Performability and Survivability Evaluation of Designing Disaster Tolerant Cloud Computing Systems

Agenda

Motivation

Approach

Architecture

Perfomability

Sensitivity Analysis

Survivability Evaluation

GeoClouds Tool

Why adopt cloud computing?

MOTIVATION

Why adopt cloud computing?

Cloud computing

- infrastructure is available on demand.
- Adopted as a service.
- Minimizes the costs of IT infrastructures
- Service Level Agreement (SLA).
  - Penalties may be applied if the defined availability level is not satisfied

Motivation

Large cloud service providers adopts service level agreements (SLAs) to regulate the availability of the cloud service.

- Costs
- Availability
- Performance (response time)

Service provider needs to carry out availability analysis

Motivation

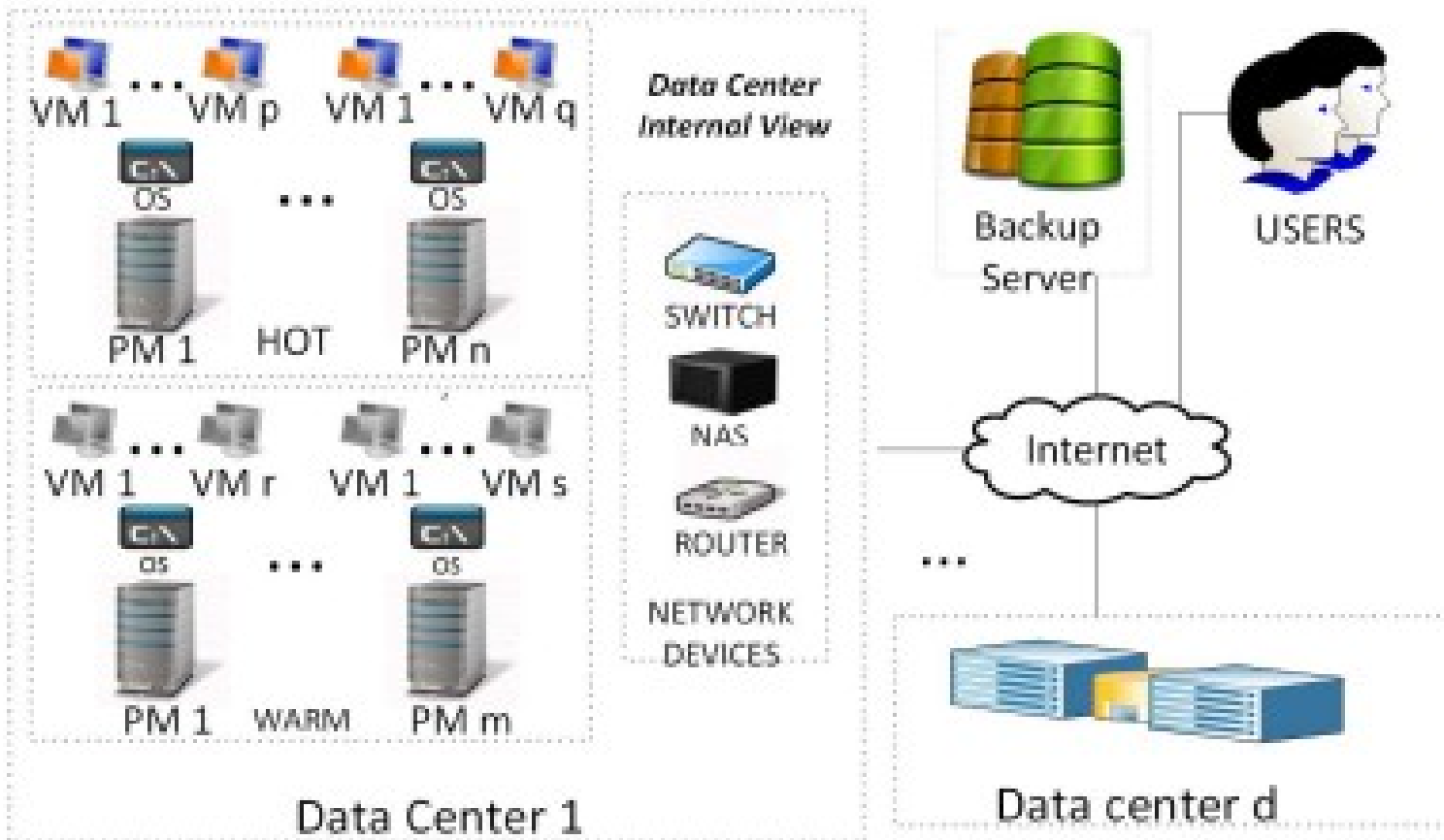
IaaS – computing resources in the form of virtual machines (VMs).

Disasters

- Multiple data located in different geographical locations
- Availability improvement
- VM migration time increases due to distance between data centers

