Using Automated Planning in data centers fault tolerance systems

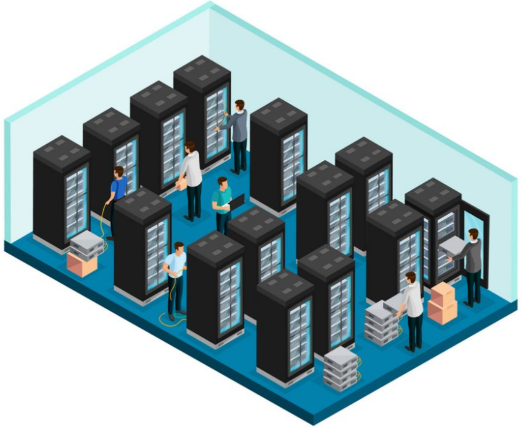
Douglas Trajano
Master’s Degree in Computer Science
Pontifical Catholic University of Rio Grande do Sul - PUCRS

Problem Statement

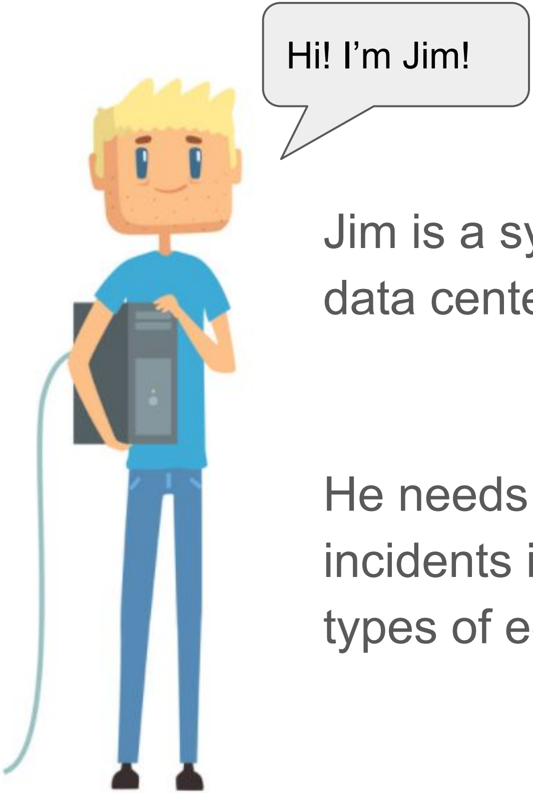
Data centers are complex systems, its components are fully integrated and an impact in one of these components can affect other components.

Engineers need to solve critical incidents in timely fashion.

Knowledge bases are built to help these engineers to follow a plan for fixing known issues.



Let’s know Jim!



Jim is a system administrator in a data center.

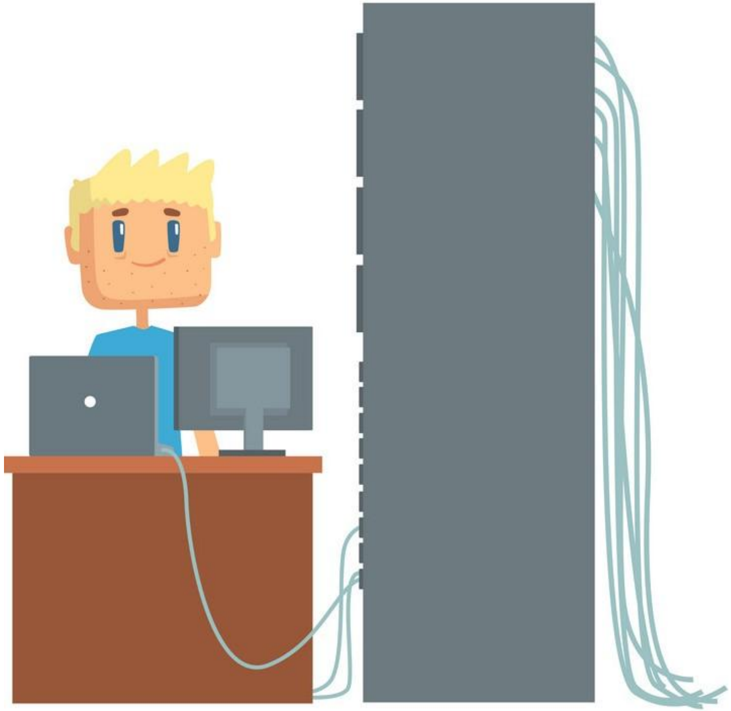
He needs our help to solve critical incidents in a variety of different types of equipment.

