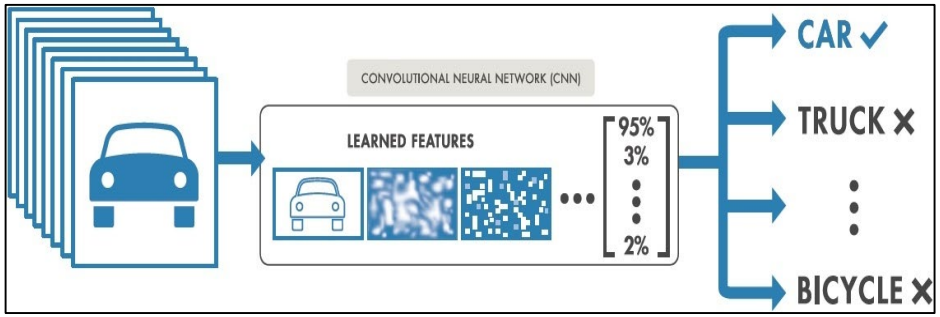
Convolutional Neural Networks

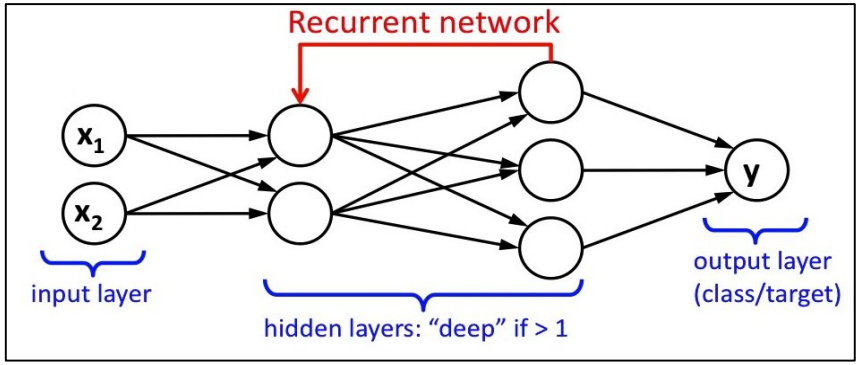
- Primarily used for image data
- Used for detecting features within an image dataset



Reference:
https://www.mathworks.com/solutions/deep-learning/convolutional-neural-network.html

Recurrent Neural Networks

- Primarily used for sequential data
- Used for identifying patterns in sequenced information

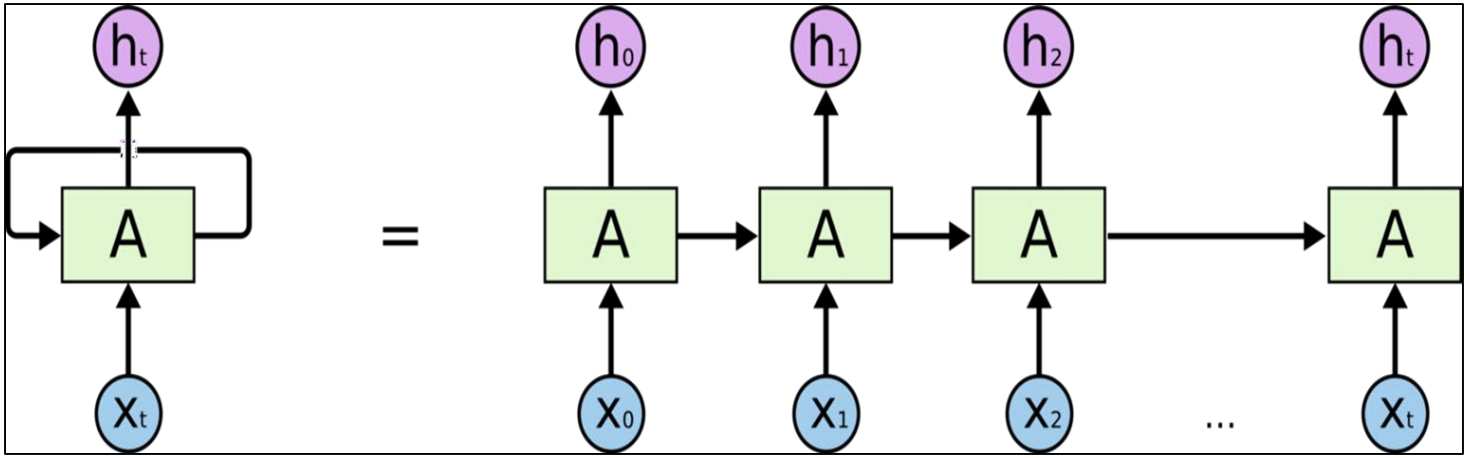


Reference:
https://leonardoaraujosantos.gitbooks.io/artificial-inteligence/content/recurrent_neural_networks.html

RNN – Long Short Term Memory (LSTM)

Recurrent Neural Networks - LSTM

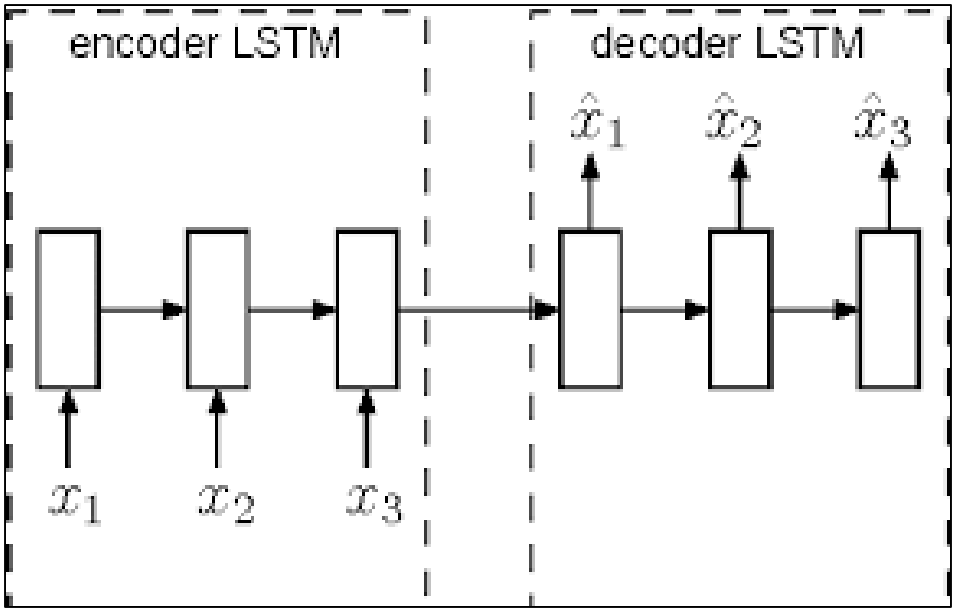
- Since we are dealing with a large amount of sequential data, it would make sense to use an RNN
- Past sequential information can be used to predict future time steps in the series