ARCHITECTURE

Architecture



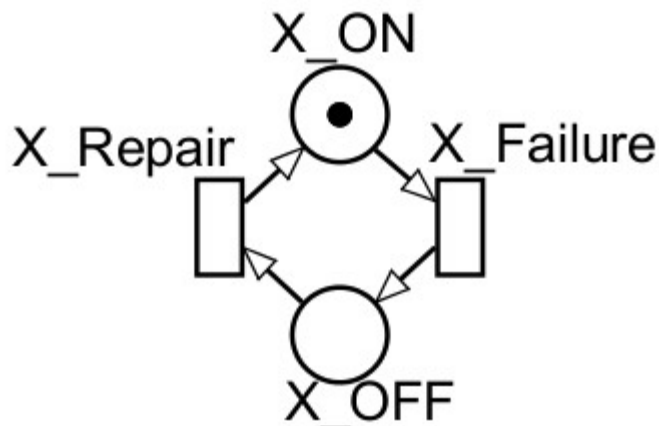
HIGH LEVEL MODEL

IaaS system corresponds to the tuple $G = (F_{lt}, T_{di}, T_{re}, MTT)$

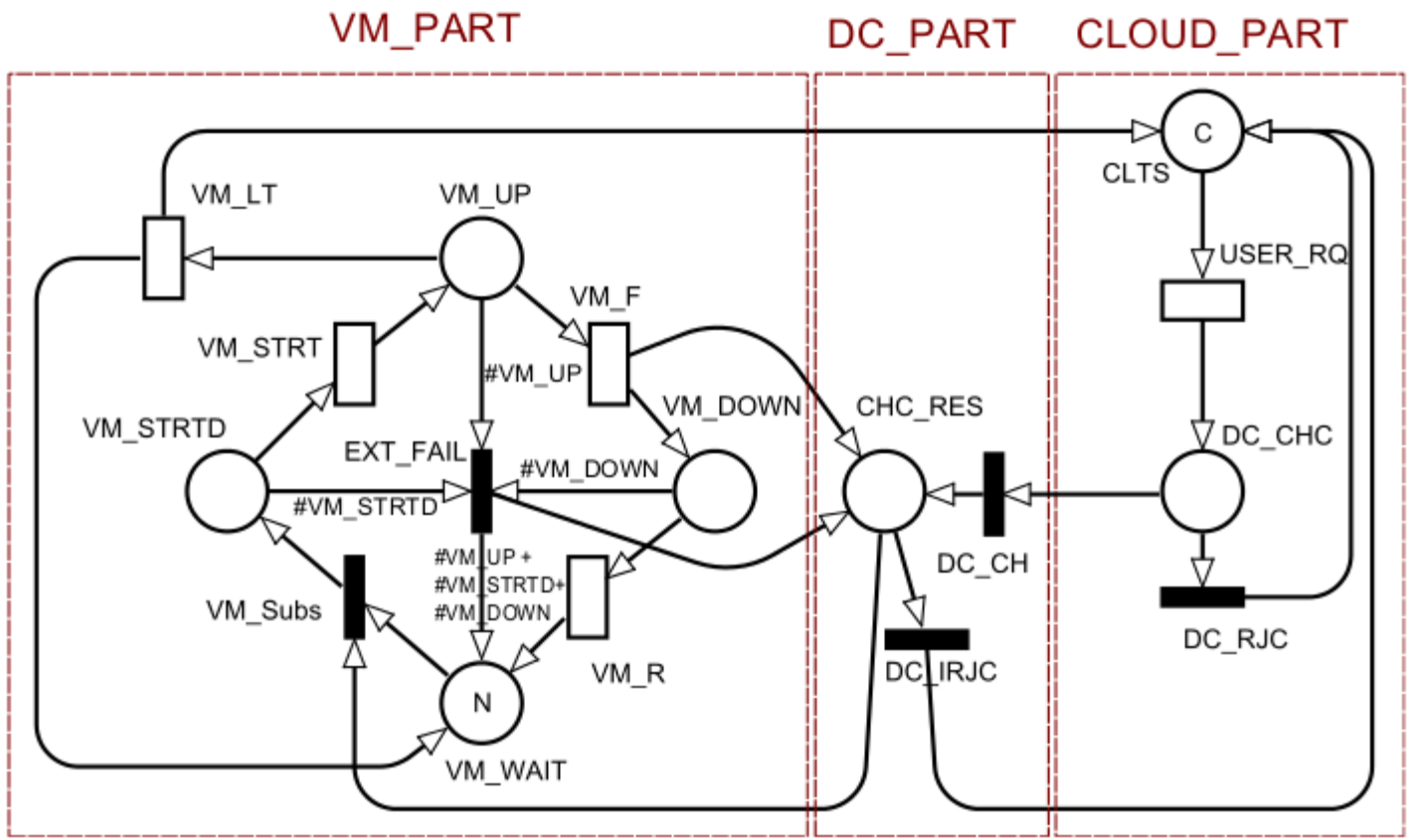
- F_{lt} is a finite set of facilities, including data centers and backup servers, such that $F_{lt} = D \cup BS$. D is a finite set of data centers and BS represents the set of backup servers;
- $T_{di} : F_{lt} \rightarrow f_{di}$ denotes the disaster occurrence function. For each facility $d_c \in F_{lt}$, a probability distribution function (PDF) f_{di} is associated. The function f_{di} provides the probability of a disaster for each instant t;
- $T_{re} : F_{lt} \rightarrow f_{re}$ represents the disaster recovery function. Similarly to the previous function, it associates a PDF (f_{re}) with each facility $d_c \in F_{lt}$. For each time t a probability of disaster recovery is provided;
- $MTT : F_{lt} \times F_{lt} \rightarrow f_{MTT}$ denotes the VM transmission function. The function relates a pair of facilities $(d_{c1}, d_{c2}) \in F_{lt} \times F_{lt}$ to a PDF f_{MTT}. The resulted function f_{MTT} provides the probability of finishing the data transmission between d_{c1} and d_{c2} at time t;