Proposed solution

With **PDDL**, we can formalize domains and problems simulating known issues in our infrastructure.

The **automated planner** provides a set of ordered actions that we need to do to solve the incidents or apply a workaround solutions.

It can act directly in the infrastructure or can be used as a guide to help Jim.

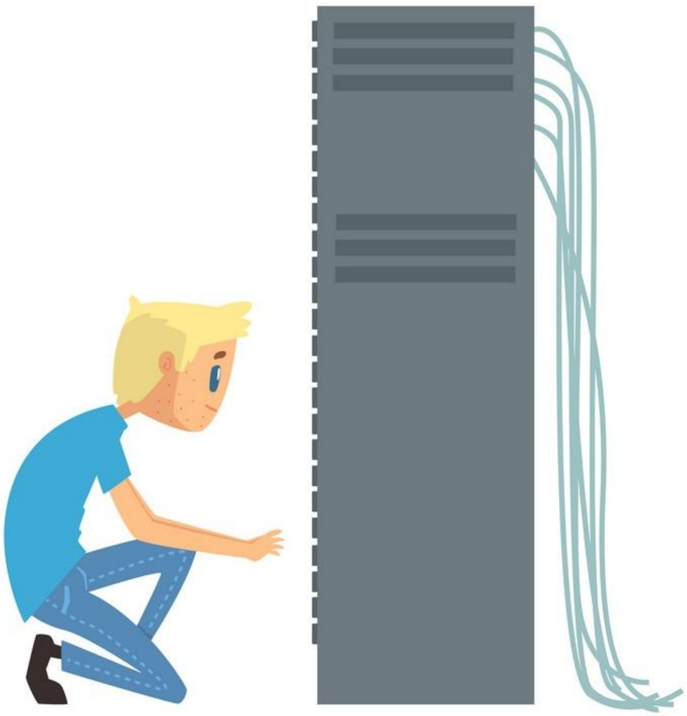


Experiments

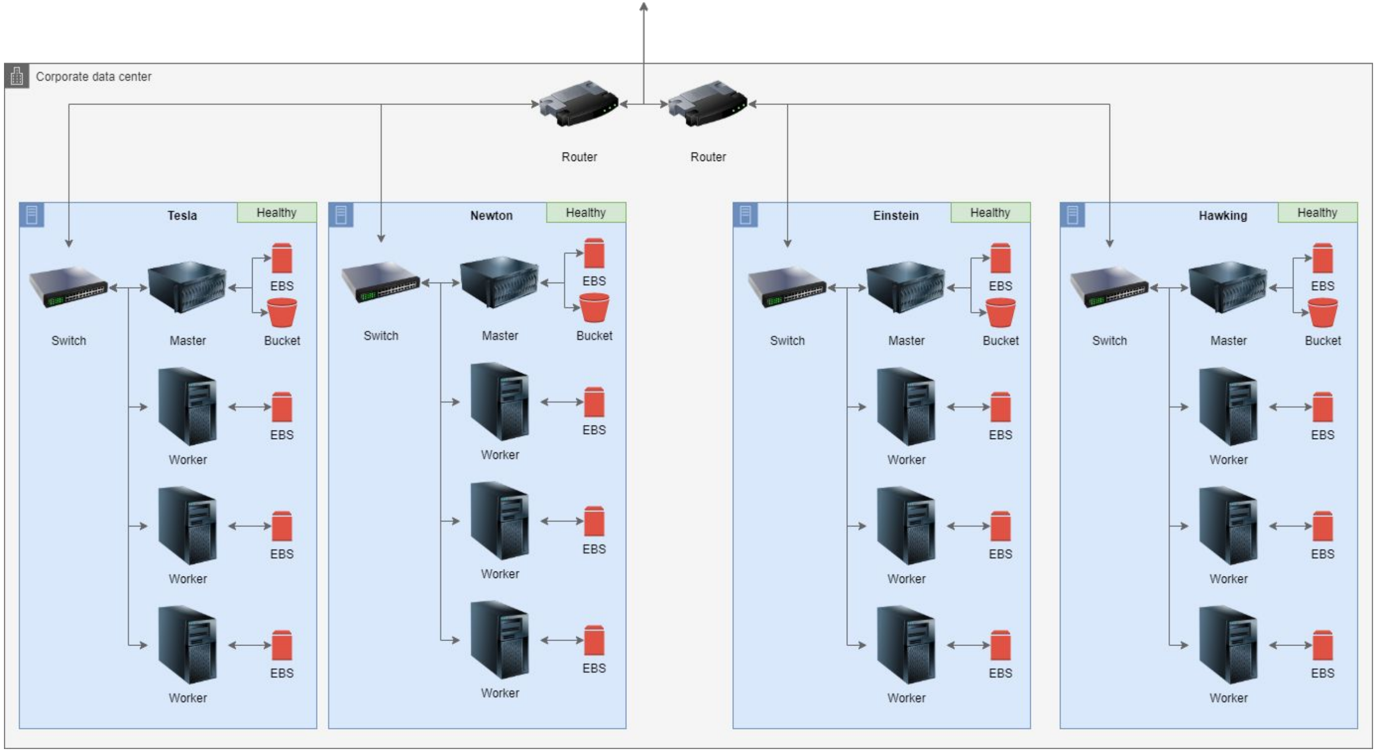
1 domain and 3 problems (scenarios) are defined in this work.