Reference: http://colah.github.io/posts/2015-08-Understanding-LSTMs/

LSTM - Autoencoders

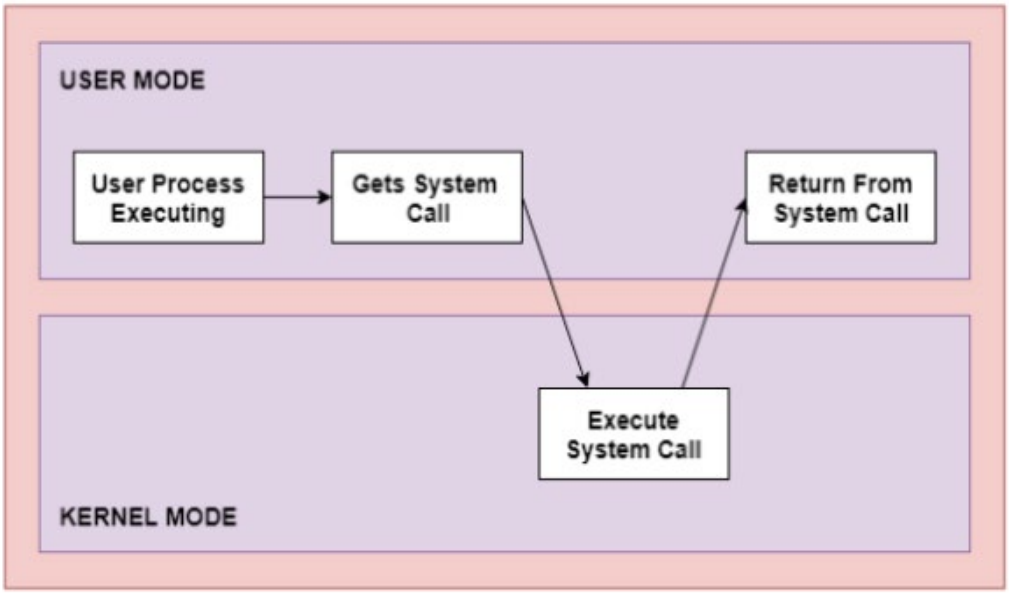
- Learns compressed representations of input data and attempts to reconstruct the original input.
- The encoder LSTM transforms an input sequence into a compressed latent space.
- The decoder LSTM tries to reconstruct the sequence from the encoder's latent vector



https://www.sciencedirect.com/science/article/pii/S0010482518300738

System Call

- System call is an OS kernel functions that work as an entry point to the kernel
- System call provides an interface between an application process and the operating system kernel
- Application programs invokes system calls to pass/retrieve data to the OS kernel



Reference: https://www.tutorialspoint.com/what-are-system-calls-in-operating-system

System Call

Types of System Calls:

- Process Control - These system calls deal with processes such as process creation, process termination etc.
- File Management - These system calls are responsible for file manipulation such as creating a file, reading a file, writing into a file etc.
- Device Management - These system calls are responsible for device manipulation such as reading from device buffers, writing into device buffers etc.
- Information Maintenance - These system calls handle information and its transfer between the operating system and the user program
- Communication - These system calls are useful for inter-process communication. They also deal with creating and deleting a communication connection

Reference: https://www.tutorialspoint.com/what-are-system-calls-in-operating-system

System Call Sequences

- System call sequence is the order in which the system calls are invoked by the application program
- Each application will invoke system calls in a particular sequence to accomplish a specific task
- Table shows the example of the system call sequence

System Call Sequence	System Call Name	System Call Number
1	NtQueryInformationProcess	25
2	NtOpenKey	18
3	NtQueryValueKey	23
4	NtOpenKey	18
5	NtOpenKey	18
6	NtQueryValueKey	23
7	NtClose	15

- Test vector can modify the system call sequence to change the application behavior
- Anomaly detection with Deep learning can be used to detect the change in the system call sequence

System Call Analysis

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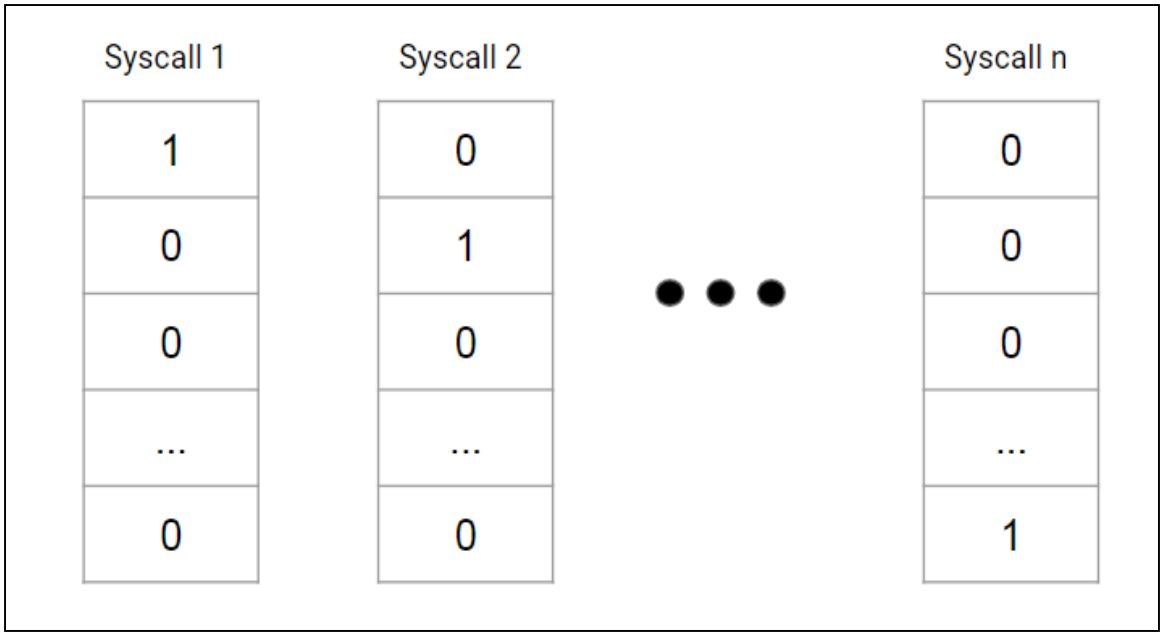
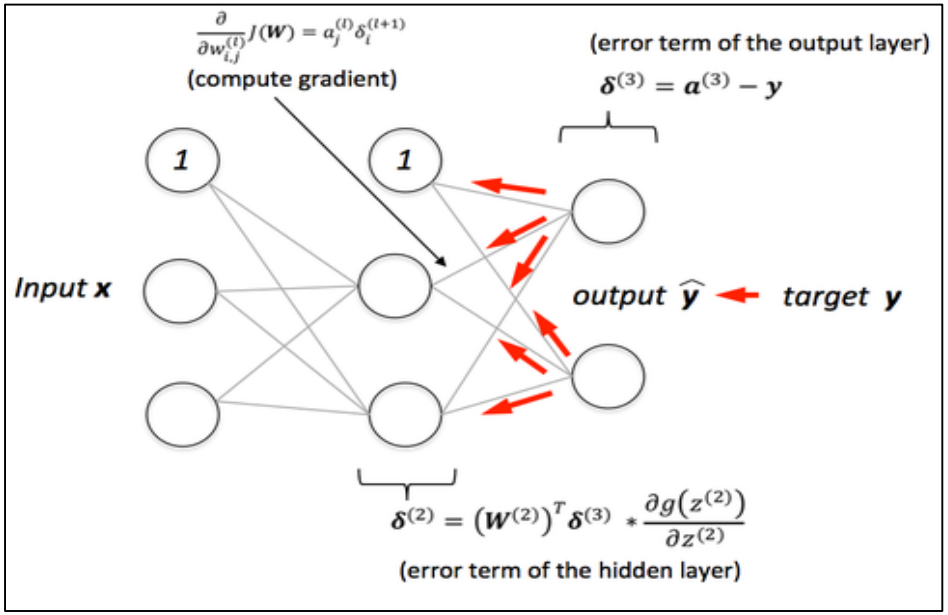
Data Pre-processing:

- Every system call is mapped to a number in a dictionary
- Represent every system call as a one-hot encoded sparse vectors so they may be used in the deep learning algorithm



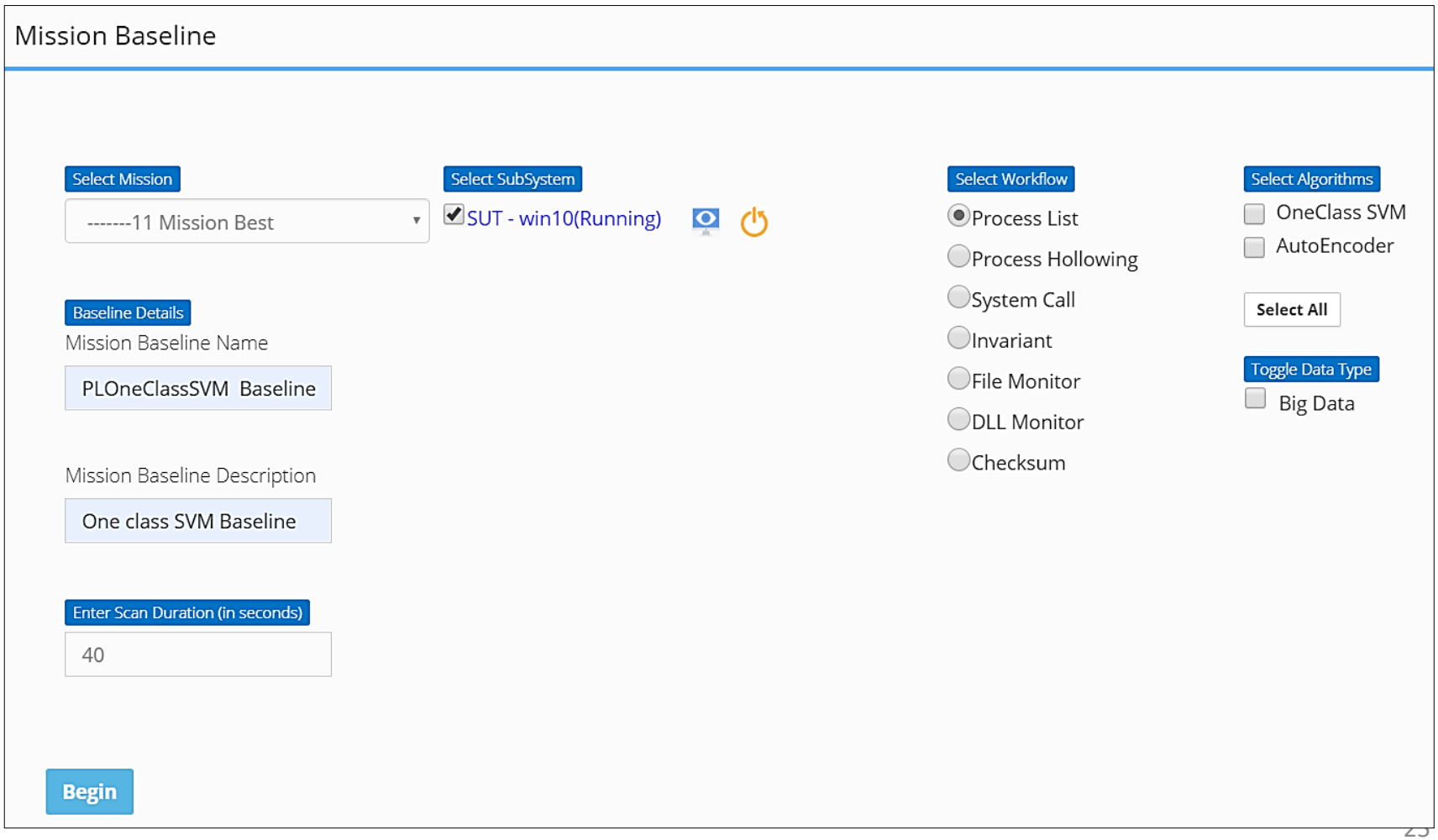
System Call Analysis

- The number of nodes and layers, along with many other hyper-parameters (learning rate, dropout, etc.)
- Weights and bias are initialized to be random
- Backwards propagation and enough training ensures that weights will converge to their optimal values



https://github.com/rasbt/python-machine-learning-book/blob/master/faq/visual-backpropagation/backpropagation.png

