CyPSA

(Cyber Physical Situational Awareness)

A rejected Blackhat talk.

kaedago

CyPSA Project

Aug 3, 2016

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Oregon State UNIVERSITY

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np network perception

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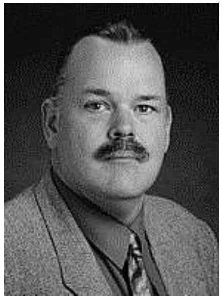
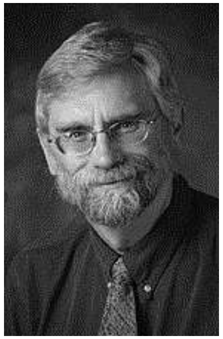




ARPA-E: Tim Heidel, Sameh Elsharkawy, Erik Derosiers

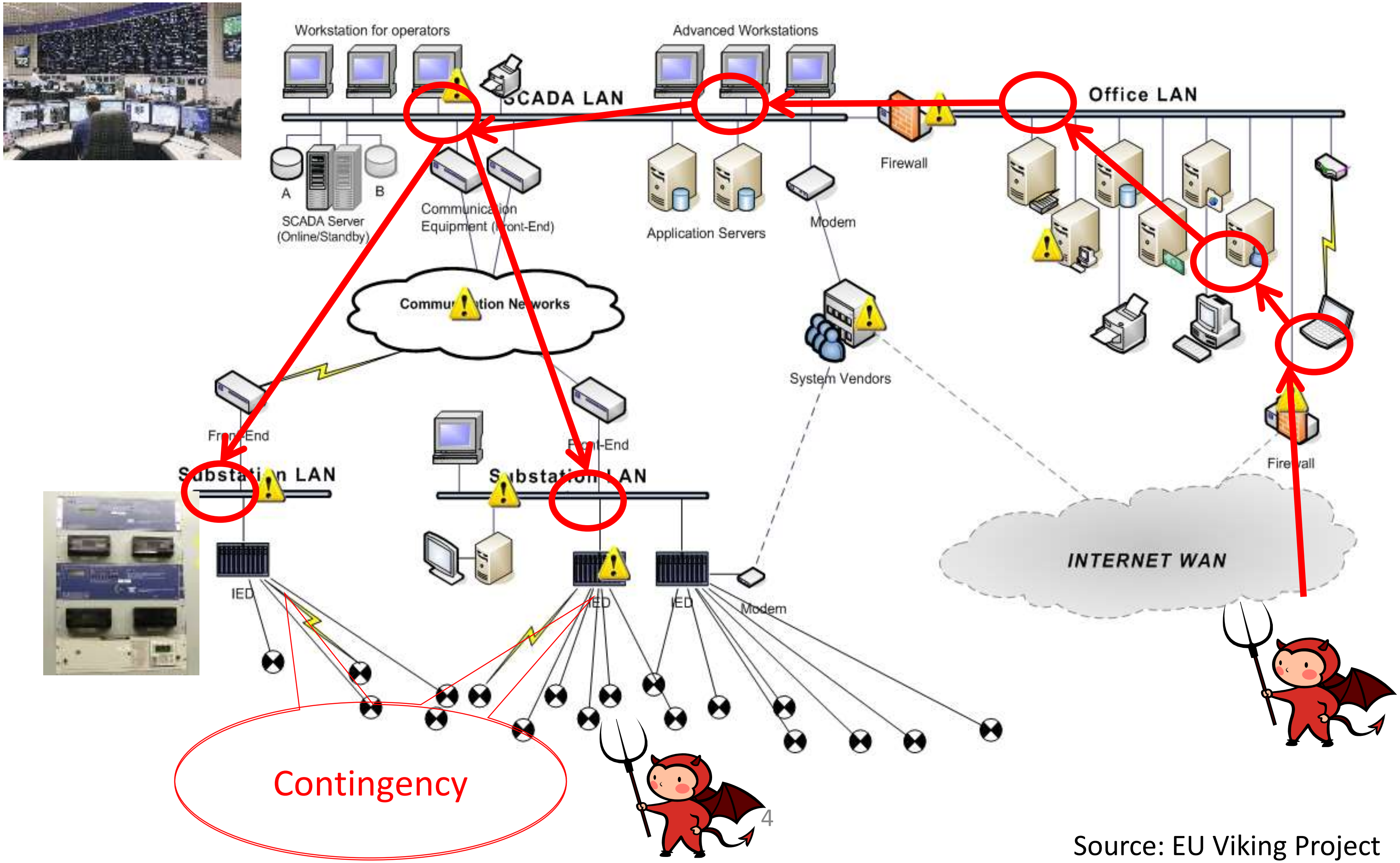
Challenges

- How to ensure operational reliability given our increasing dependence on cyber systems?

- How to understand the impact of cyber vulnerabilities on grid operations?

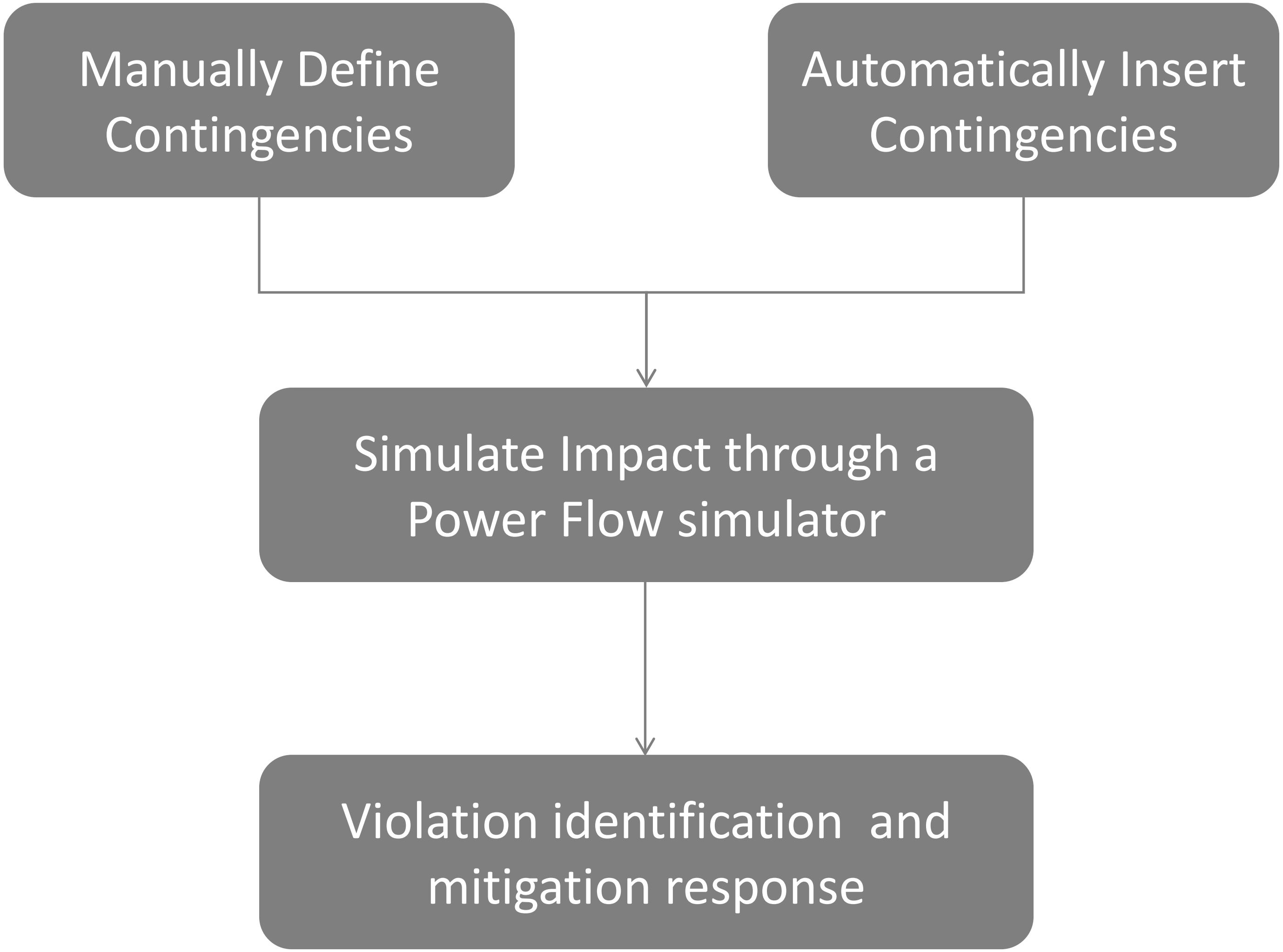
- How to prioritize cyber security efforts in control networks and substations?

What is the Problem?



Source: EU Viking Project

Traditional Contingency Analysis



Manually Define Contingencies

Automatically Insert Contingencies

Simulate Impact through a Power Flow simulator

Violation identification and mitigation response

Traditional Contingency Analysis

- Meant to be prepared for one outage (“N - 1” criteria)
  - no violations when any one element (line, generator or major transformer) goes out of service
  - “N - 1” criteria is reliability standard

- Is preparedness for one outage enough?
  - probability of multiple independent failures is considered small enough to accept the risk

- Cyber-assets are not considered
  - redundant provisioning
  - probability of multiple independent failures is considered small enough to accept the risk

Limitations with Current Practice

- With threat of cyber-attacks
  - multiple failures no longer unlikely
  - redundant provisioning alone not sufficient

- Prevention/protection mechanisms are not foolproof

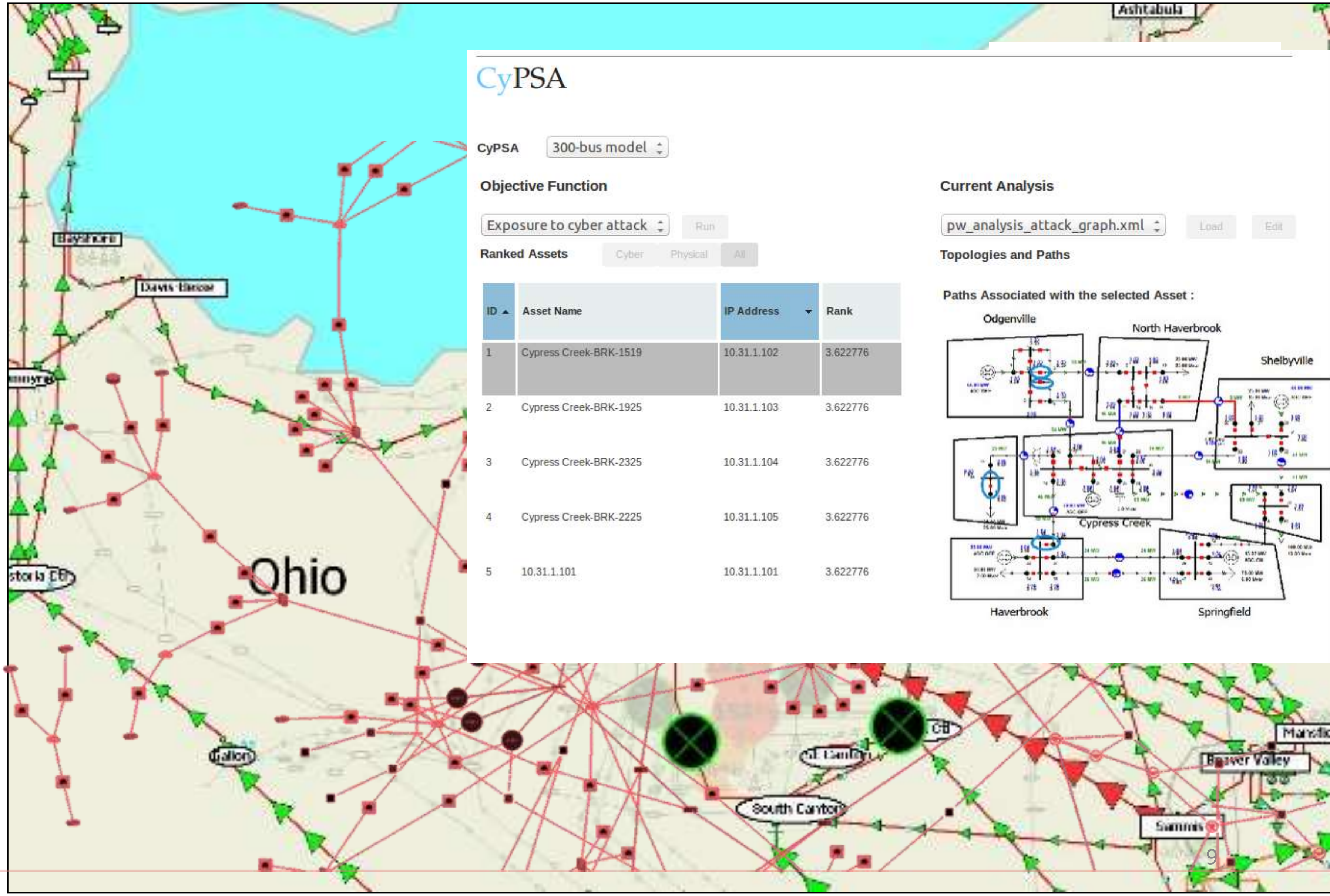
- Power system needs to be reliable even in the face of cyber-attacks
  - Need to deal with multiple outages ("N – x")
  - Need to deal with failures of "cyber assets"

Challenges of multiple outages

- Size of the contingency list can grow very large*
    - For 1000 line system
        - N-1 means solving 1000 line outages
        - N-2 means solving 499500 line outages (1000 choose 2)!
        - WECC N-2 for transmission lines ~135M contingencies
            - ~15 days with super computer!