The **initial states** represent a known issue in our infrastructure.

The **goal** for all the problems is the same. All clusters and components with a healthy state.



Experiments - Domain



Router

Establish a connection between clusters (switches) and the external world.

Predicates

- router-healthy
- router-pair

Actions

- router-turn-on
- router-turn-off
- router-mesh-on
- router-mesh-off

Switch

Connect all components in a cluster.

Predicates

- switch-healthy
- switch-attach-router
- switch-attach-master
- switch-attach-worker

Actions

- switch-turn-on
- switch-turn-off

Master computer

A controller inside the cluster, it provides server tools to worker computers.

Predicates

- master-healthy

Actions

- master-turn-on
- master-turn-off

Worker computer

Provide computational power, applications is deployed in worker computers.

Predicates

- worker-healthy
- worker-high-mem
- worker-high-cpu
- worker-high-network

Actions

- worker-turn-on
- worker-turn-off

EBS

It works as a HDD (hard disk drive) for computers.

Predicates

- ebs-healthy
- ebs-locked
- ebs-attached

Actions

- ebs-turn-on
- ebs-turn-off

Bucket

Object storage. It is used to provide a shareable storage between applications.

Predicates

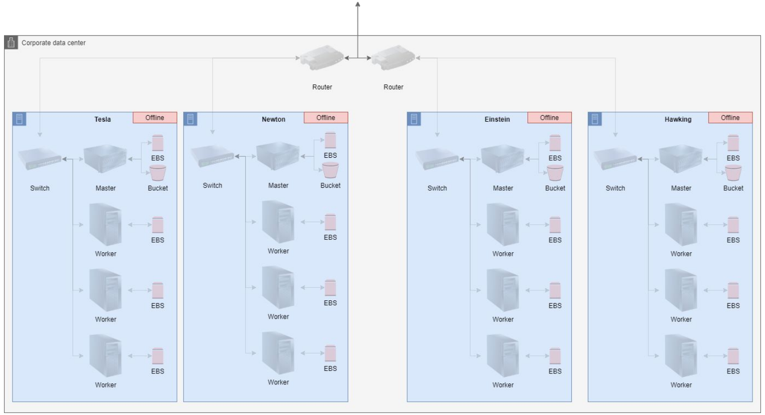
- bucket-healthy
- bucket-locked
- bucket-attached