Process List – One Class SVM Mission Baseline



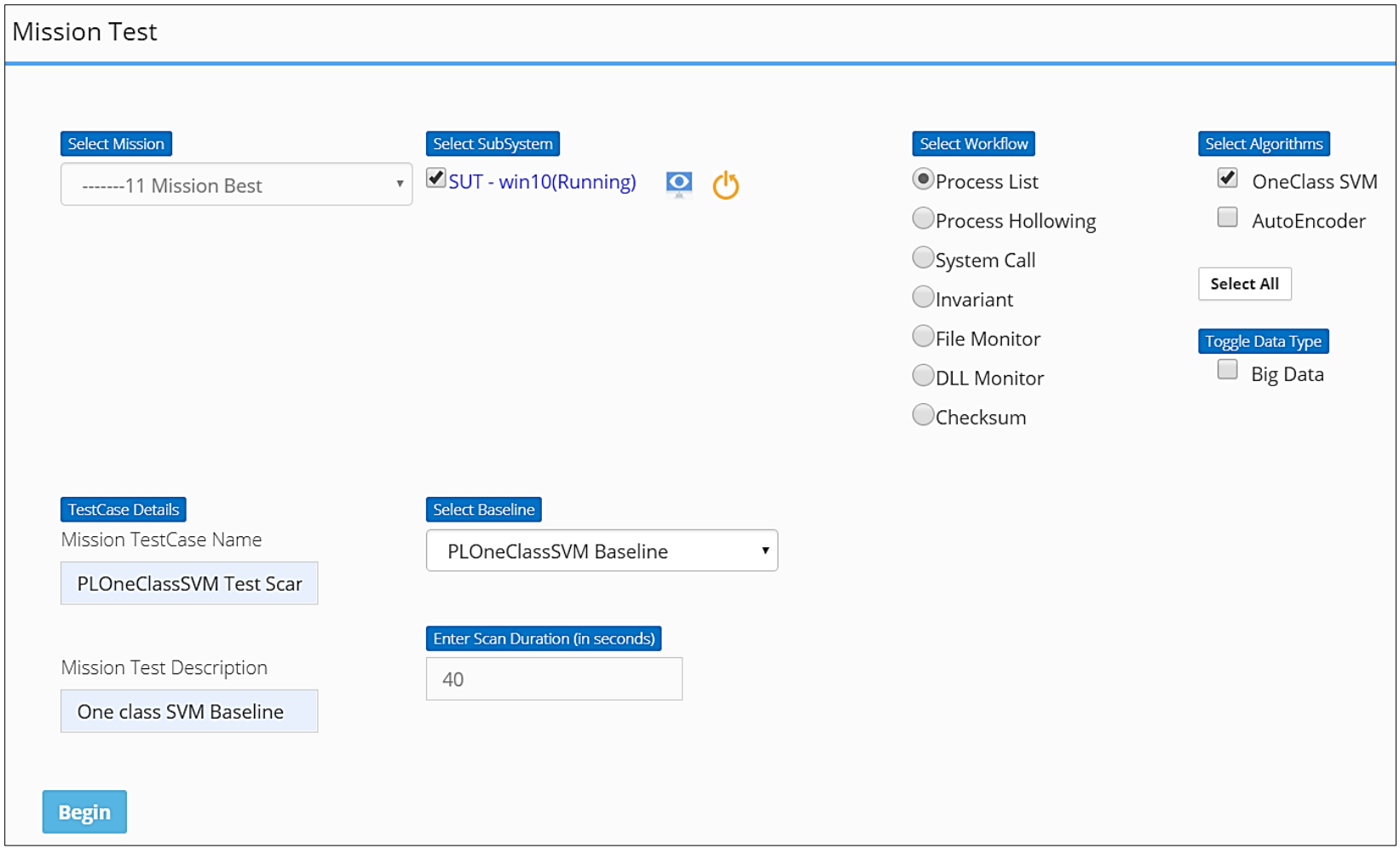
Process List – One Class SVM Mission Baseline Validation

6867	win10	Process List Baseline 08/29/2019	Full Process List Baseline	8/29/2019 4:04:01 PM	View Details

Model ID	Model Workflow	Baseline Scan Results
6867	Process List	

ProcessName	SimilarityScore
GPS.exe	83.9
Weather.exe	97.65
SUT.exe	97.68

Process List – One Class SVM Mission Test



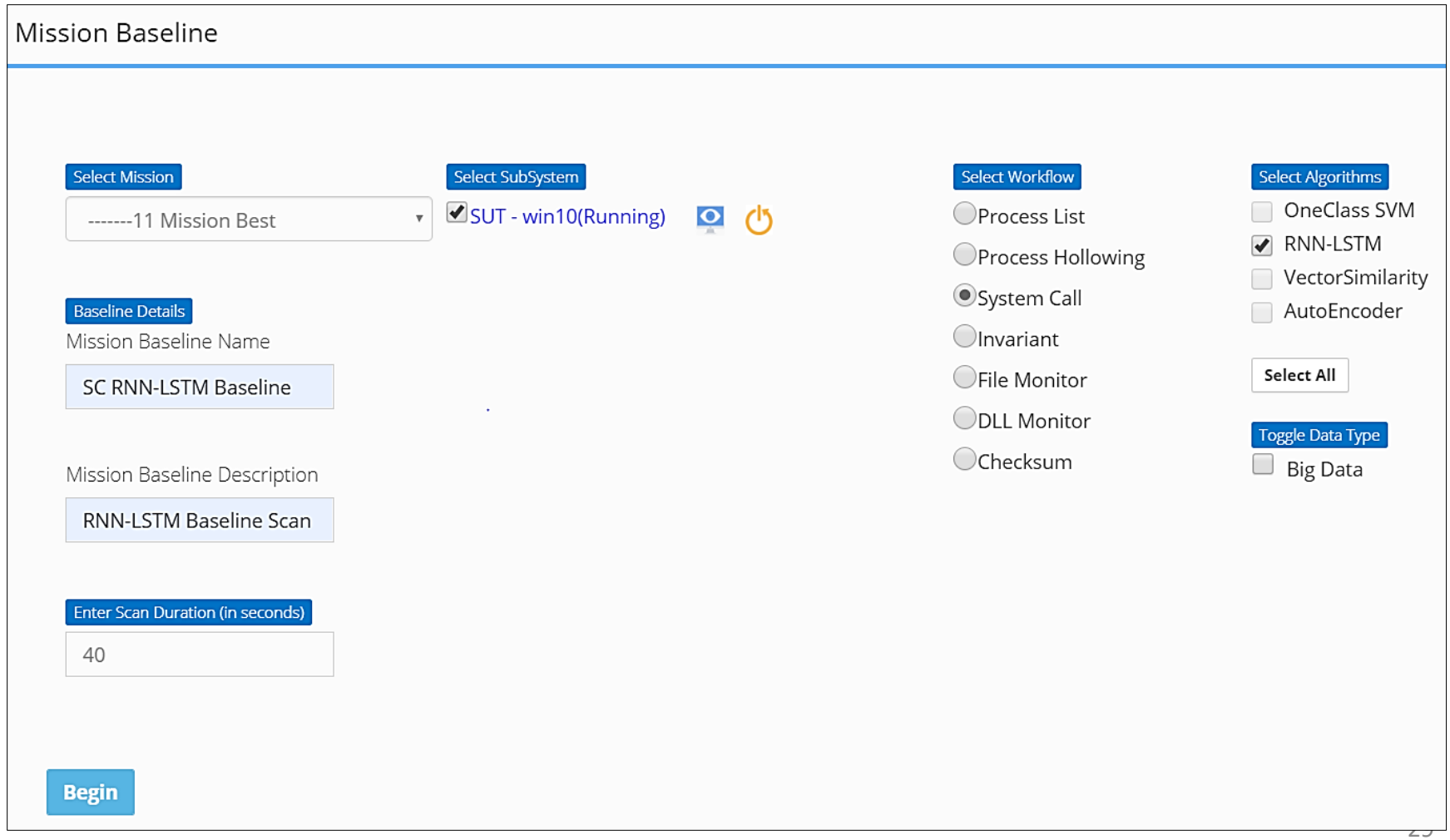
Process List – One Class SVM Mission Test Results