BUILDING BLOCKS

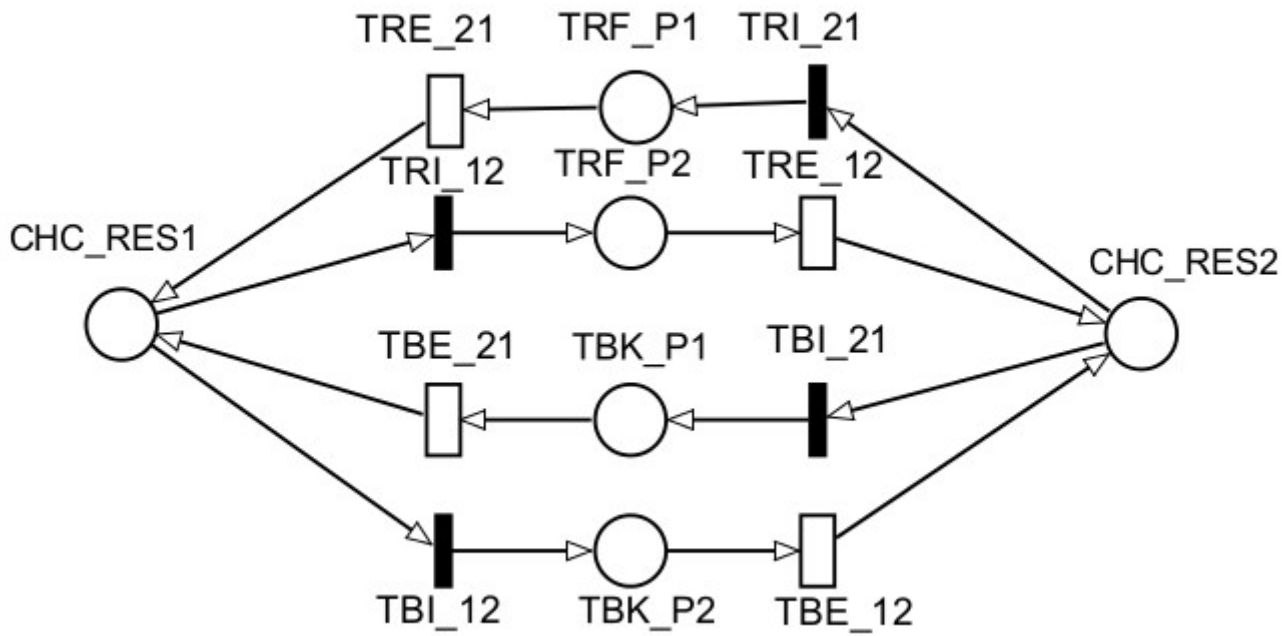
SIMPLE COMPONENT



VM_BEHAVIOR


VM_PART
DC_PART
CLOUD_PART
C
CLTS
USER_RQ
VM_LT
VM_UP
VM_F
VM_STRT
#VM_UP
VM_DOWN
CHC_RES
VM_STRTD
EXT_FAIL
#VM_DOWN
DC_CHC
#VM_STRTD
#VM_UP +
#VM_STRTD+
#VM_DOWN
DC_CH
VM_Subs
VM_R
DC_RJC
DC_IRJC
N
VM_WAIT