- Operating at “N – x” reliability criterion can be expensive
    - limits flow capacity

*Charles Davis, Thomas Overbye: Linear Analysis of Multiple Outage Interaction. HICSS 2009: 1-8



CyPSA

CyPSA: 300-bus model

Objective Function

Exposure to cyber attack — Run

Ranked Assets — Cyber | Physical | All

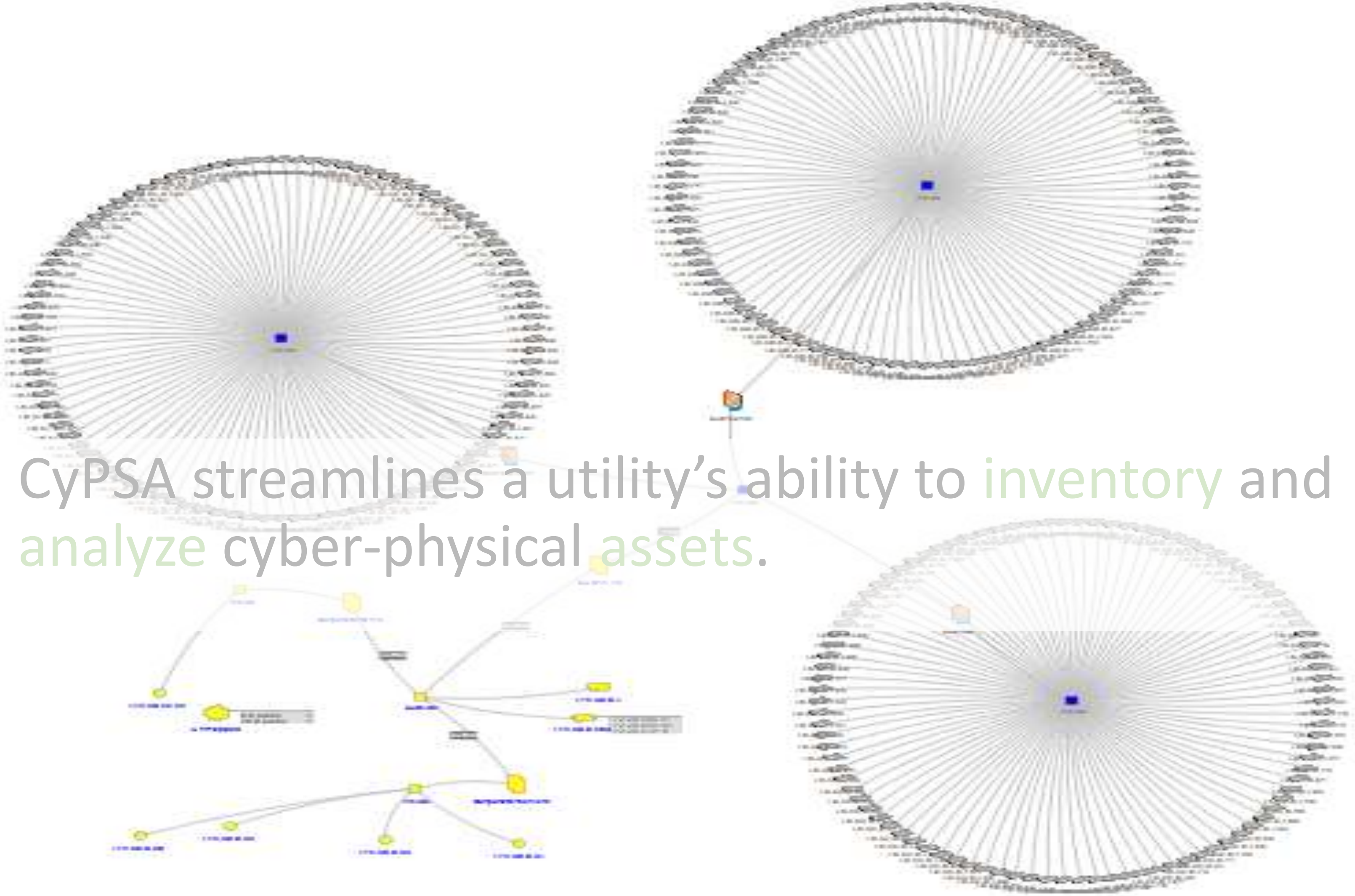
ID ▲	Asset Name	IP Address ▼	Rank
1	Cypress Creek-BRK-1519	10.31.1.102	3.622776
2	Cypress Creek-BRK-1925	10.31.1.103	3.622776
3	Cypress Creek-BRK-2325	10.31.1.104	3.622776
4	Cypress Creek-BRK-2225	10.31.1.105	3.622776
5	10.31.1.101	10.31.1.101	3.622776

Current Analysis

pw_analysis_attack_graph.xml — Load — Edit

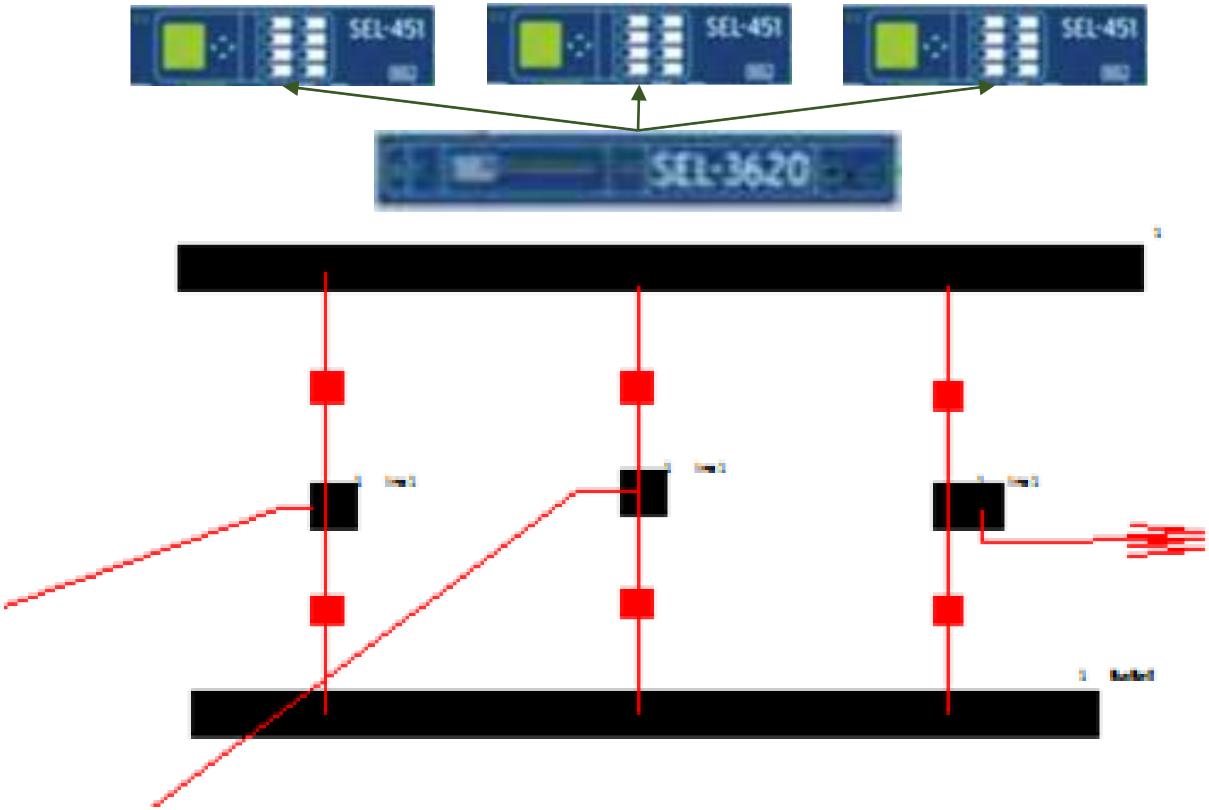
Topologies and Paths

Paths Associated with the selected Asset :



CyPSA streamlines a utility’s ability to inventory and analyze cyber-physical assets.

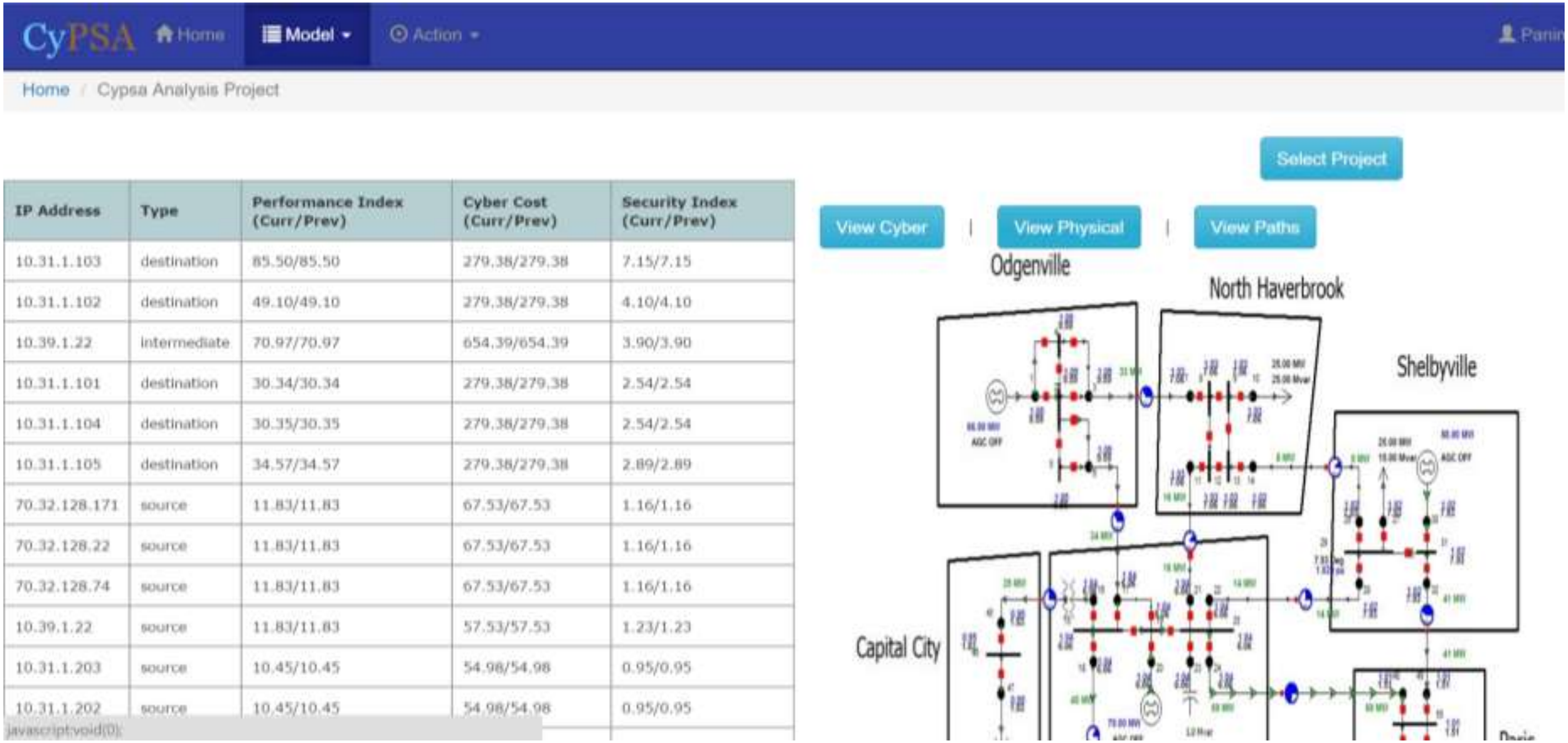
Collect and manage inventory data



Use Case: Asset Ranking

Description	Analyze all attack paths for a given set of assets Rank based on both *impact* and *cyber exposure* • *Impact*: power system performance index based on severity metrics • *Cyber exposure*: metrics include the number of potential attack paths and ease of realizing at attack
Role	**Manager**
Inputs	• A model • A source of vulnerability information • A set of assets to be ranked
Outputs	• A list of attack paths annotated with and ordered by a ranking