2358	win10	Process List Baseline 08/29/2019	Testing	8/29/2019 5:34:45 PM	View Details

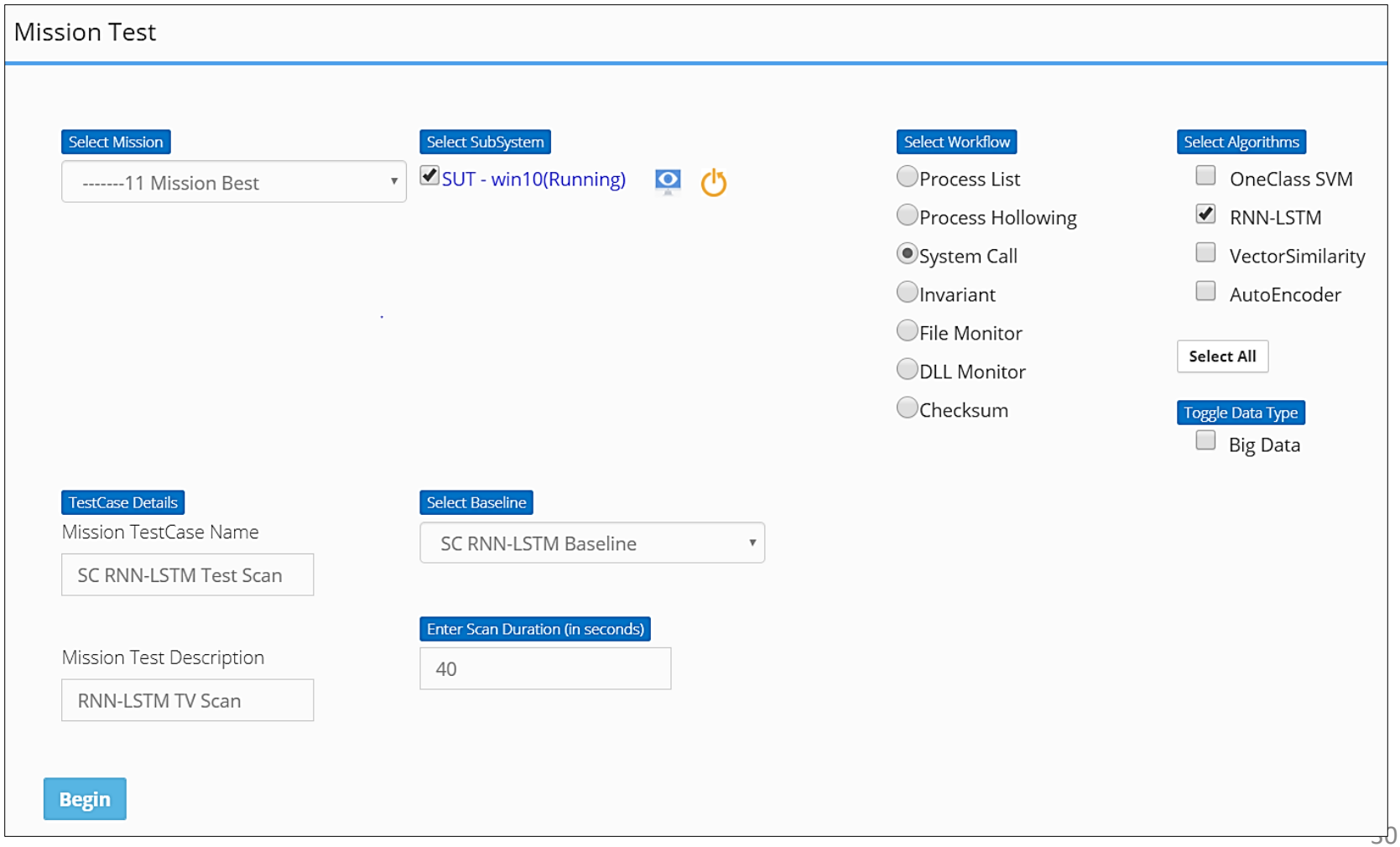
TestCase Result ID	Mission Workflow	Mission Result	
8137	Process List	Normal	
8138	Process List	Compromised	View Details

Baseline Scan Results		Test Vector Scan Results		Status
ProcessName	**SimilarityScore**	**ProcessName**	**SimilarityScore**	
GPS.exe	83.9	SUT.exe	76.44	Compromised
Weather.exe	97.65	Weather.exe	100.0	
SUT.exe	97.68	GPS.exe	94.21	

System Call – RNN – LSTM Mission Baseline



System Call – RNN – LSTM Mission Test



System Call – RNN – LSTM Mission Test Results

TestCaseID	VM Name	Model Name	TestCase Name	Inserted On	Detailed View
2431	win10	SC RNN-LSTM Baseline	SC RNN-LSTM Test Scan	9/12/2019 1:27:32 PM	View Details