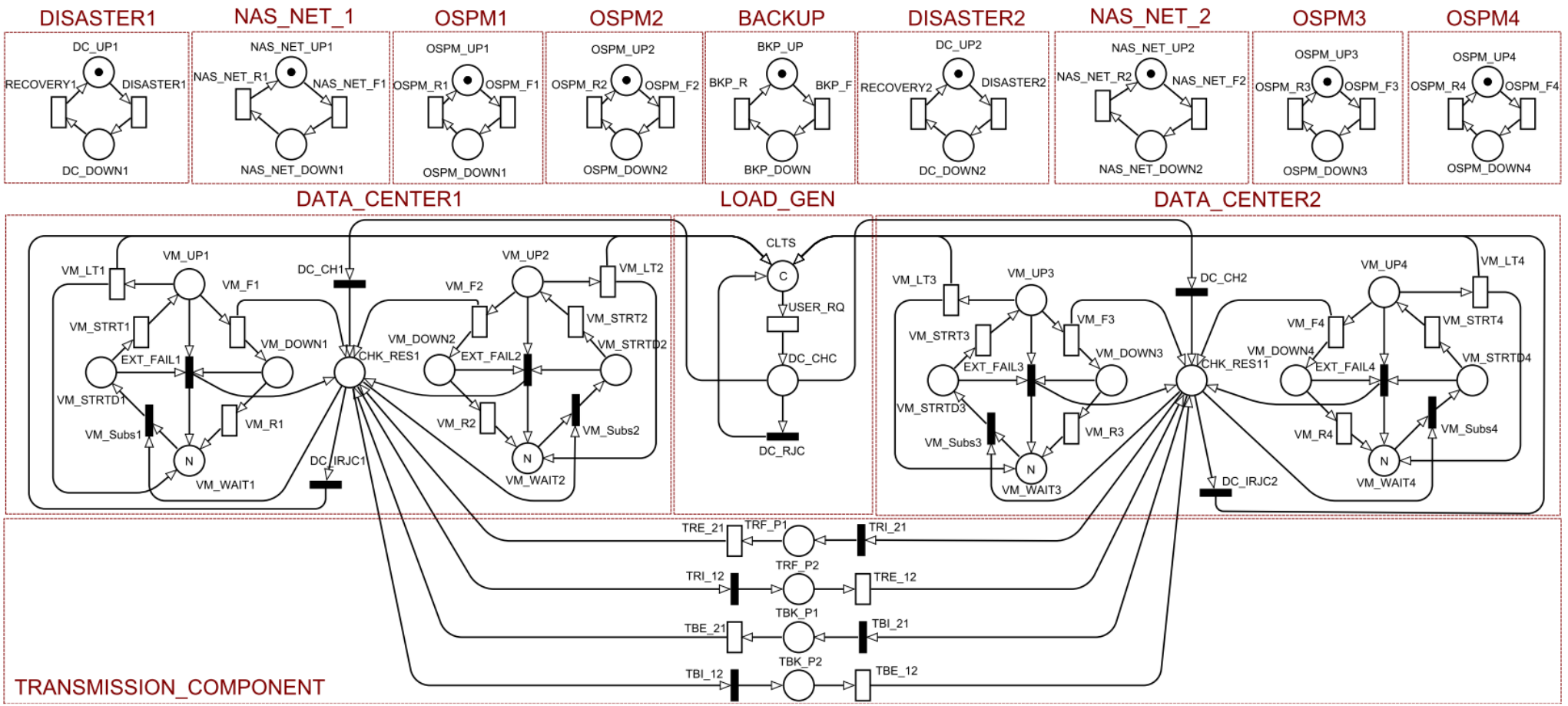
VM_TRANSMISSION



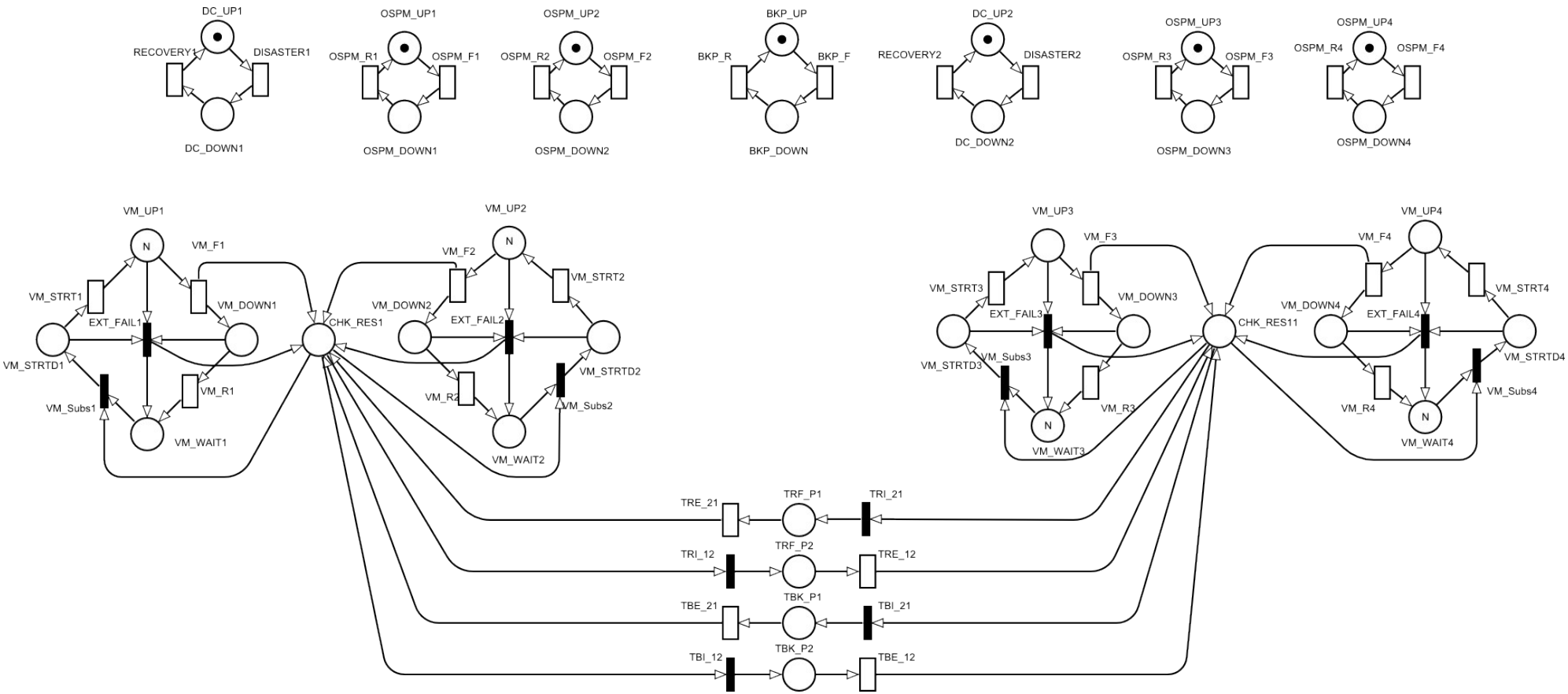
FINAL MODEL GENERATION

```
01 SPN parseModel(G =< F_lt, T_di, T_re, MTT >)
02 {
03   SPN result = EMPTY_SPN;
04   bs = getBackupServer(F_lt);
05   result.increment(parseSimpleComponent(T_di(bs), T_re(bs)));
06   for each(d = < P_d, C_d > ∈ D){
07     result.increment(parseSimpleComponent(T_di(d), T_re(d)));
08     for each(pm = < V_p, S_p, os, hw, m > ∈ P_d){
09       result.increment(parseSimpleComponent(T_fr(os), T_rp(os)));
10       result.increment(parseSimpleComponent(T_fr(hw), T_rp(hw)));
11       result.increment(parseVmBehaviorComponent(V_p, S_p, m));
12     }
13     networkDependabilityParams := RBDEvaluation(C_d);
14     result.increment(parseSimpleComponent(networkDependabilityParams));
15   }
16   for each ((f1, f2) | f1, f2 ∈ F_lt and f1 ≠ f2){
17     result.increment(parseDataCenterTransmission(f1, f2, MTT));
18   }
19  return result;
```