CyPSA Control Panel

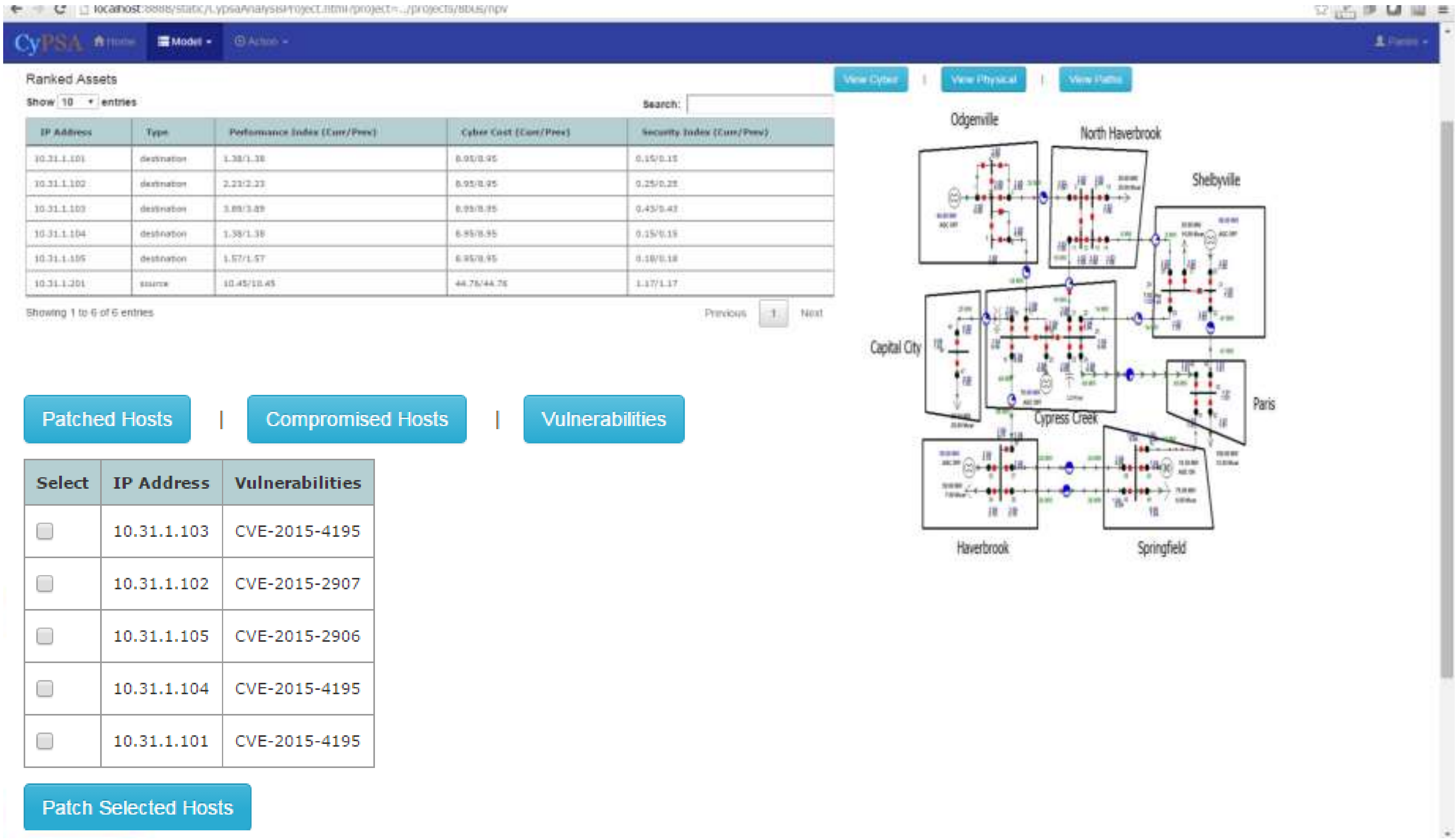


IP Address	Type	Performance Index (Curr/Prev)	Cyber Cost (Curr/Prev)	Security Index (Curr/Prev)
10.31.1.103	destination	85.50/85.50	279.38/279.38	7.15/7.15
10.31.1.102	destination	49.10/49.10	279.38/279.38	4.10/4.10
10.39.1.22	intermediate	70.97/70.97	654.39/654.39	3.90/3.90
10.31.1.101	destination	30.34/30.34	279.38/279.38	2.54/2.54
10.31.1.104	destination	30.35/30.35	279.38/279.38	2.54/2.54
10.31.1.105	destination	34.57/34.57	279.38/279.38	2.89/2.89
70.32.128.171	source	11.83/11.83	67.53/67.53	1.16/1.16
70.32.128.22	source	11.83/11.83	67.53/67.53	1.16/1.16
70.32.128.74	source	11.83/11.83	67.53/67.53	1.16/1.16
10.39.1.22	source	11.83/11.83	57.53/57.53	1.23/1.23
10.31.1.203	source	10.45/10.45	54.98/54.98	0.95/0.95
10.31.1.202	source	10.45/10.45	54.98/54.98	0.95/0.95

Use Case: Patching

Description	Select hosts or vulnerabilities to patch and re-compute attack path rankings.
Role	**IT Administrator** **Manager**
Inputs	• A model • A source of vulnerability information • A set of assets to be ranked
Outputs	A list of attack paths whose rankings have been updated based upon which assets were patched.

Mark devices patched then recalculate ranking



Ranked Assets

Show 10 entries

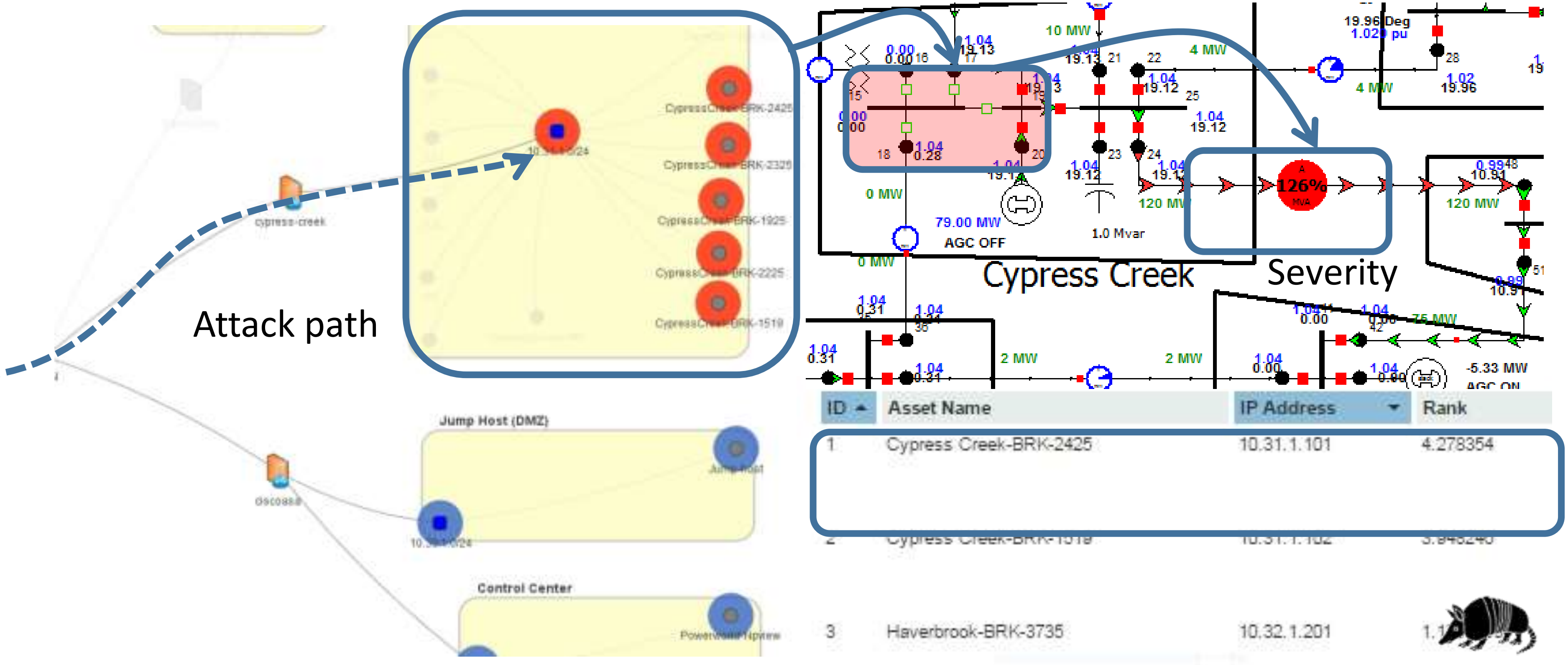
Search:

IP Address	Type	Performance Index (Curr/Prev)	Cyber Cost (Curr/Prev)	Security Index (Curr/Prev)
10.31.1.101	destination	1.38/1.38	0.95/0.95	0.15/0.15
10.31.1.102	destination	2.23/2.23	0.95/0.95	0.25/0.25
10.31.1.103	destination	3.89/3.89	0.95/0.95	0.43/0.43
10.31.1.104	destination	1.38/1.38	0.95/0.95	0.15/0.15
10.31.1.105	destination	1.57/1.57	0.95/0.95	0.18/0.18
10.31.1.201	source	10.45/10.45	44.76/44.76	1.17/1.17

Showing 1 to 6 of 6 entries

Select	IP Address	Vulnerabilities
□	10.31.1.103	CVE-2015-4195
□	10.31.1.102	CVE-2015-2907
□	10.31.1.105	CVE-2015-2906
□	10.31.1.104	CVE-2015-4195
□	10.31.1.101	CVE-2015-4195

Rank assets and paths based on physical topology, impact, cyber connectivity, and vulnerabilities



ID	Asset Name	IP Address	Rank
1	Cypress Creek-BRK-2425	10.31.1.101	4.278354
2	Cypress Creek-BRK-1519	10.31.1.102	3.948240
3	Haverbrook-BRK-3735	10.32.1.201	1.1

Use Case: Aggregate Exposure

Description	Analyze all attack paths for a given grouping of assets, e.g. all paths through assets of a given type or with a given vulnerability that lead to another asset of a given type (i.e., breakers). Rank based on both *impact* and *cyber exposure*
Role	**Manager**
Inputs	• A model • A source of vulnerability information • A set of assets to be ranked
Outputs	• A list of attack paths annotated with and ordered by a ranking

Annotation, Vulnerability Information: Manager

ⓘ ⓧ

Annotate Model

Name	OS	CVE Vulns	Freq
SEL 3620 1			
SEL 421 1			
SEL 421 2			
...			
SEL 451 1			
...			