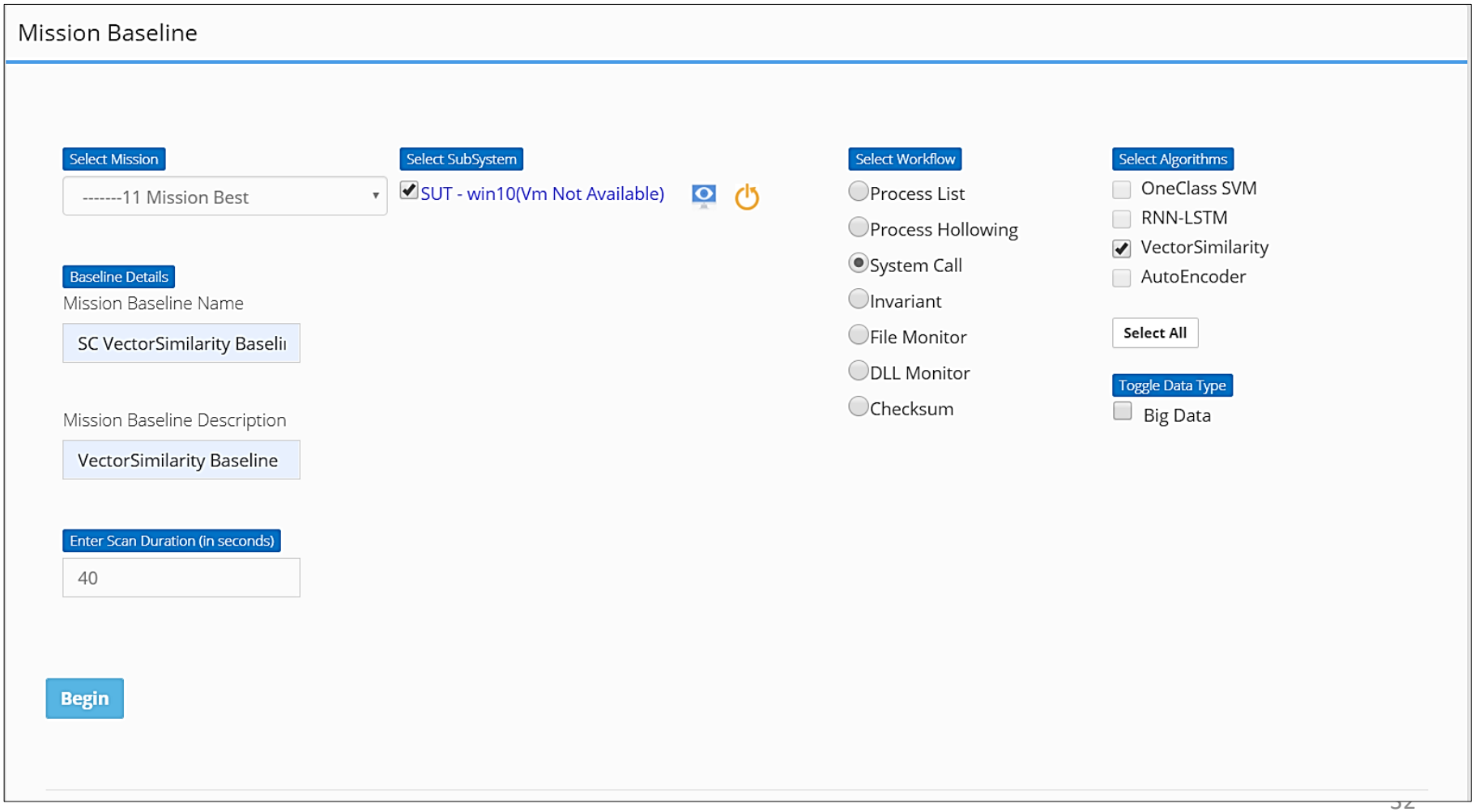
TestCase Result ID	Mission Workflow	Mission Result	
8195	System Call	Compromised	View Details

Result Summary

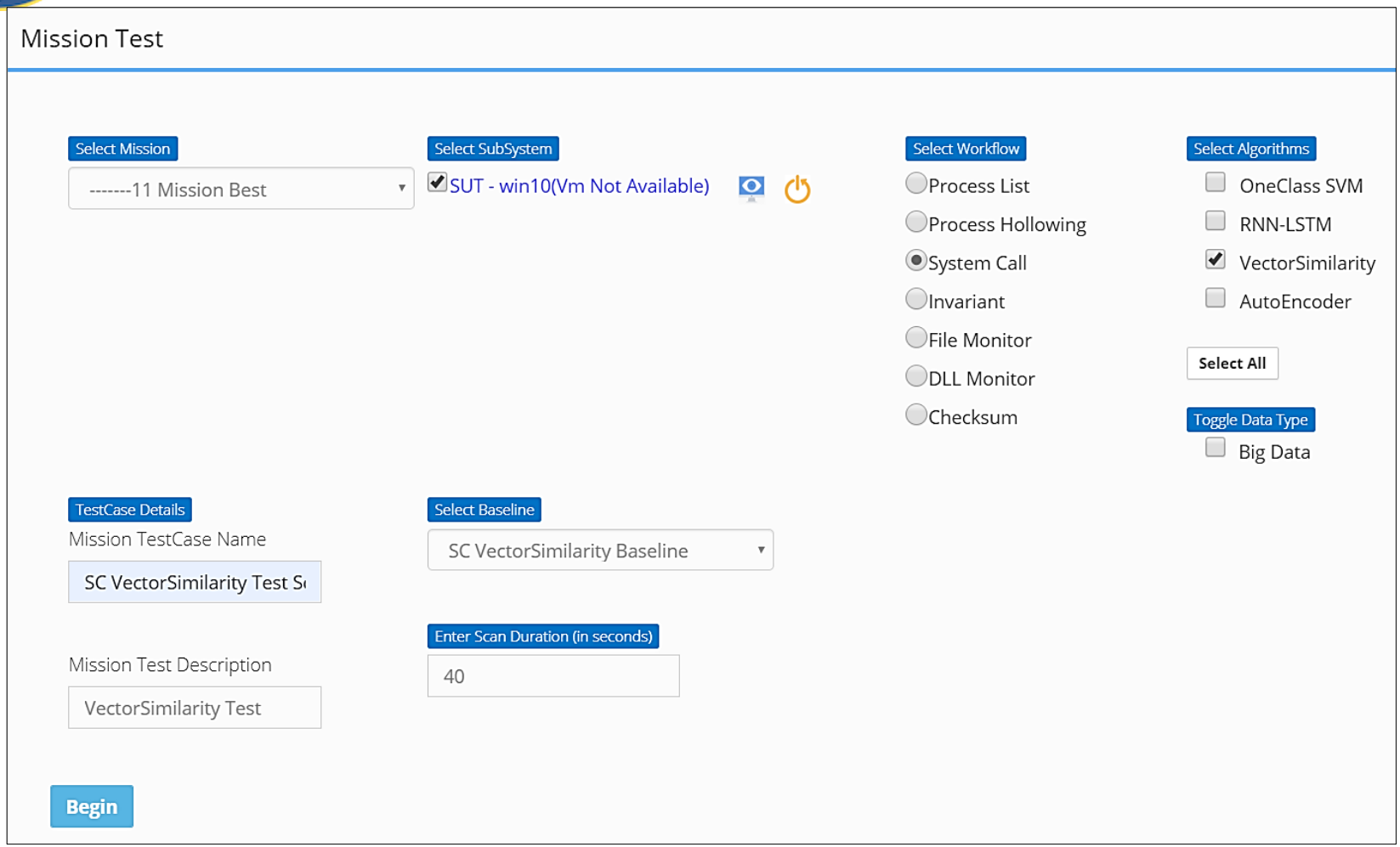
TestCase Details

Baseline Scan Results	Test Vector Scan Results	Status
97.0%	0.002%	Compromised

System Call – Vector Similarity Mission Baseline



System Call – Vector Similarity Mission Test



System Call – Vector Similarity Mission Test Results

2428	win10	Vector Similarity Baseline	Vector Similarity Test	9/12/2019 12:27:01 PM	View Details