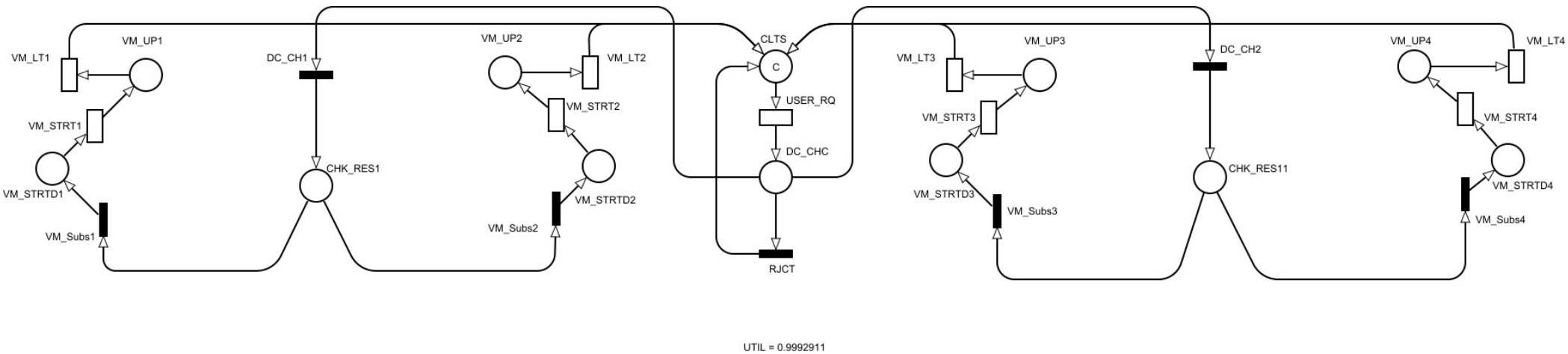
PERFORMABILITY MODEL



DEPENDABILITY MODEL



DEPENDABILITY MODEL



UTIL = 0.9992911

METRICS

* DEPENDABILITY MODELS

  AVAILABILITY = P{(#VMS_UP)>=REQ_VMS}

* PERFORMANCE

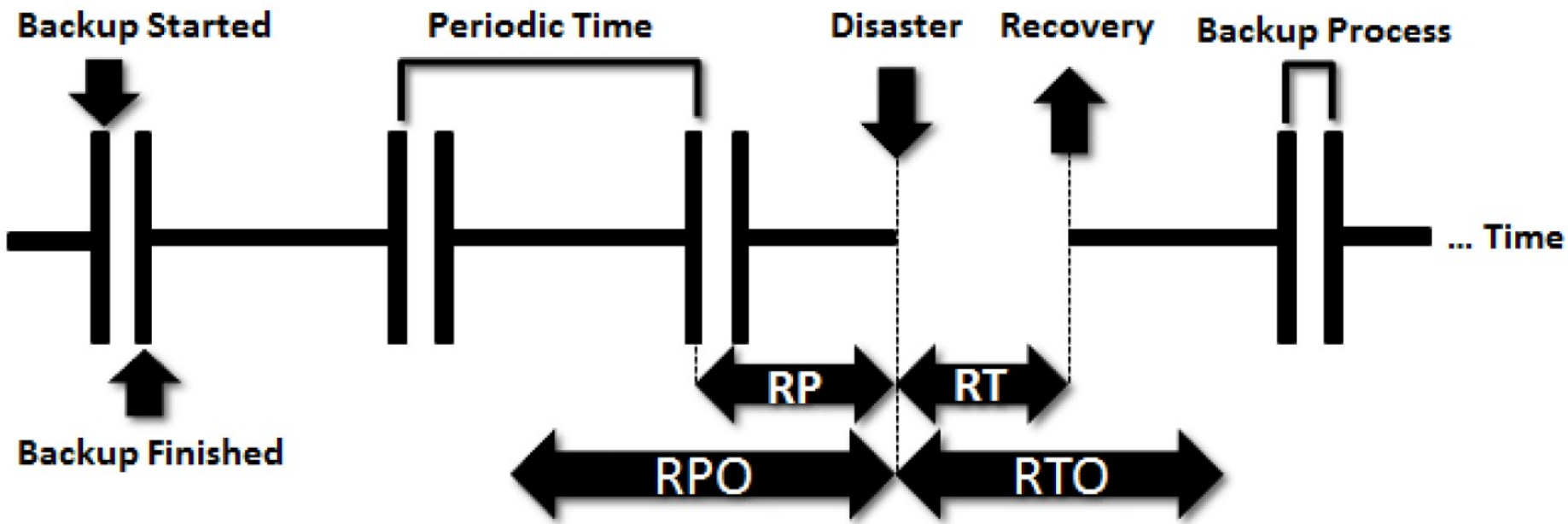
  UTILIZATION = E{#VMS_UP} / MAX_VMS

* PERFORMABILITY

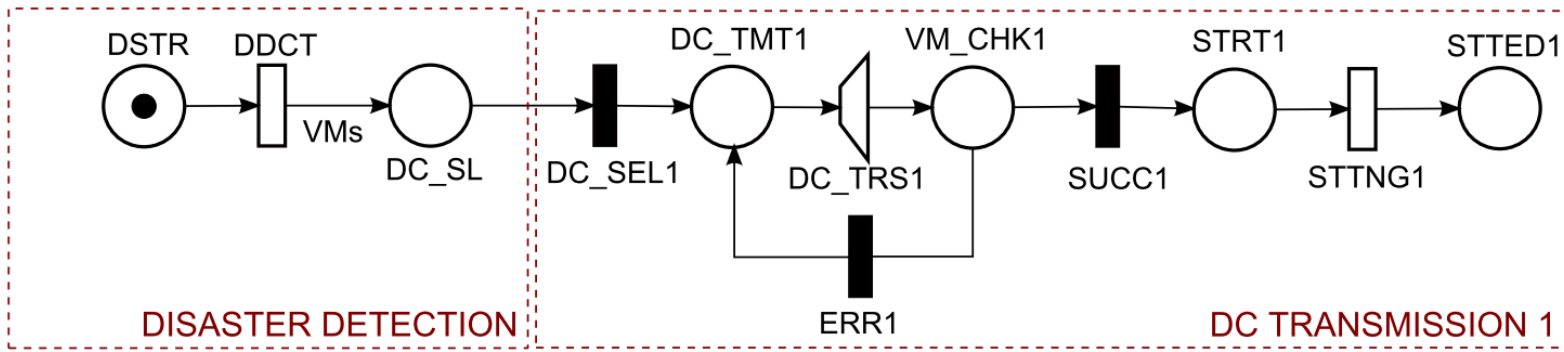
  UTILIZATION = E{#VMS_UP} / MAX_VMS