Load annotations data
on **CVE Vulns**

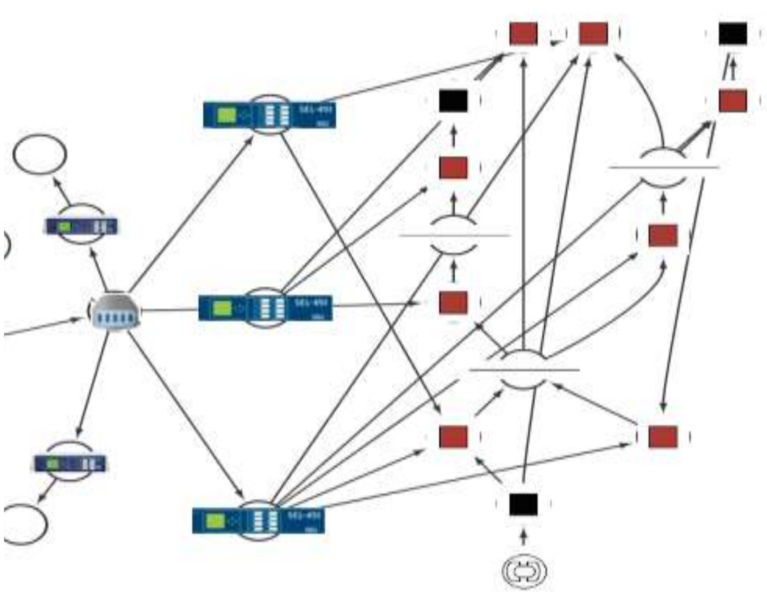
from **URL or Path to Annotation**

Join on **OS**

GO

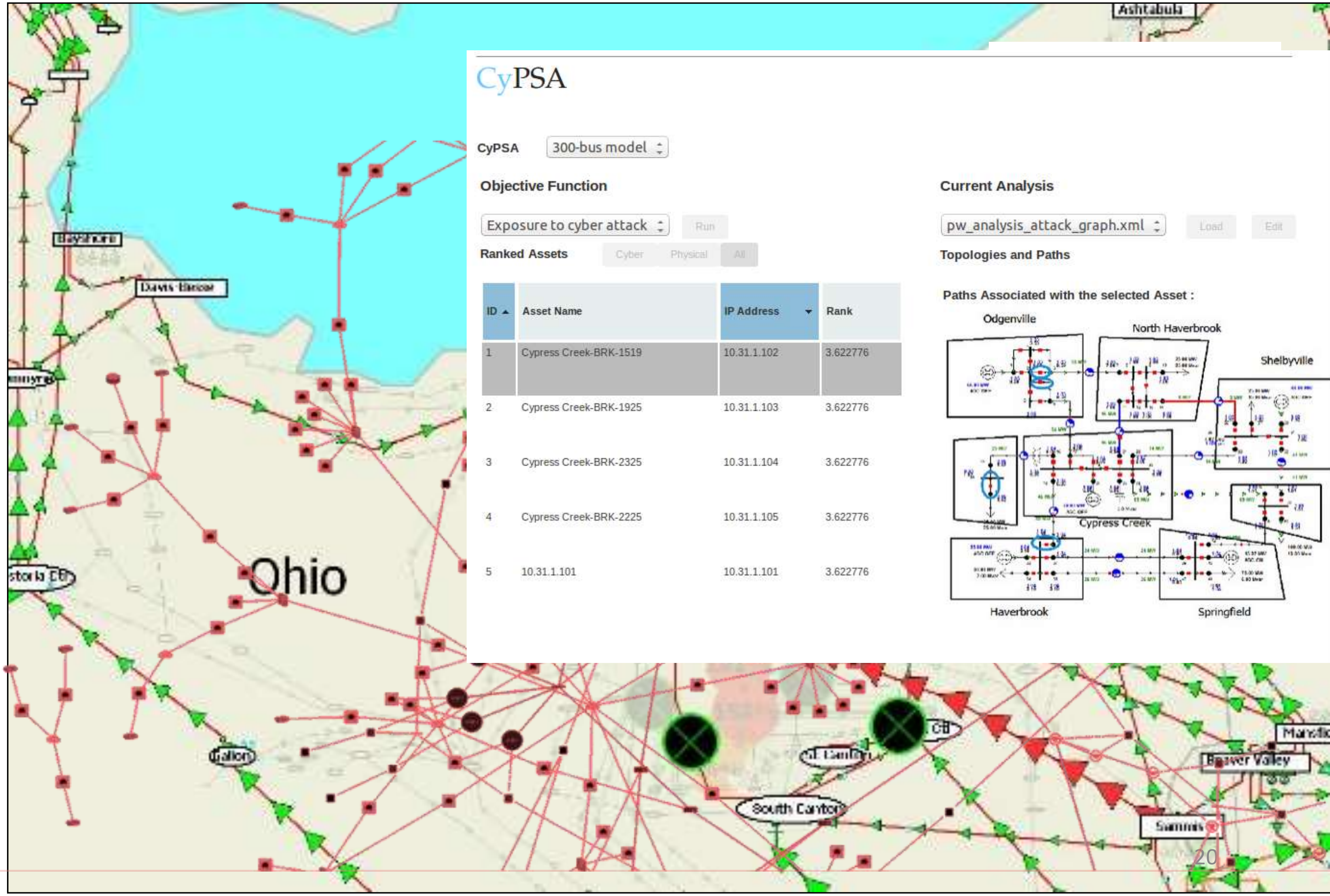
ⓘ ⓧ

Cypress Creek, Substation Network



Use Case: Cyber Incident Planning

Description	Devices are marked as compromised and asset rankings are re-computed.
Role	**IT Administrator** **Manager** **Power Engineer**
Inputs	• A model • A source of vulnerability information • A set of assets to be ranked
Outputs	A list of assets whose rankings have been updated based upon which assets were compromised.



CyPSA

CyPSA: 300-bus model

Objective Function

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Ranked Assets — Cyber | Physical | All

ID	Asset Name	IP Address	Rank
1	Cypress Creek-BRK-1519	10.31.1.102	3.622776
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4	Cypress Creek-BRK-2225	10.31.1.105	3.622776
5	10.31.1.101	10.31.1.101	3.622776

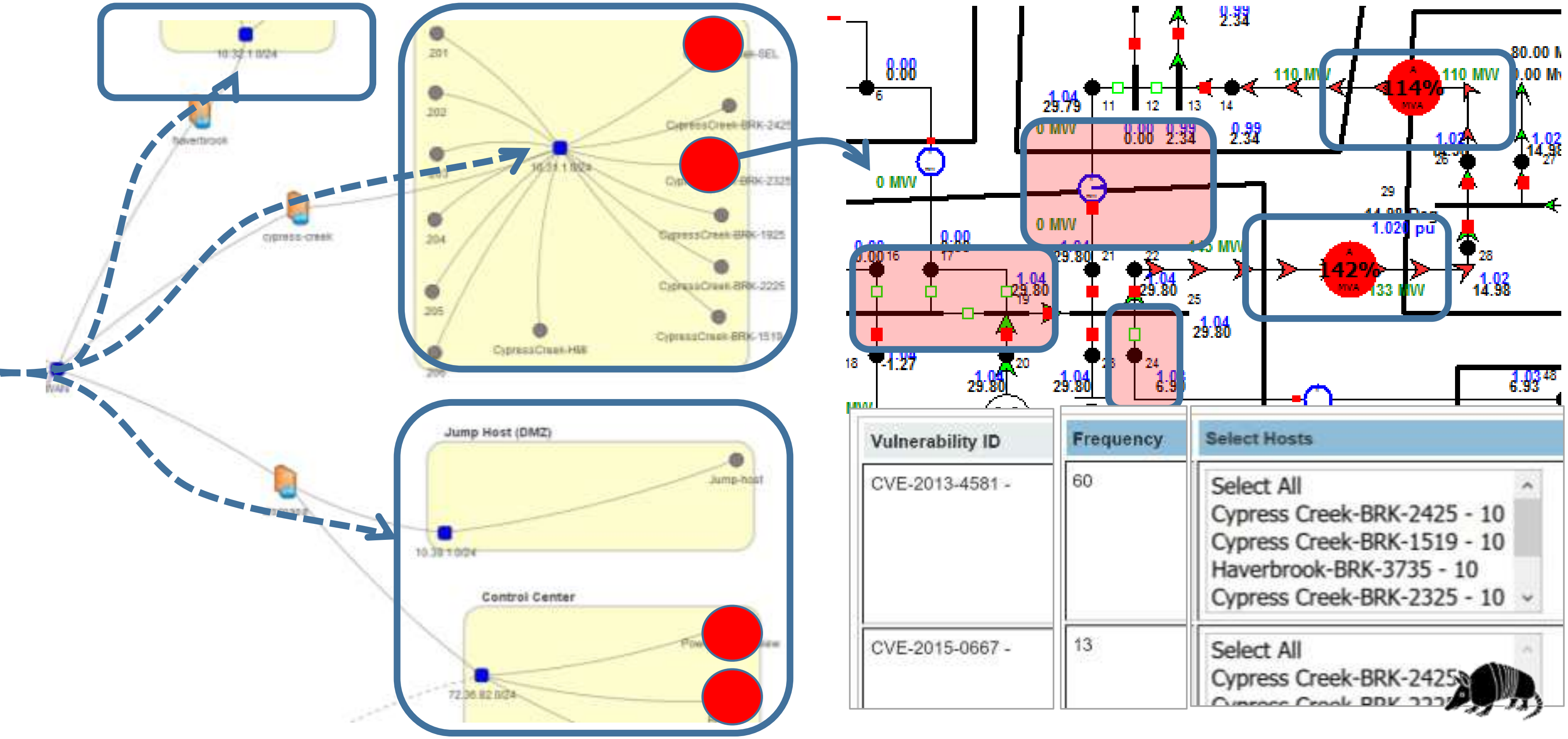
Current Analysis

pw_analysis_attack_graph.xml — Load | Edit

Topologies and Paths

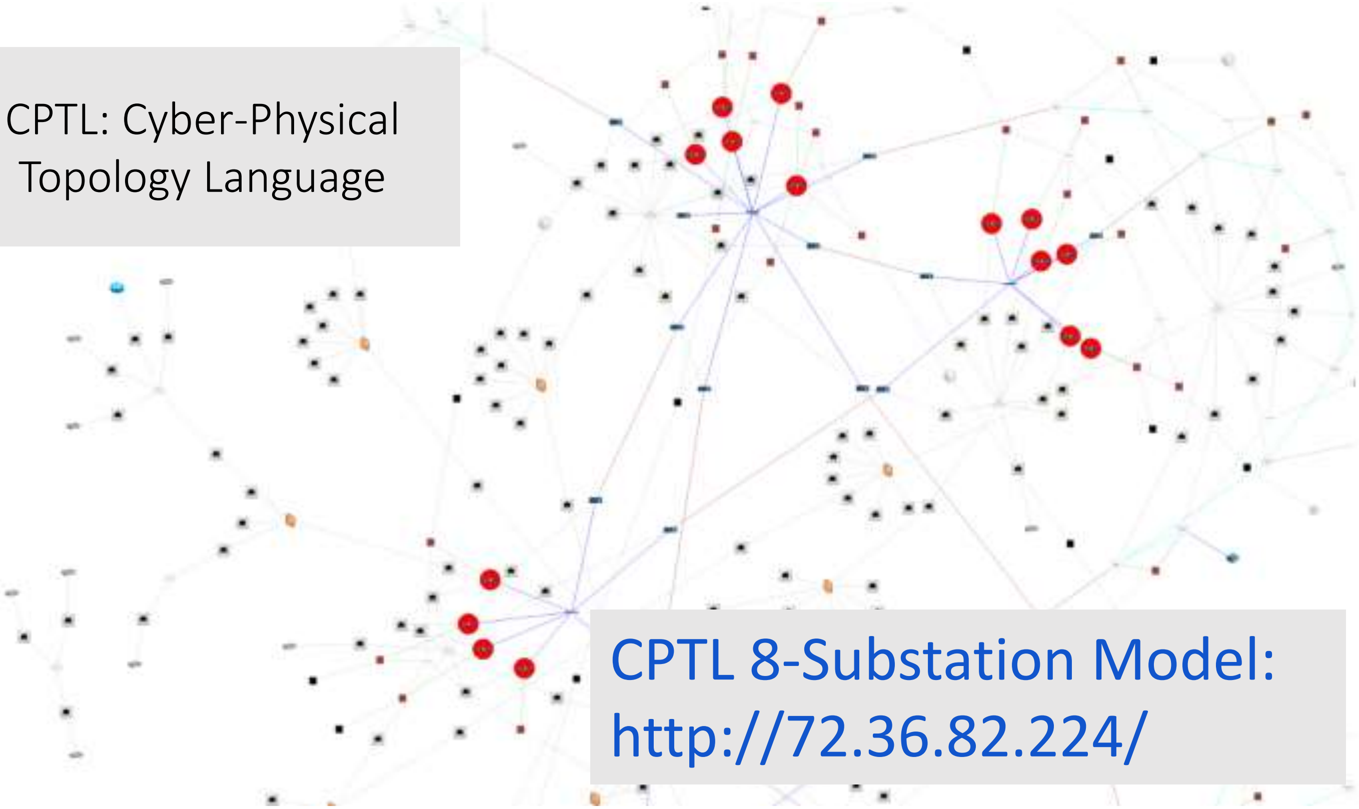
Paths Associated with the selected Asset :