TestCase Result ID	Mission Workflow	Mission Result	
8190	System Call	Compromised	View Details

Baseline Scan	Test Scan	Status
Weather.exe, SUT.exe, GPS.exe	SUT.exe	Compromised

Artificial Intelligence & Big Data Hub
On-Premise | Cloud | Hybrid

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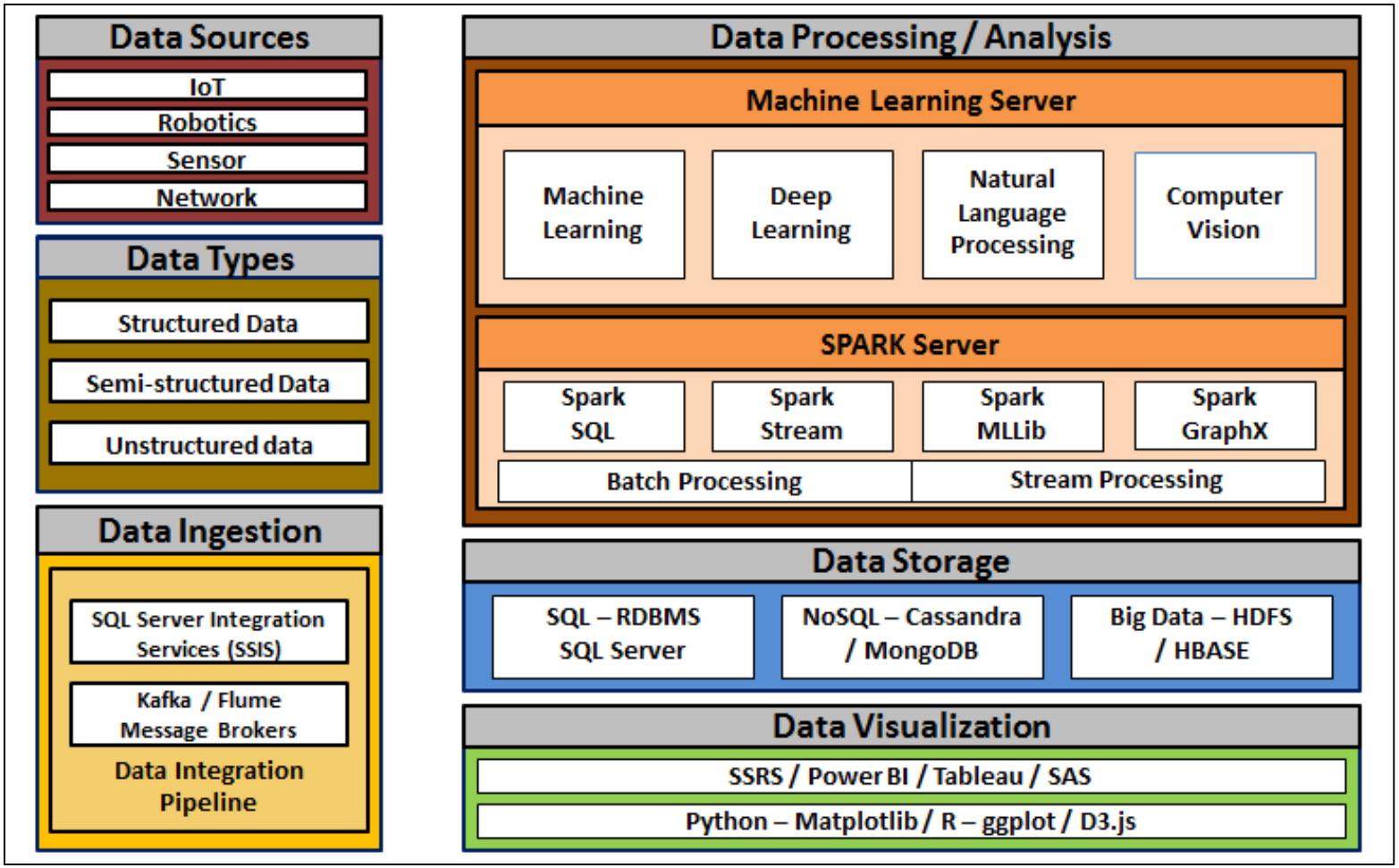
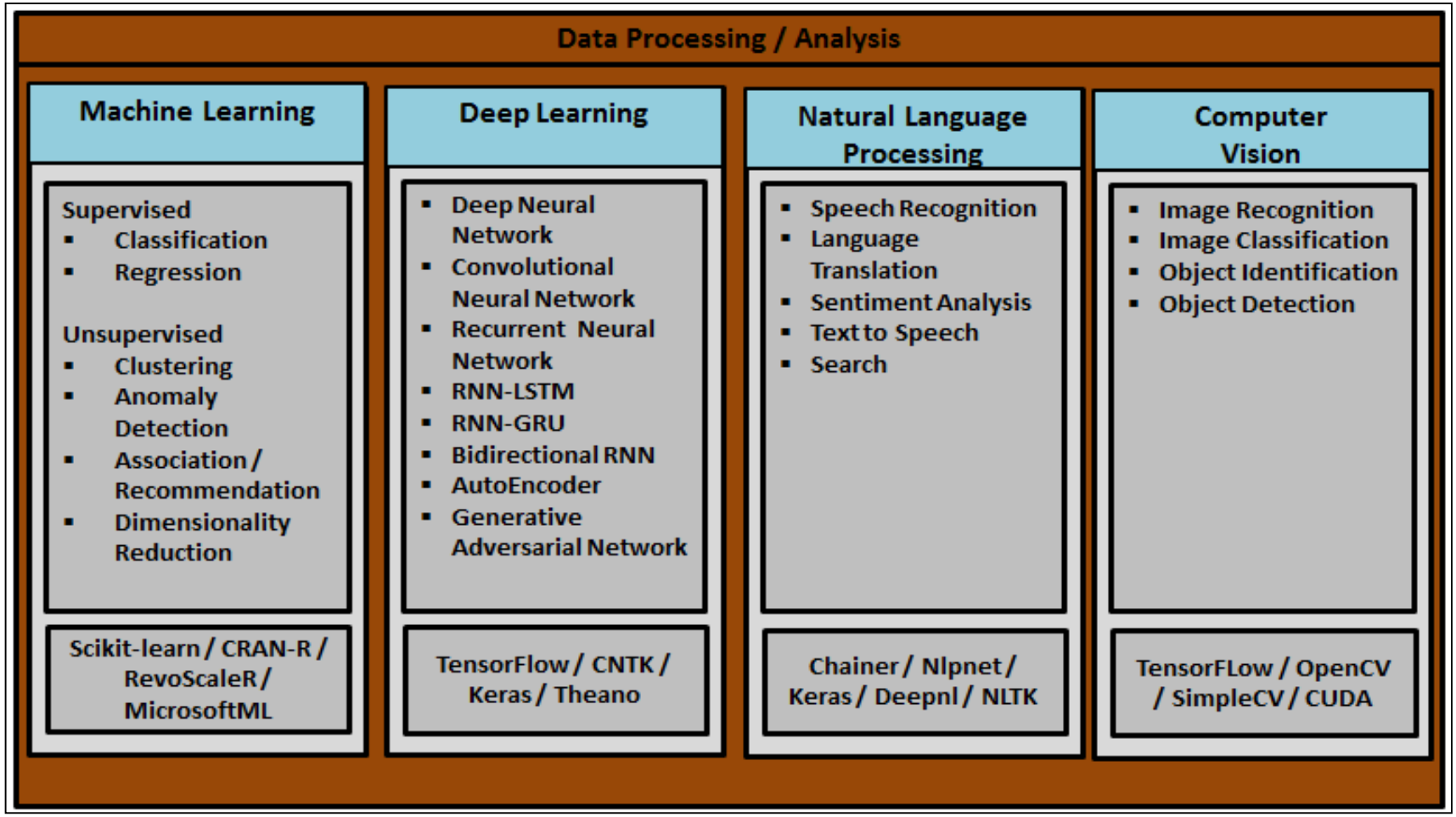