  UDOA= E{#VMS_UP} / E{#REQUESTED_VMS}

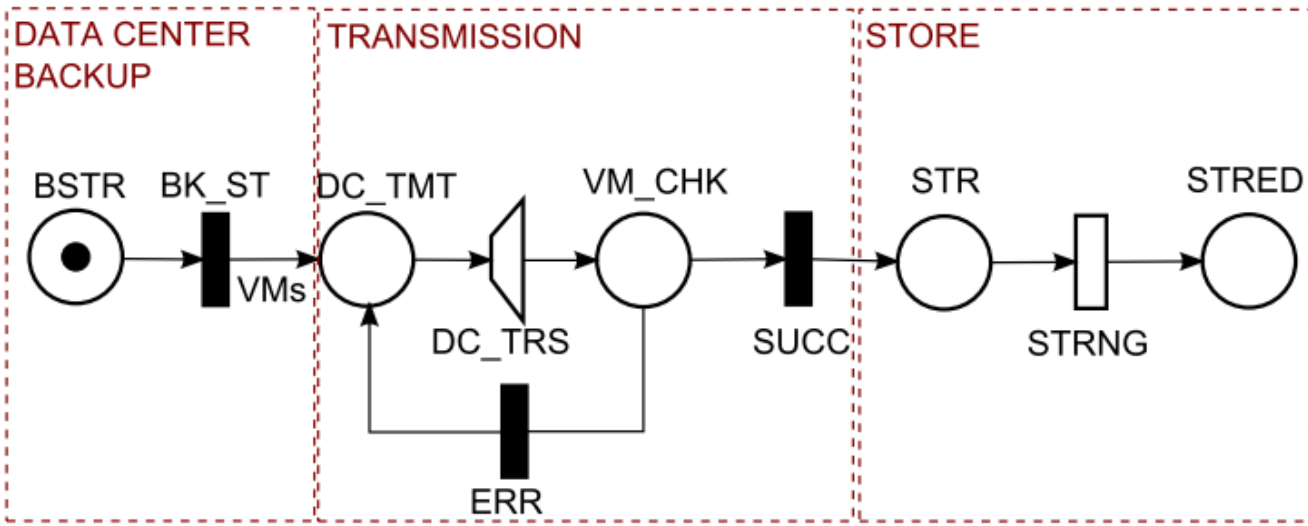
Survivability Evaluation



RTO and RPO Evaluation

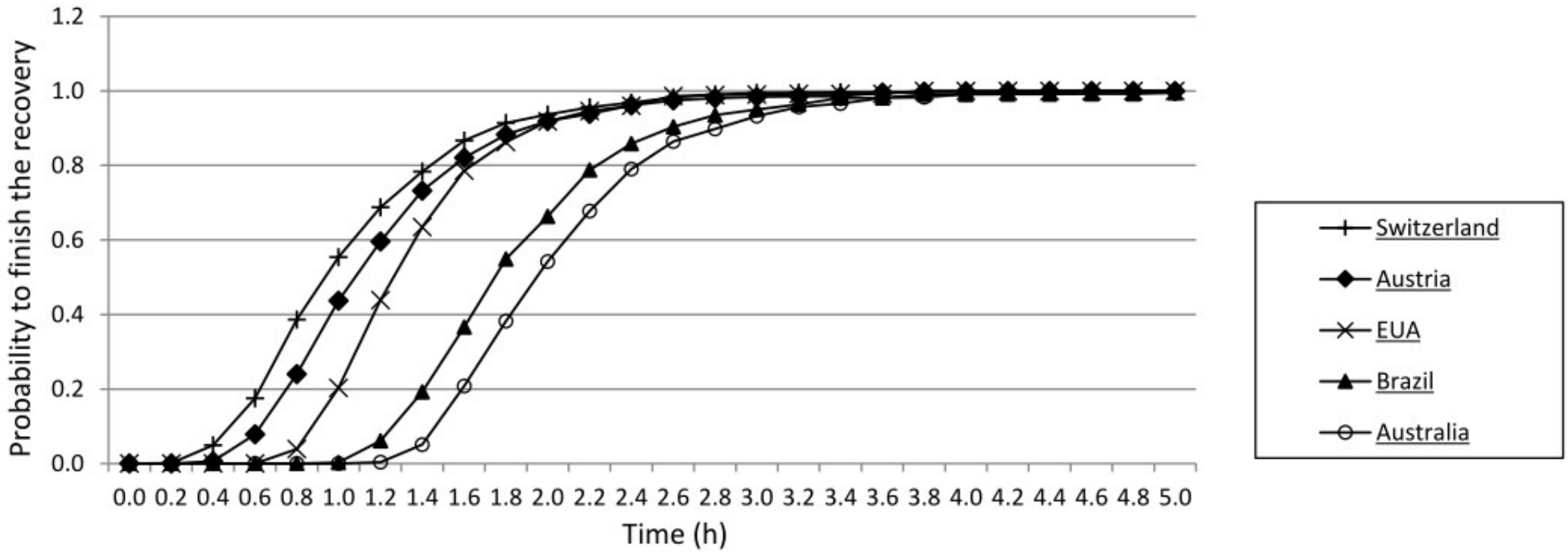


RTO Model

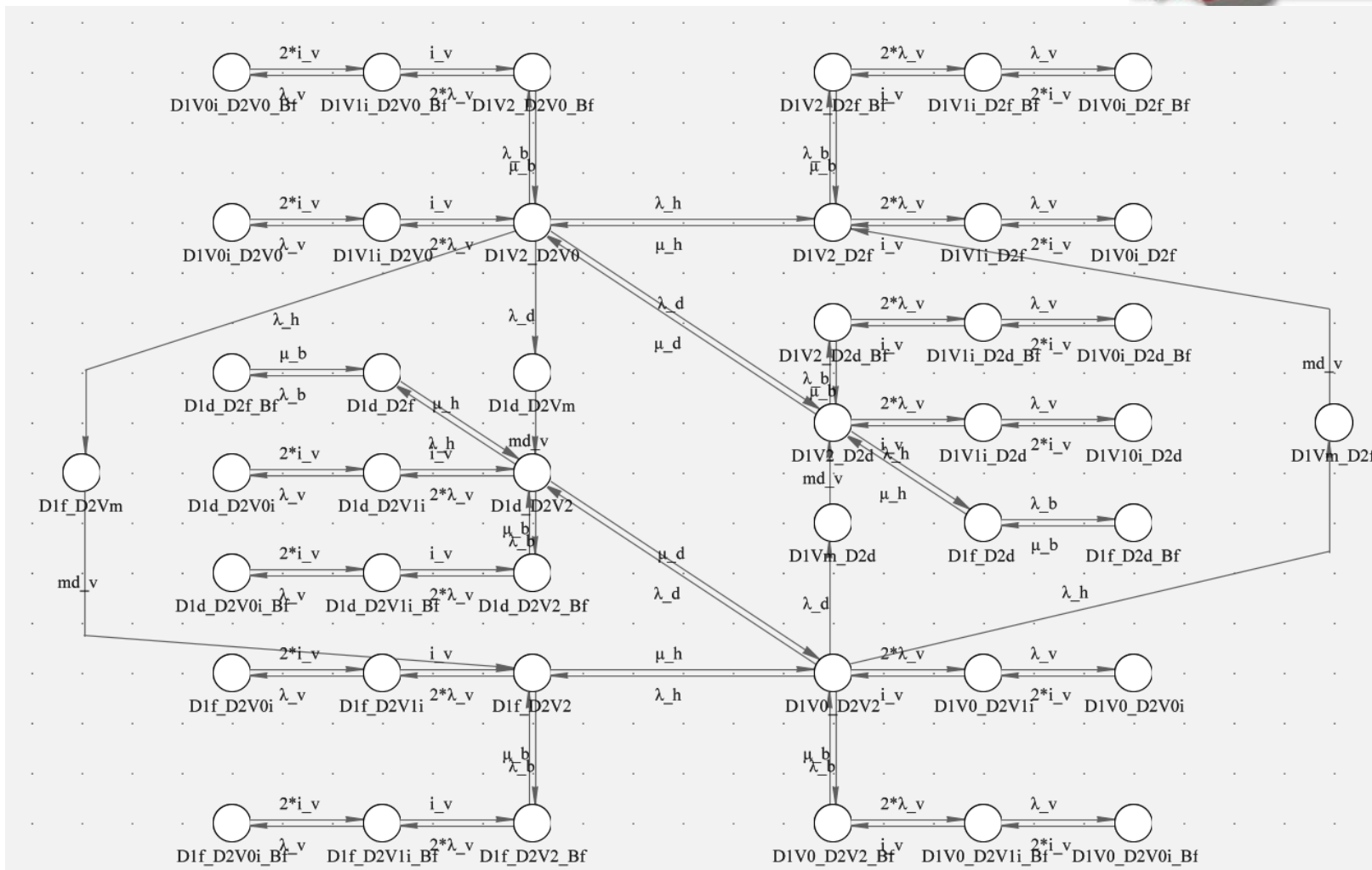


RPO Model

Results


Probability to finish the recovery
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0 4.2 4.4 4.6 4.8 5.0
Time (h)
Switzerland
Austria
EUA
Brazil
Australia