Aggregate information and plan actions



Vulnerability ID	Frequency	Select Hosts
CVE-2013-4581 -	60	Select All Cypress Creek-BRK-2425 - 10 Cypress Creek-BRK-1519 - 10 Haverbrook-BRK-3735 - 10 Cypress Creek-BRK-2325 - 10
CVE-2015-0667 -	13	Select All Cypress Creek-BRK-2425

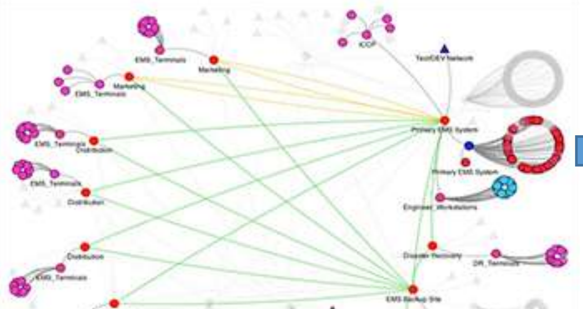
Analyze cyber-physical dependencies

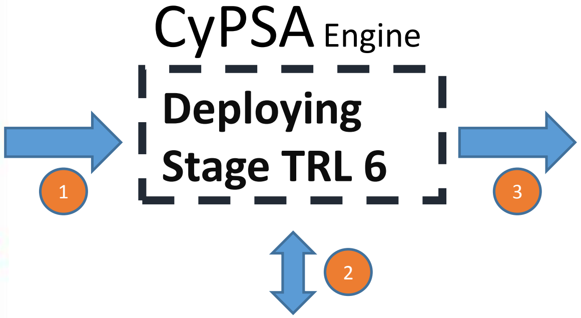


CPTL: Cyber-Physical Topology Language

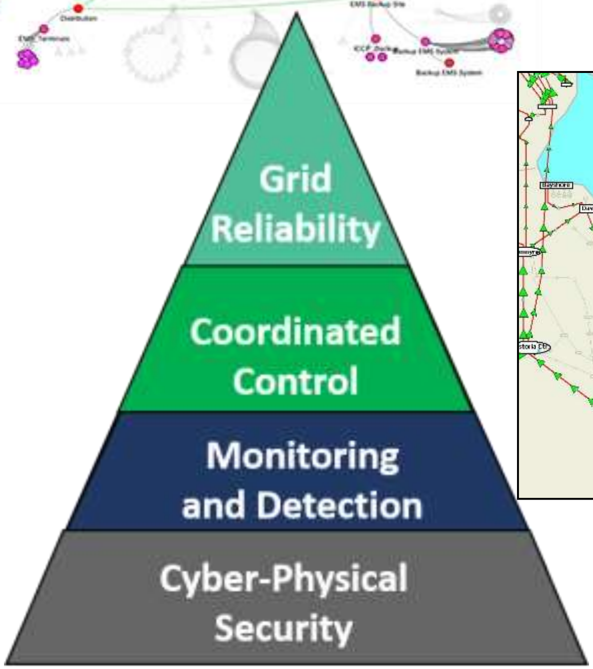
CPTL 8-Substation Model: http://72.36.82.224/

Cyber-Physical Security Assessment (CyPSA)




CyPSA Engine

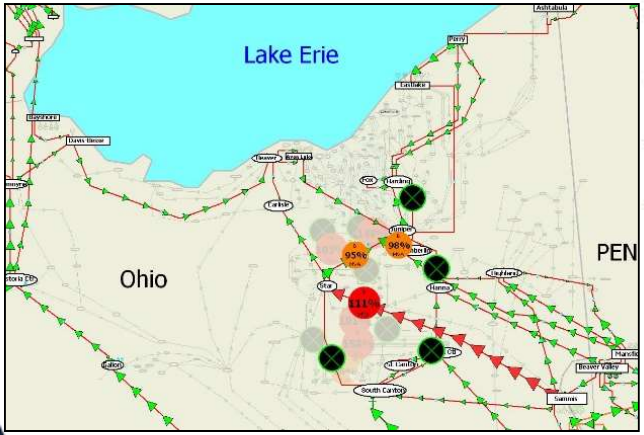
Deploying
Stage TRL 6

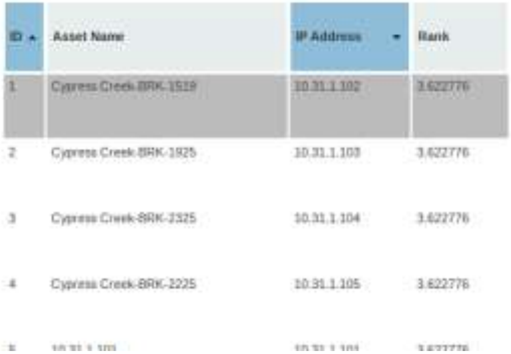

Grid Reliability

Coordinated Control

Monitoring and Detection

Cyber-Physical Security





ID ▲	Asset Name	IP Address ▼	Rank
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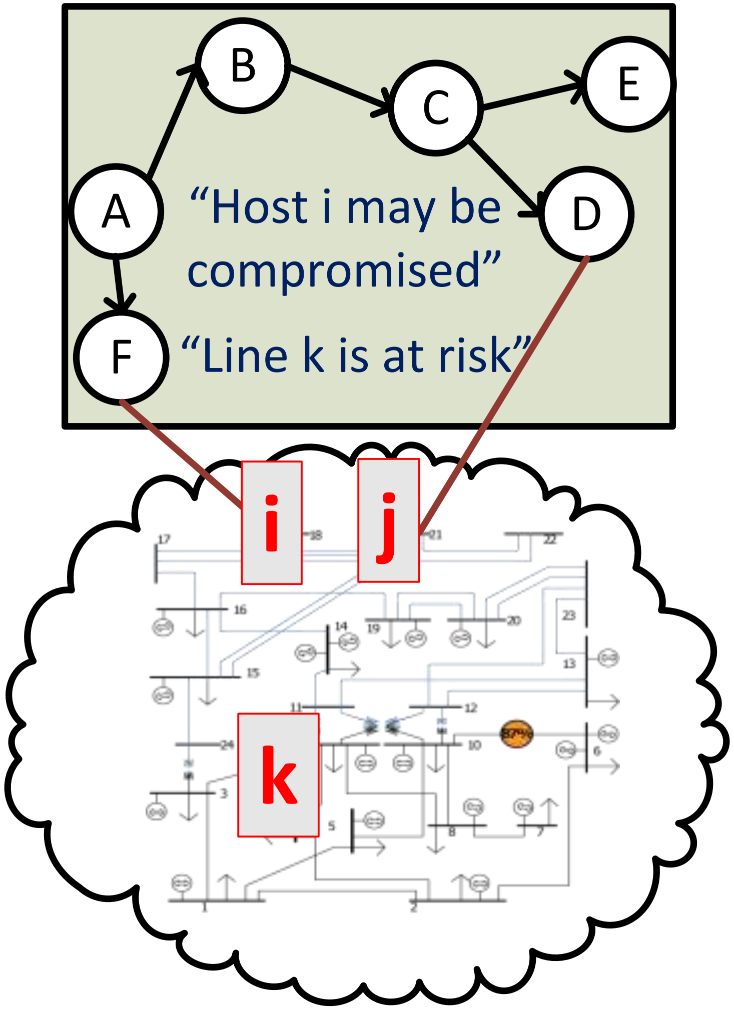
4	Cypress Creek-BRK-2225	10.31.1.105	3.622776
5	10.31.1.101	10.31.1.101	3.622776

CyPSA Open Source Release : Armadillo

- Use high-fidelity modeling and simulation to assess the ***interdependency*** between ***cyber*** and ***physical*** infrastructure

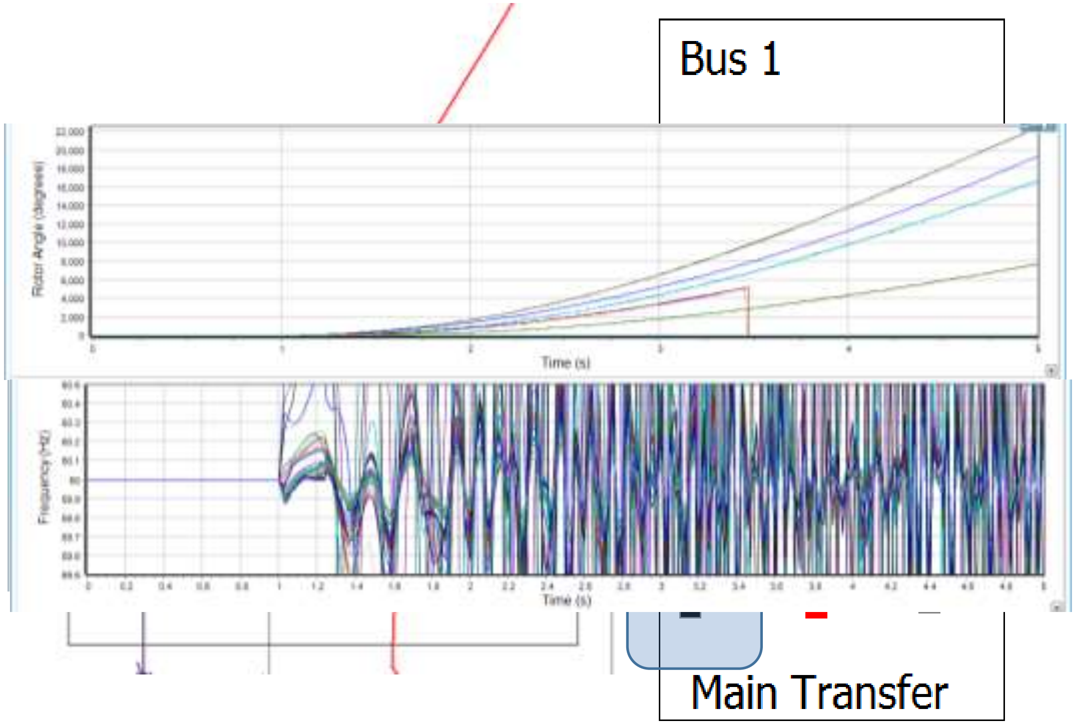
- Co-utilize information from ***cyber*** and ***power*** network to determine the ***state*** of the ***cyber-physical*** system and provide a scalable approach to detecting reliability threats due to cyber threats

Physical Connections and Impact



“Host i may be compromised”

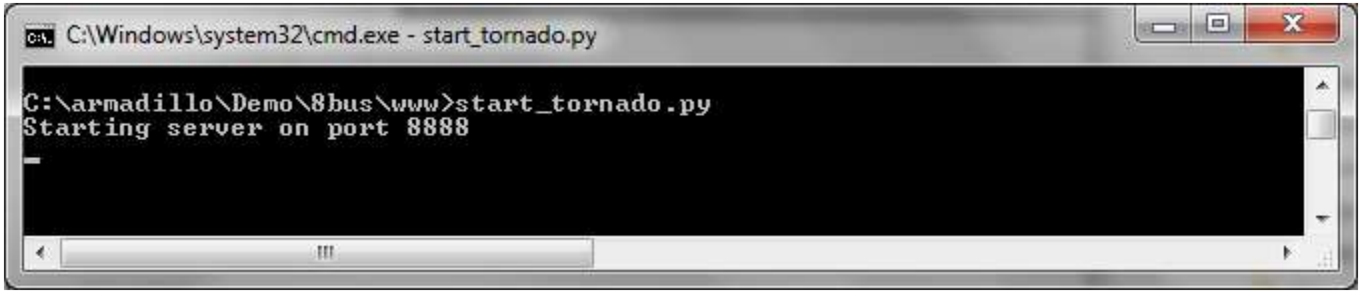
“Line k is at risk”



Demo?