Artificial Intelligence Applications & Algorithms

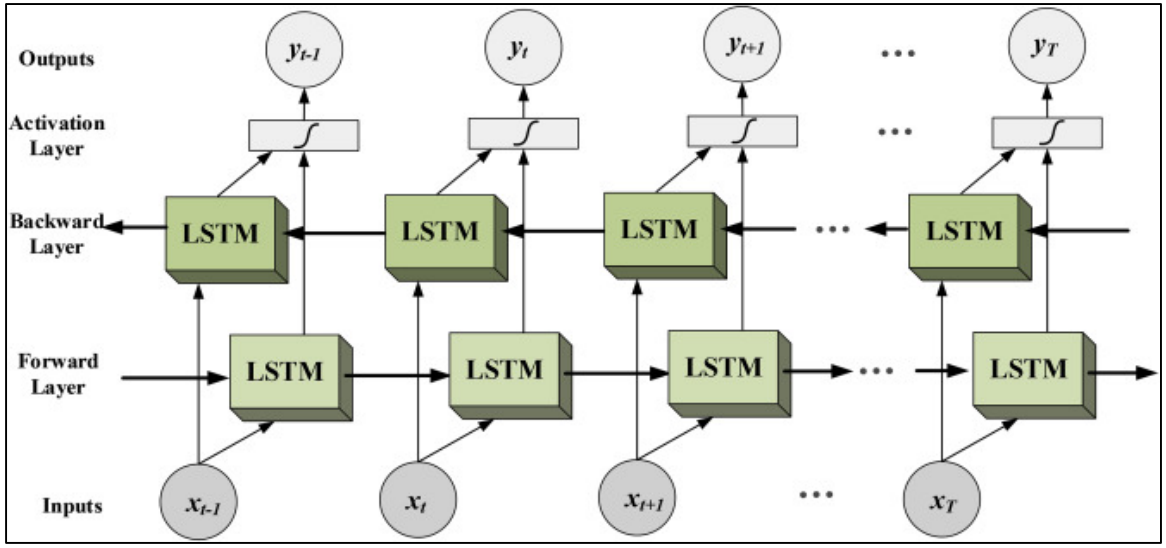


QUESTIONS AND DISCUSSION

Bidirectional RNN-LSTM

Bidirectional RNN-LSTM

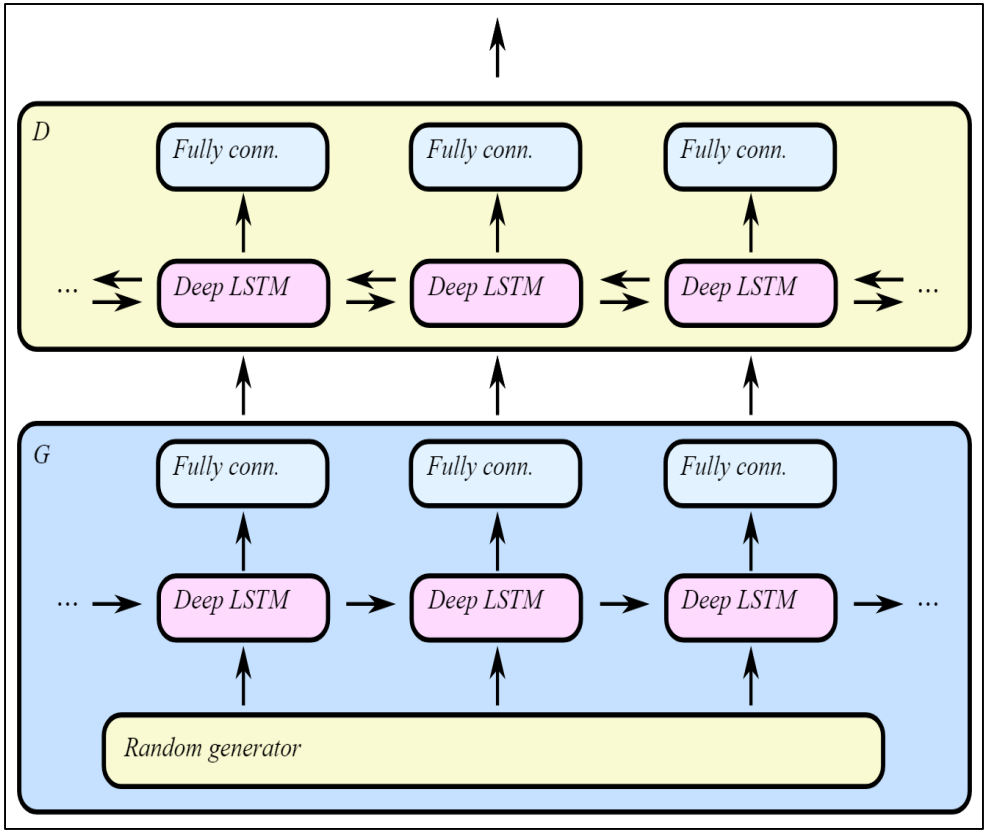
- Utilizes past and future sequence data.
- Gives "context" to our predictions.



https://www.sciencedirect.com/science/article/pii/S0010482518300738

LSTM - Generative Adversarial Networks (GANs)

- Comprised of a “generator” model and a “discriminator” model
- Generator creates benign sequences
- The discriminator determines if a given sequence is valid



https://www.sciencedirect.com/science/article/pii/S0010482518300738