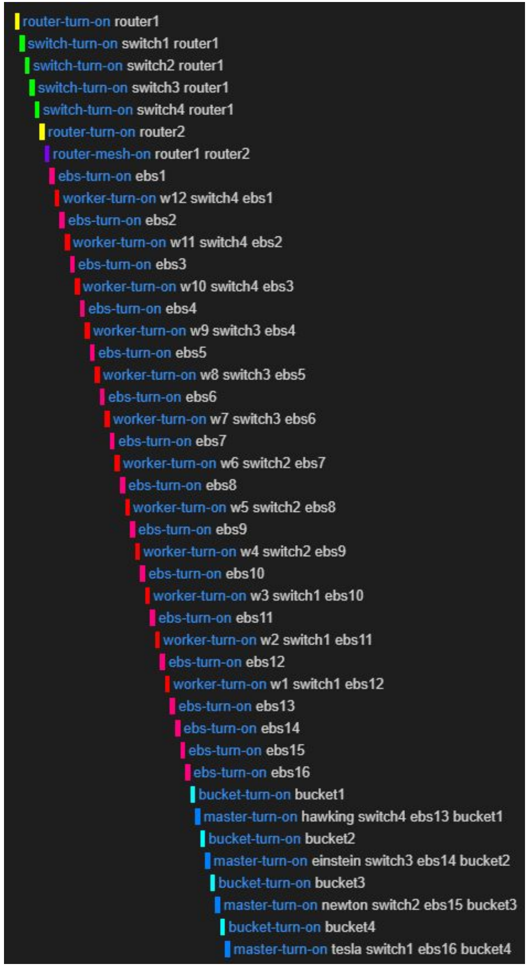
Actions

- bucket-turn-on
- bucket-turn-off

Experiments - Problem 1

Problem 1 explore the initial state of our data center, with all components offline.

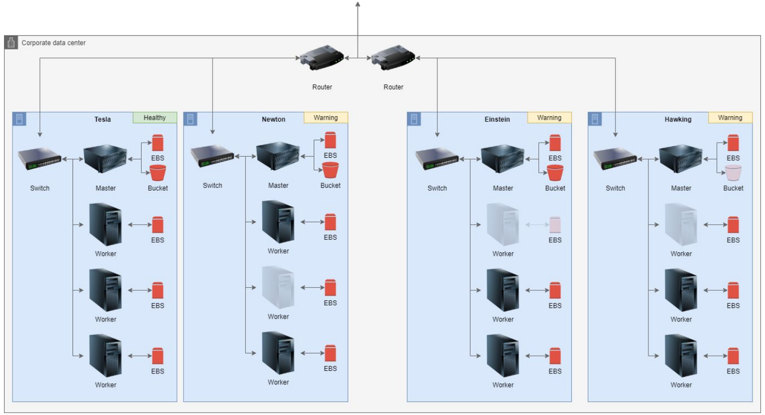


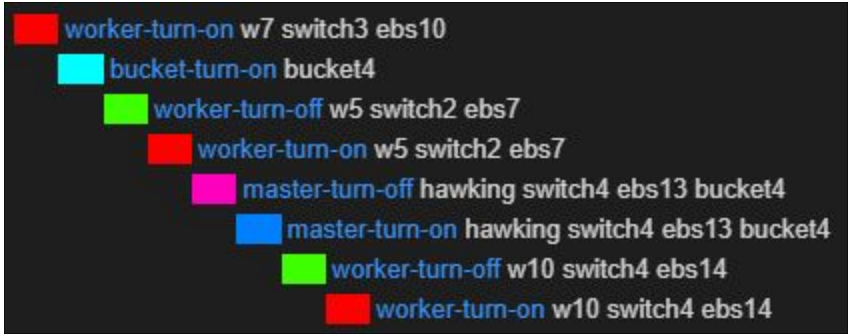


```
router-turn-on router1
 switch-turn-on switch1 router1
  switch-turn-on switch2 router1
   switch-turn-on switch3 router1
    switch-turn-on switch4 router1
     router-turn-on router2
      router-mesh-on router1 router2
       ebs-turn-on ebs1
        worker-turn-on w12 switch4 ebs1
         ebs-turn-on ebs2
          worker-turn-on w11 switch4 ebs2
           ebs-turn-on ebs3
            worker-turn-on w10 switch4 ebs3
             ebs-turn-on ebs4
              worker-turn-on w9 switch3 ebs4
               ebs-turn-on ebs5
                worker-turn-on w8 switch3 ebs5
                 ebs-turn-on ebs6
                  worker-turn-on w7 switch3 ebs6
                   ebs-turn-on ebs7
                    worker-turn-on w6 switch2 ebs7
                     ebs-turn-on ebs8
                      worker-turn-on w5 switch2 ebs8
                       ebs-turn-on ebs9
                        worker-turn-on w4 switch2 ebs9
                         ebs-turn-on ebs10
                          worker-turn-on w3 switch1 ebs10
                           ebs-turn-on ebs11
                            worker-turn-on w2 switch1 ebs11
                             ebs-turn-on ebs12
                              worker-turn-on w1 switch1 ebs12
                               ebs-turn-on ebs13
                                ebs-turn-on ebs14
                                 ebs-turn-on ebs15
                                  ebs-turn-on ebs16
                                   bucket-turn-on bucket1
                                    master-turn-on hawking switch4 ebs13 bucket1
                                     bucket-turn-on bucket2
                                      master-turn-on einstein switch3 ebs14 bucket2
                                       bucket-turn-on bucket3
                                        master-turn-on newton switch2 ebs15 bucket3
                                         bucket-turn-on bucket4
                                          master-turn-on tesla switch1 ebs16 bucket4
```

Experiments - Problem 2

Here we have some components in three different clusters with errors.