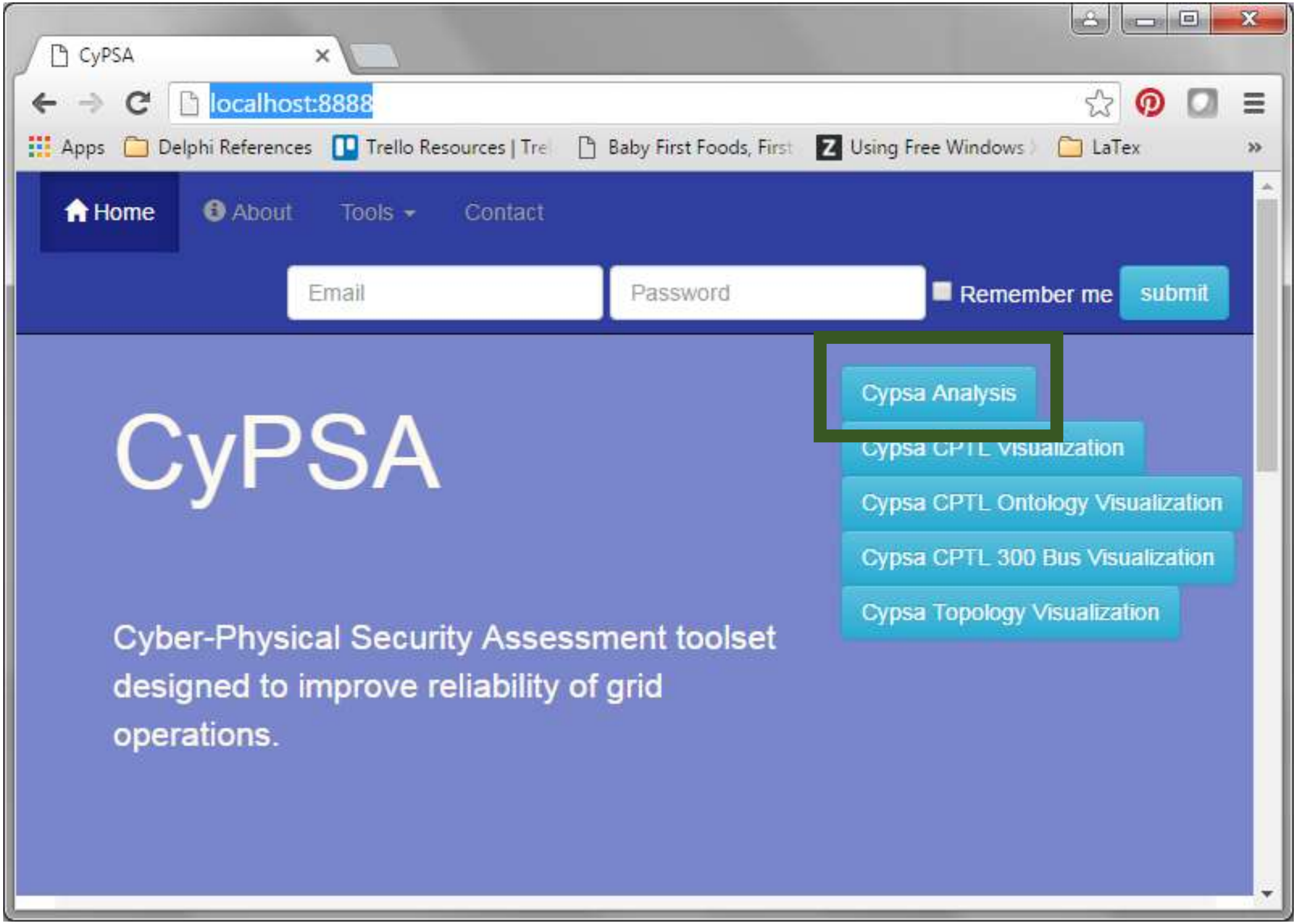
Running Armadillo

- Start backend



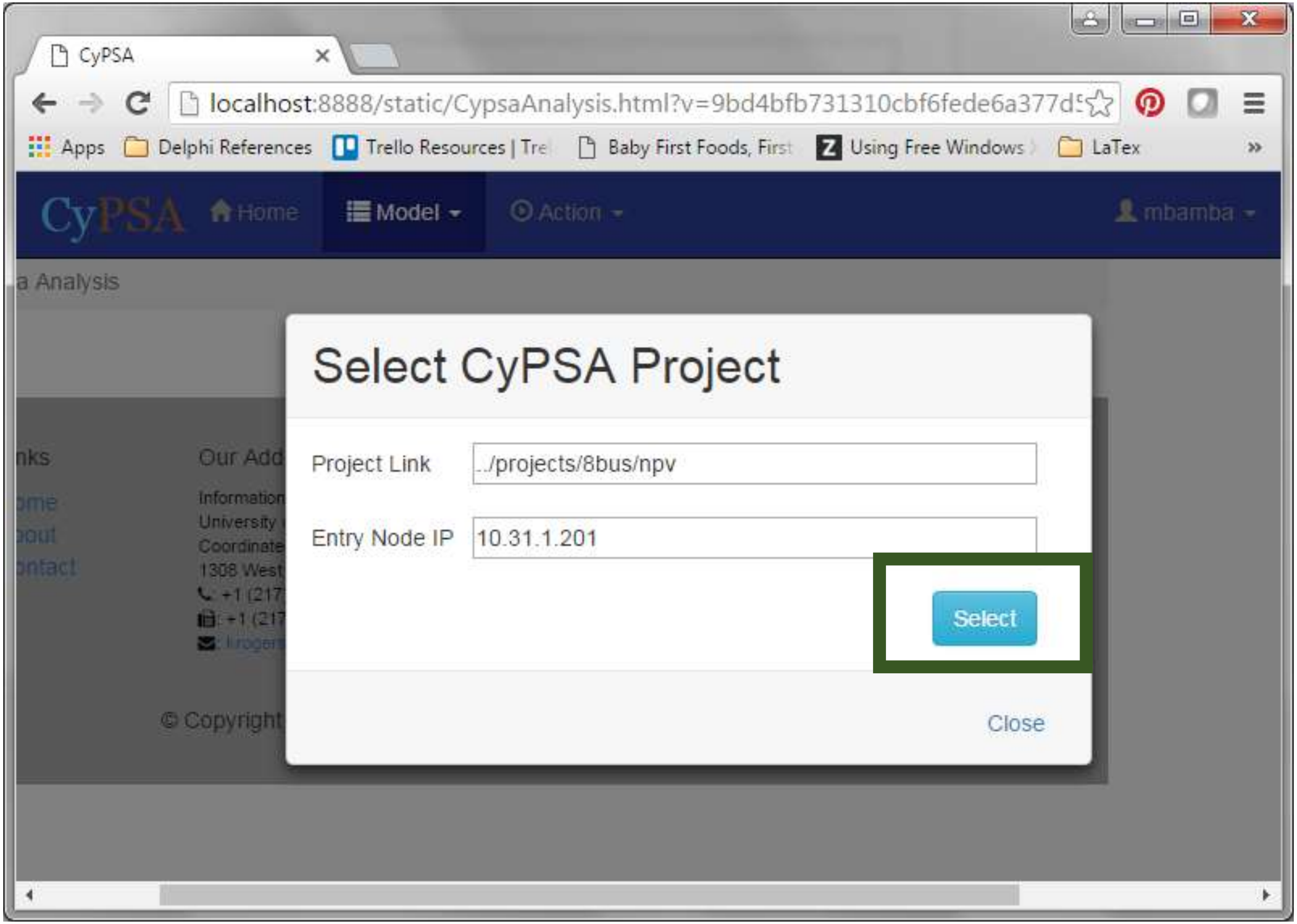
```
C:\armadillo\Demo\8bus\www>start_tornado.py
Starting server on port 8888
_
```

- Launch control panel in browser



CyPSA

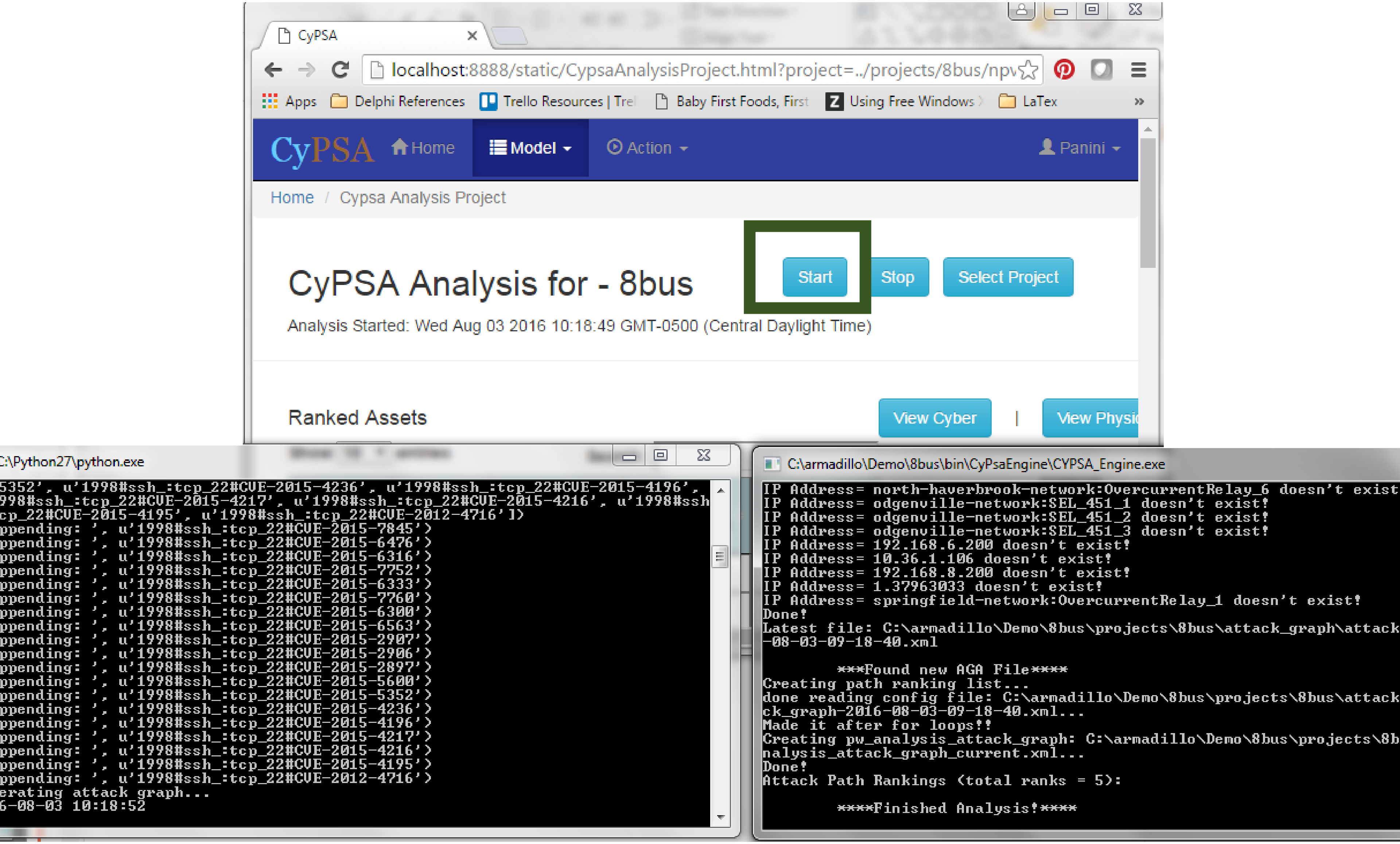
Cyber-Physical Security Assessment toolset designed to improve reliability of grid operations.