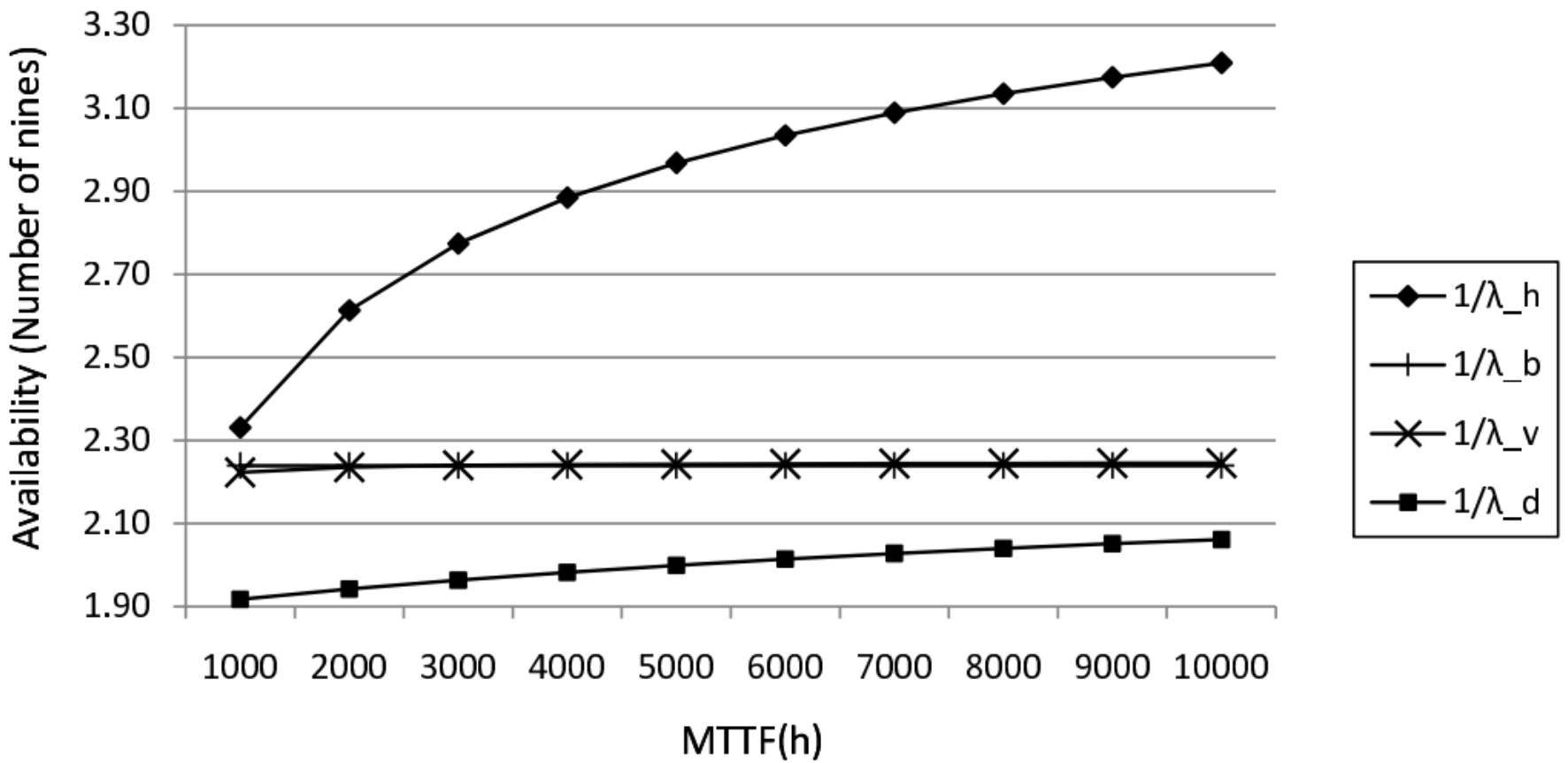
Sensitivity Analysis



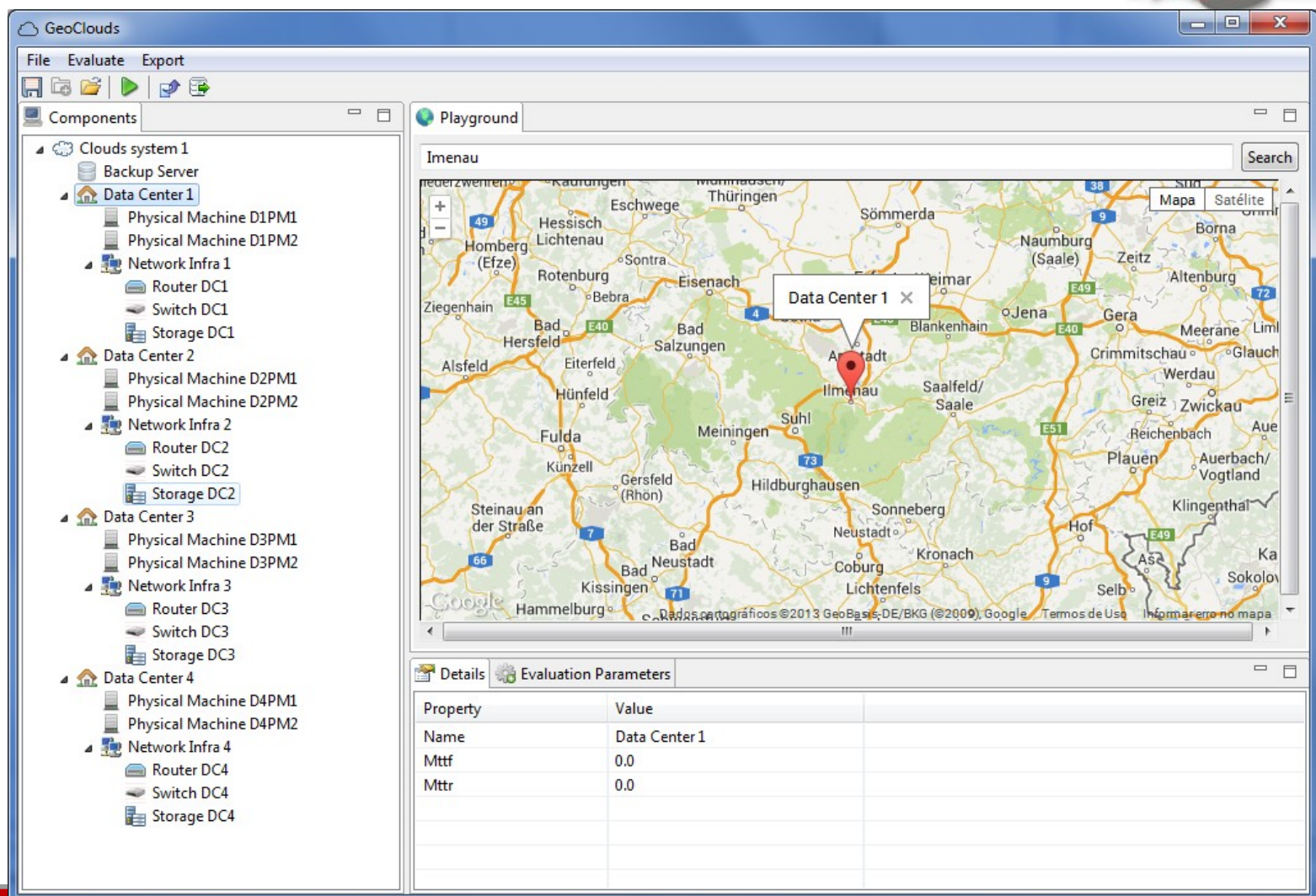
Results

Parameter	$\widehat{SS}(Nines)$
λ_h	4.186×10^{-1}
md_v	3.481×10^{-1}
μ_h	7.373×10^{-2}
λ_d	4.861×10^{-2}
μ_d	4.546×10^{-2}
λ_v	4.395×10^{-4}
i_v	4.395×10^{-4}
λ_b	3.481×10^{-5}
μ_b	3.481×10^{-5}

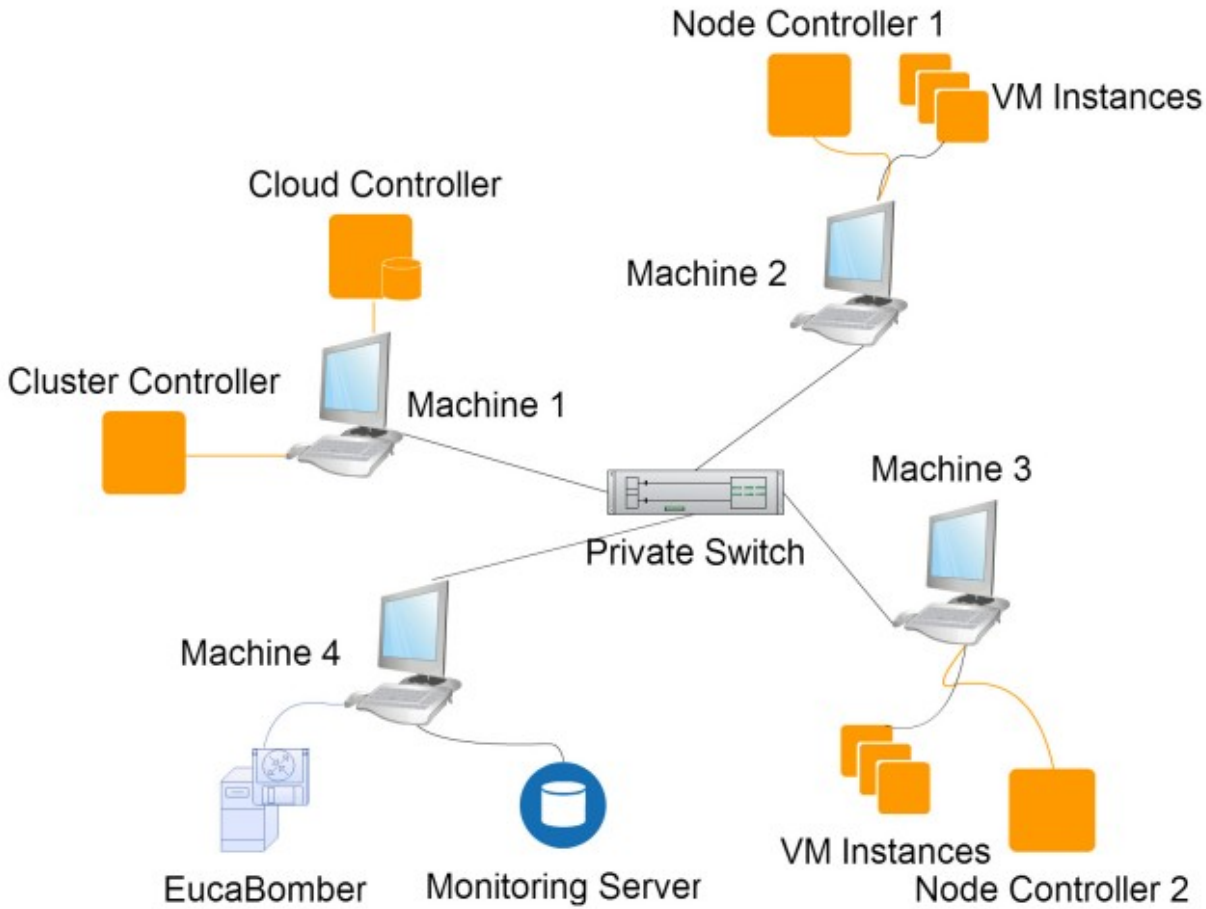
Results


Availability (Number of nines)
3.30
3.10
2.90
2.70
2.50
2.30
2.10
1.90
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
MTTF(h)
1/λ_h
1/λ_b
1/λ_v
1/λ_d

Geoclouds Modcs



Validation


Node Controller 1
VM Instances
Cloud Controller
Machine 2
Cluster Controller
Machine 1
Machine 3
Private Switch
Machine 4
VM Instances
EucaBomber
Monitoring Server
Node Controller 2

Validation

Scenario	N of Errors	Confidence interval of availability	Estimated value
A1	14	(0.993420433 , 0.998626244)	0.9935857
A2	20	(0.987658509 , 0.993537325)	0.9879326
B1	9	(0.807462045 , 0.965819035)	0.8279075
B2	20	(0.650996494 , 0.867691751)	0.7921259

Conclusion

- Performability
- Survivability
- Tool
- Validation
- Sensitivity Analysis

Next Steps :

Write Papers ☺

Questions