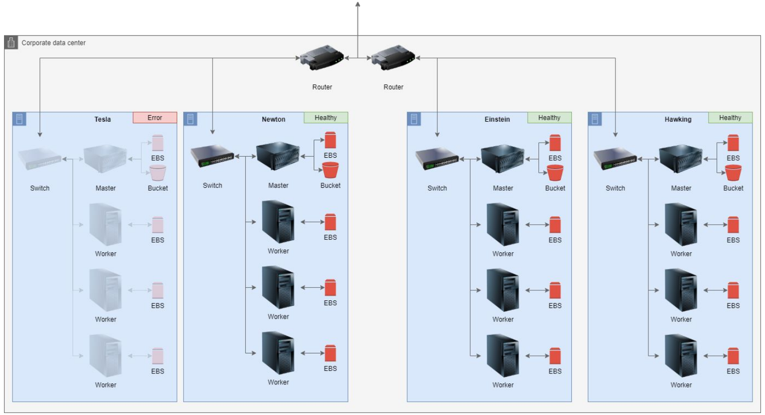


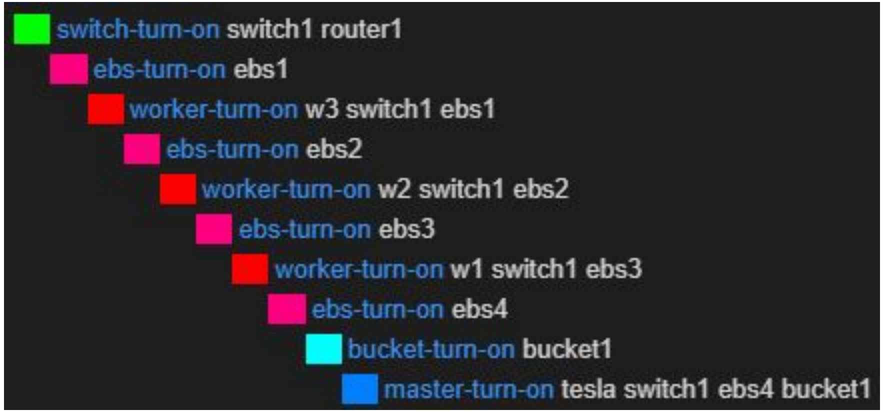


```
worker-turn-on w7 switch3 ebs10
    bucket-turn-on bucket4
        worker-turn-off w5 switch2 ebs7
            worker-turn-on w5 switch2 ebs7
                master-turn-off hawking switch4 ebs13 bucket4
                    master-turn-on hawking switch4 ebs13 bucket4
                        worker-turn-off w10 switch4 ebs14
                            worker-turn-on w10 switch4 ebs14
```

Experiments - Problem 3

An entire cluster here is offline, and a plan to turn on needs to be provided.





```
switch-turn-on switch1 router1
  ebs-turn-on ebs1
    worker-turn-on w3 switch1 ebs1
      ebs-turn-on ebs2
        worker-turn-on w2 switch1 ebs2
          ebs-turn-on ebs3
            worker-turn-on w1 switch1 ebs3
              ebs-turn-on ebs4
                bucket-turn-on bucket1
                  master-turn-on tesla switch1 ebs4 bucket1
```

Conclusions

The idea of using PDDL to formalize domains of data centers is very interesting, but there are still many questions to be answered.

- Is it reasonable to require PDDL knowledge for engineers? Can engineers develop and maintain the domain and problem definitions?
- How the information represented by predicates will be collected for the planner?
- Can we allow the planner to act directly on the infrastructure? Should some actions be restricted to engineers?

Future work

As the future work, is interesting to explore more complex architectures, with more components, involving applications and more possible situations (problems).

Define more appropriate actions for the components will provide better plans avoiding a sequence of the turn off and turn on that ca be stressful for the system.