Select CyPSA Project

Project Link: ../projects/8bus/npv

Entry Node IP: 10.31.1.201



CyPSA Analysis for - 8bus

Analysis Started: Wed Aug 03 2016 10:18:49 GMT-0500 (Central Daylight Time)

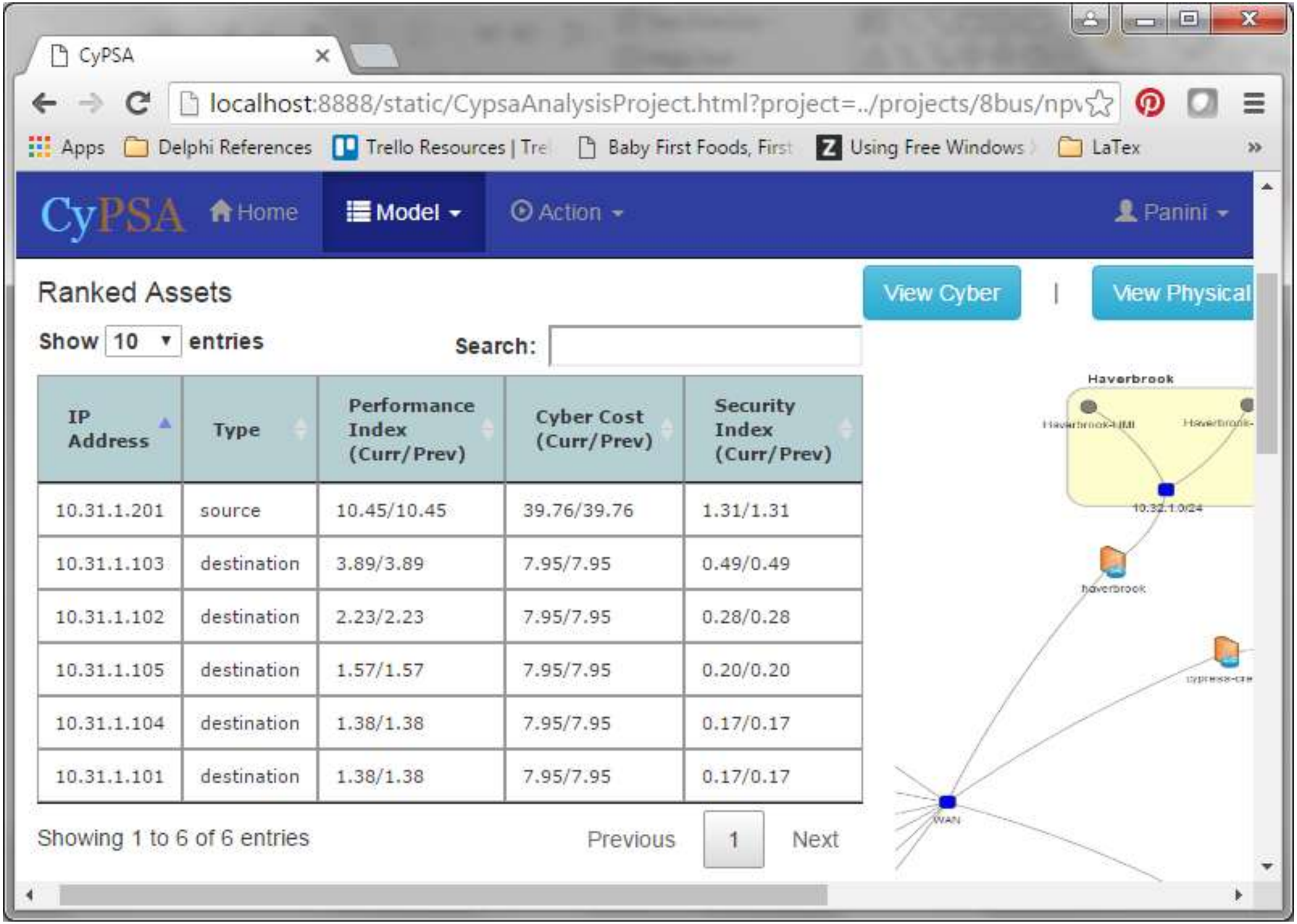
Ranked Assets

```
5352', u'1998#ssh_:tcp_22#CVE-2015-4236', u'1998#ssh_:tcp_22#CVE-2015-4196',
998#ssh_:tcp_22#CVE-2015-4217', u'1998#ssh_:tcp_22#CVE-2015-4216', u'1998#ssh
cp_22#CVE-2015-4195', u'1998#ssh_:tcp_22#CVE-2012-4716'])
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-7845')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-6476')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-6316')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-7752')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-6333')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-7760')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-6300')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-6563')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-2907')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-2906')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-2897')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-5600')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-5352')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-4236')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-4196')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-4217')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-4216')
ppending: ', u'1998#ssh_:tcp_22#CVE-2015-4195')
ppending: ', u'1998#ssh_:tcp_22#CVE-2012-4716')
erating attack graph...
6-08-03 10:18:52
```

```
IP Address= north-haverbrook-network:OvercurrentRelay_6 doesn't exist
IP Address= odgenville-network:SEL_451_1 doesn't exist!
IP Address= odgenville-network:SEL_451_2 doesn't exist!
IP Address= odgenville-network:SEL_451_3 doesn't exist!
IP Address= 192.168.6.200 doesn't exist!
IP Address= 10.36.1.106 doesn't exist!
IP Address= 192.168.8.200 doesn't exist!
IP Address= 1.37963033 doesn't exist!
IP Address= springfield-network:OvercurrentRelay_1 doesn't exist!
Done!
Latest file: C:\armadillo\Demo\8bus\projects\8bus\attack_graph\attack
-08-03-09-18-40.xml

        ***Found new AGA File****
Creating path ranking list...
done reading config file: C:\armadillo\Demo\8bus\projects\8bus\attack
ck_graph-2016-08-03-09-18-40.xml...
Made it after for loops!!
Creating pw_analysis_attack_graph: C:\armadillo\Demo\8bus\projects\8b
nalysis_attack_graph_current.xml...
Done!
Attack Path Rankings (total ranks = 5):

        ****Finished Analysis!****
```



Ranked Assets

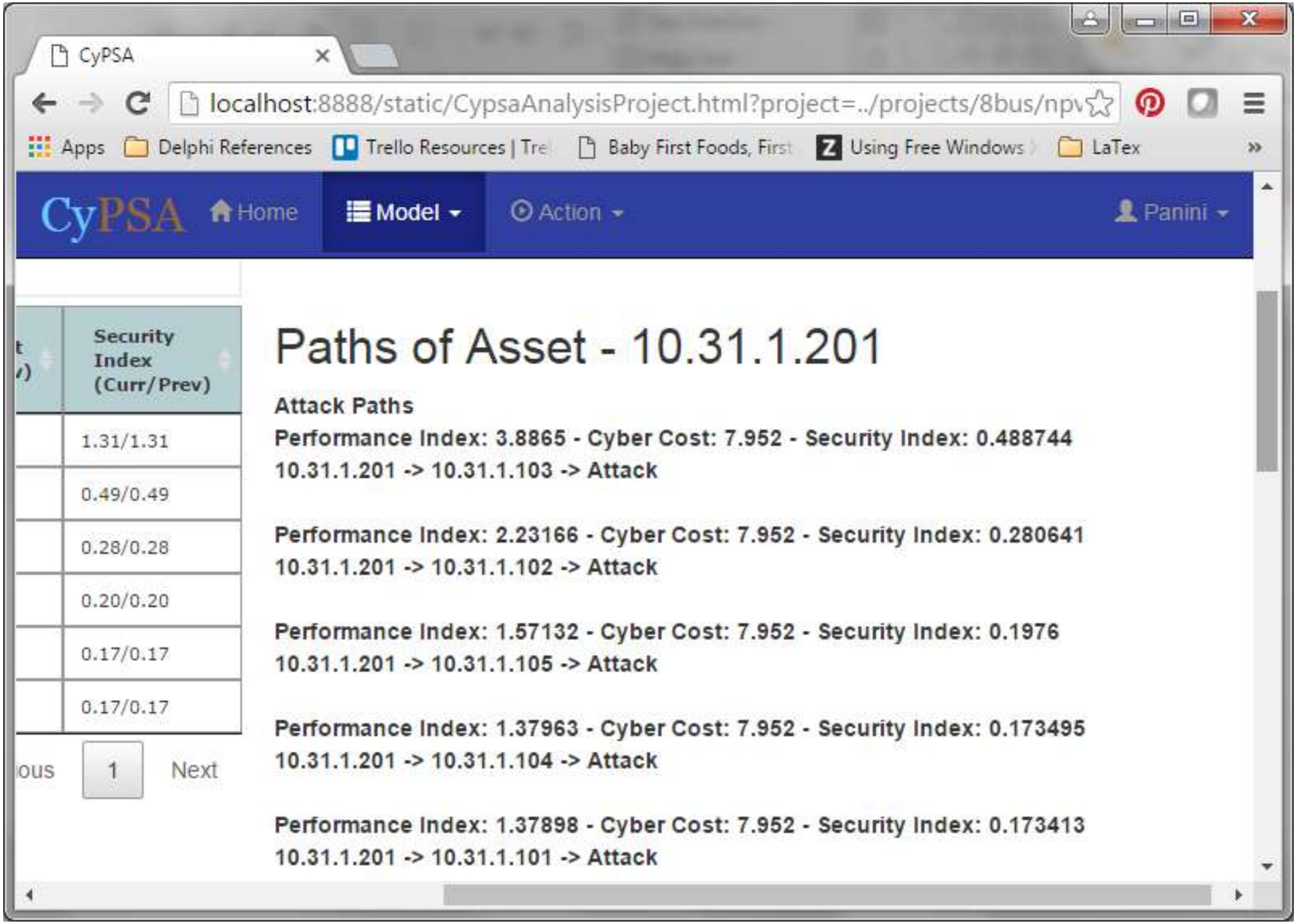
Show 10 ▾ entries

Search:

IP Address	Type	Performance Index (Curr/Prev)	Cyber Cost (Curr/Prev)	Security Index (Curr/Prev)
10.31.1.201	source	10.45/10.45	39.76/39.76	1.31/1.31
10.31.1.103	destination	3.89/3.89	7.95/7.95	0.49/0.49
10.31.1.102	destination	2.23/2.23	7.95/7.95	0.28/0.28
10.31.1.105	destination	1.57/1.57	7.95/7.95	0.20/0.20
10.31.1.104	destination	1.38/1.38	7.95/7.95	0.17/0.17
10.31.1.101	destination	1.38/1.38	7.95/7.95	0.17/0.17

Showing 1 to 6 of 6 entries

Previous 1 Next



Security Index (Curr/Prev)
1.31/1.31
0.49/0.49
0.28/0.28
0.20/0.20
0.17/0.17
0.17/0.17

Paths of Asset - 10.31.1.201

Attack Paths

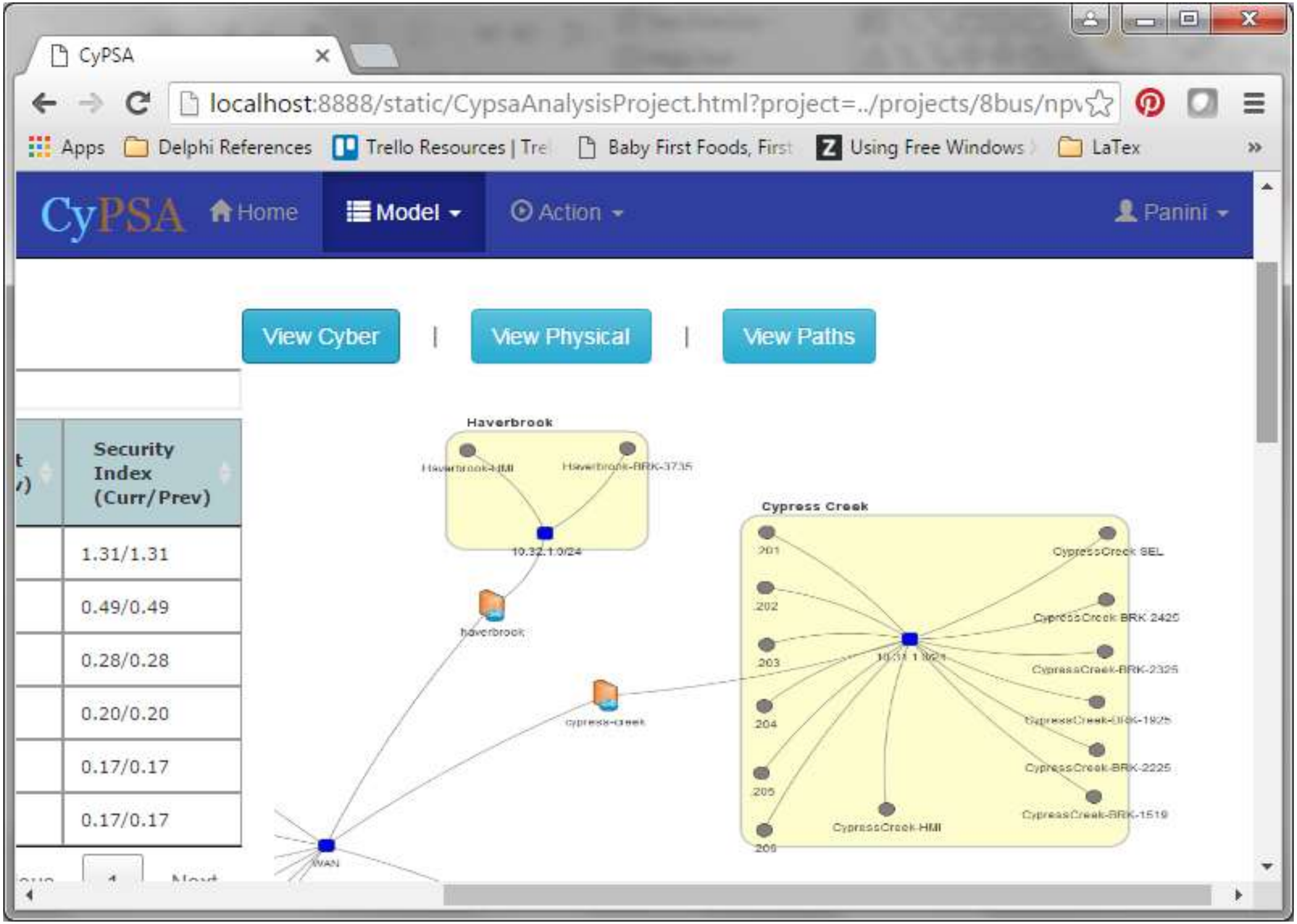
Performance Index: 3.8865 - Cyber Cost: 7.952 - Security Index: 0.488744
10.31.1.201 -> 10.31.1.103 -> Attack

Performance Index: 2.23166 - Cyber Cost: 7.952 - Security Index: 0.280641
10.31.1.201 -> 10.31.1.102 -> Attack

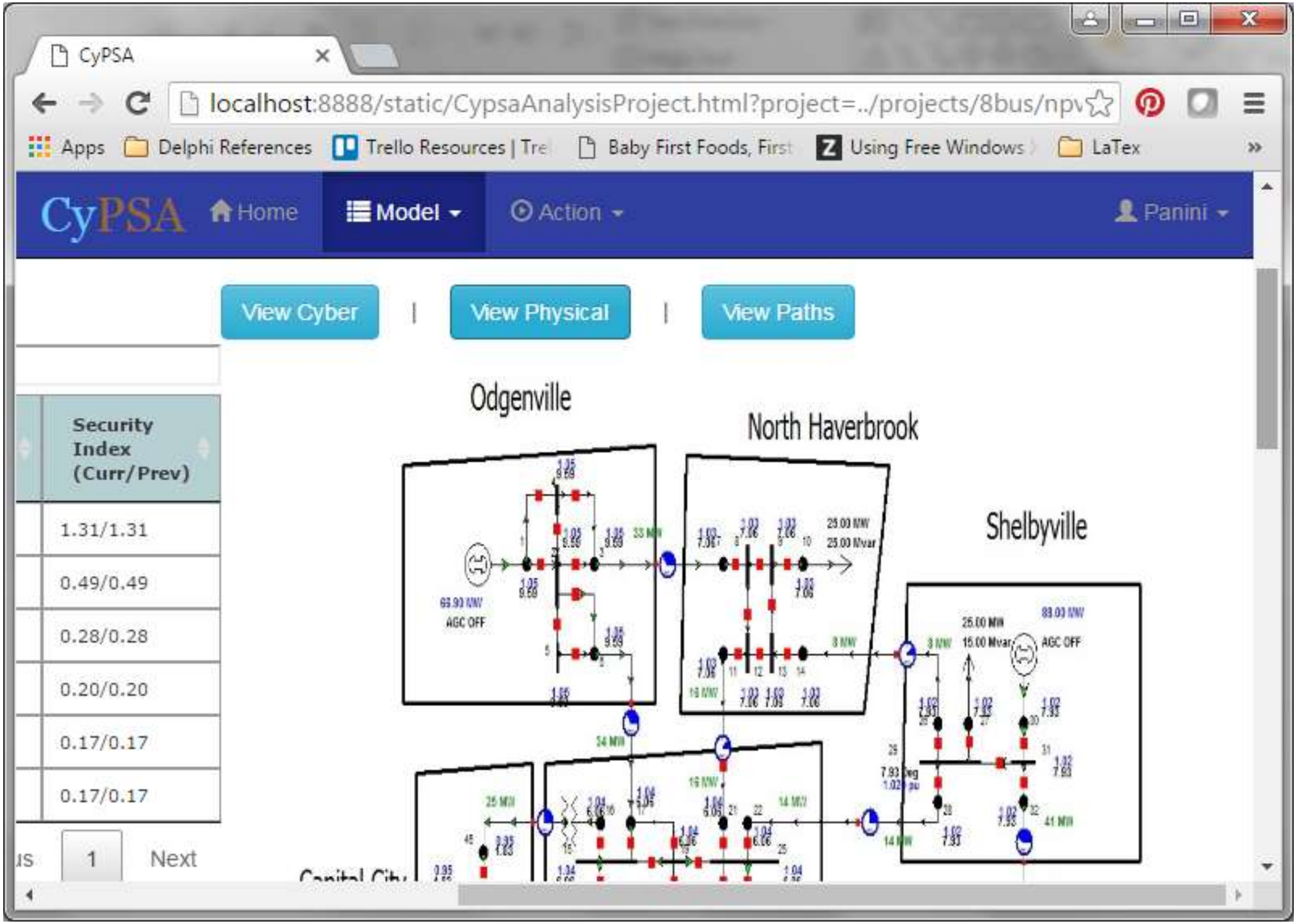
Performance Index: 1.57132 - Cyber Cost: 7.952 - Security Index: 0.1976
10.31.1.201 -> 10.31.1.105 -> Attack

Performance Index: 1.37963 - Cyber Cost: 7.952 - Security Index: 0.173495
10.31.1.201 -> 10.31.1.104 -> Attack

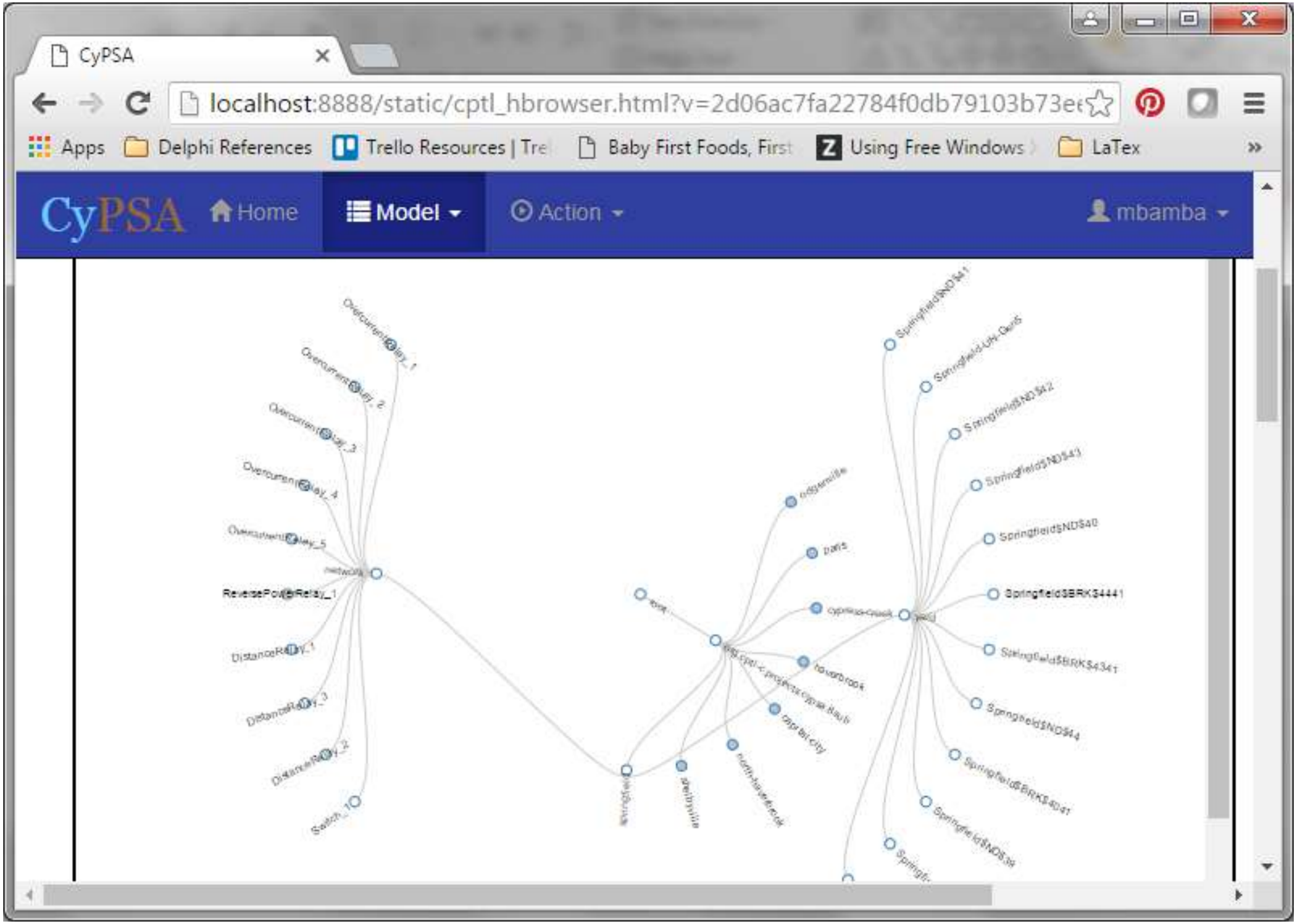
Performance Index: 1.37898 - Cyber Cost: 7.952 - Security Index: 0.173413
10.31.1.201 -> 10.31.1.101 -> Attack



t /)	Security Index (Curr/Prev)
	1.31/1.31
	0.49/0.49
	0.28/0.28
	0.20/0.20
	0.17/0.17
	0.17/0.17



Security Index (Curr/Prev)
1.31/1.31
0.49/0.49
0.28/0.28
0.20/0.20
0.17/0.17
0.17/0.17


CyPSA
localhost:8888/static/cptl_hbrowser.html?v=2d06ac7fa22784f0db79103b73e
Apps
Delphi References
Trello Resources | Tre
Baby First Foods, First
Using Free Windows
LaTex
CyPSA
Home
Model
Action
mbamba
OvercurrentRelay_1
OvercurrentRelay_2
OvercurrentRelay_3
OvercurrentRelay_4
OvercurrentRelay_5
network
ReversePowerRelay_1
DistanceRelay_1
DistanceRelay_3
DistanceRelay_2
Switch_1
root
ogdenville
paris
cypress-creek
grid
haverbrook
capital city
north-haverbrook
shelbyville
Springfield
Springfield$ND$41
Springfield-UN-Gen5
Springfield$ND$42
Springfield$ND$43
Springfield$ND$40
Springfield$BRK$4441
Springfield$BRK$4341
Springfield$ND$44
Springfield$BRK$4041
Springfield$ND$39
Springfi

More than just power

- The CyPSA engine can be used on things other than the power grid
- The open source release have JSON templates for entering your own impact data
- This allows for the engine to be run stand alone to make a list of top Cyber/Physical contingencies

How do I do that shit?

In order to run offline mode manually, do the following steps:

1. Make sure the CPGenOutput.csv file is located in the project folder. You should also configure the location in the config.dat file under the tag "CP_GEN_OUTPUT_FILE".

2. When using runCypsa.bat, just add a 3rd command line option "offline".
For example, to run the 8bus model, just call "runCypsa.bat 8bus 10.31.1.201 offline"

STOP
$2
-A-HOOP

CYPSA

Cyber/Physical Situational Awareness

Thank You!

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