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# Distributed Simulation of Multiple Failure Events on Optical Networks

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# Introduction

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- The routing and wavelength assignment (RWA) algorithms with survivability has a great interest in optical networking
  - A fiber cut can affect thousands or even millions of users
- The application to be “gridified” simulate a single failure of each component (link or node) of the network and repeat this process at different time intervals. Indeed, the simulation of each failure must be repeated many times to be statistically significant
- Problem: simulations of multiple sequential failure events need a lot of processing power

# Motivation

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- Let  $N$  be the number of nodes,  $L$  the number of links of a network, and  $F$  the number of simulated failure events at a different time
- The total number of simulations needed is equal to  $N F$  (for single node failure) or  $L F$  (for single link failure)
- For a double sequential failure, the total number of simulations needed is equal to  $N (N - 1) F^2$  or  $L (L - 1) F^2$ , respectively
- Finally, a simulation of a triple failure sequential event would require a number of simulations of  $N (N - 1) (N - 2) F^3$  or  $L (L - 1) (L - 2) F^3$ , respectively

# Restorability

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- Restorability is the average fraction of failed connections that can be restored by a specified mechanism within the spare capacity that is provided in a network
  - The average is taken over some previously stipulated set of failure scenarios, most often the set of all complete single-link failures
- Current research works do not simulate double or higher-order failures due to the huge amount of processing needed to achieve consistent results
  - A large Grid infrastructure can be the answer to this problem

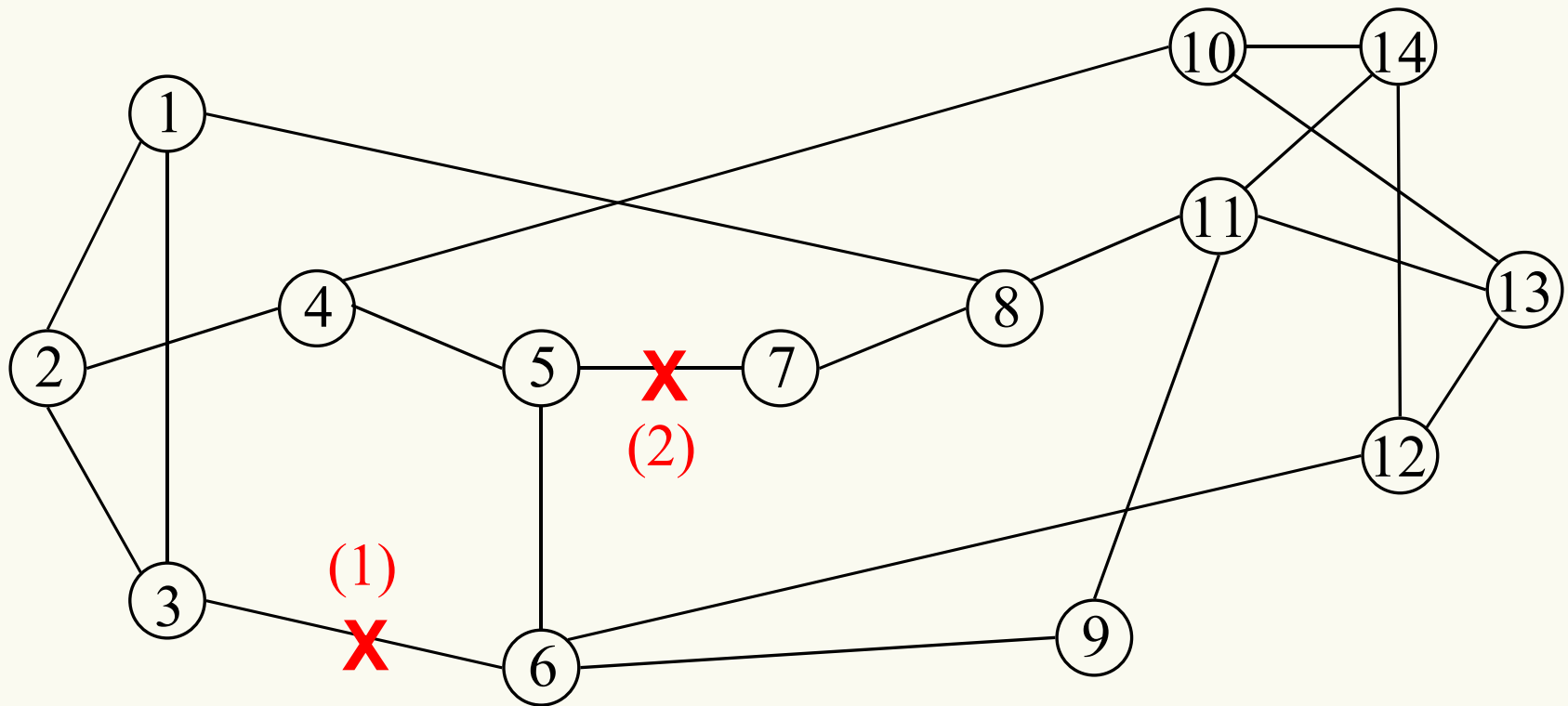
# Envisioned Grid Architecture

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- **Use of a central entity to act as a broker**
  - The broker assigns the simulation of a failure event to a machine elsewhere in the grid
  - The simulation is performed at the remote machine
  - At the end of the simulation, its state is recorded. Then, the results and the simulation state are transferred back to the broker.
- **Example: a double sequential failure simulation**
  - The state of the single failure simulation is uploaded to the broker, which applies a second failure to it, assigning the processing to a remote machine. After the simulation is done, the resulting state is again recorded and uploaded to the broker, being ready to be the base for a triple failure simulation, and so on.
- The broker plays a very important role by coordinating the parameters of the simulation, assigning the simulations with a failure event to the processing nodes and managing the upload and download of the recorded states from/to the processing nodes.



# Double-failure example in the NSFNet Network



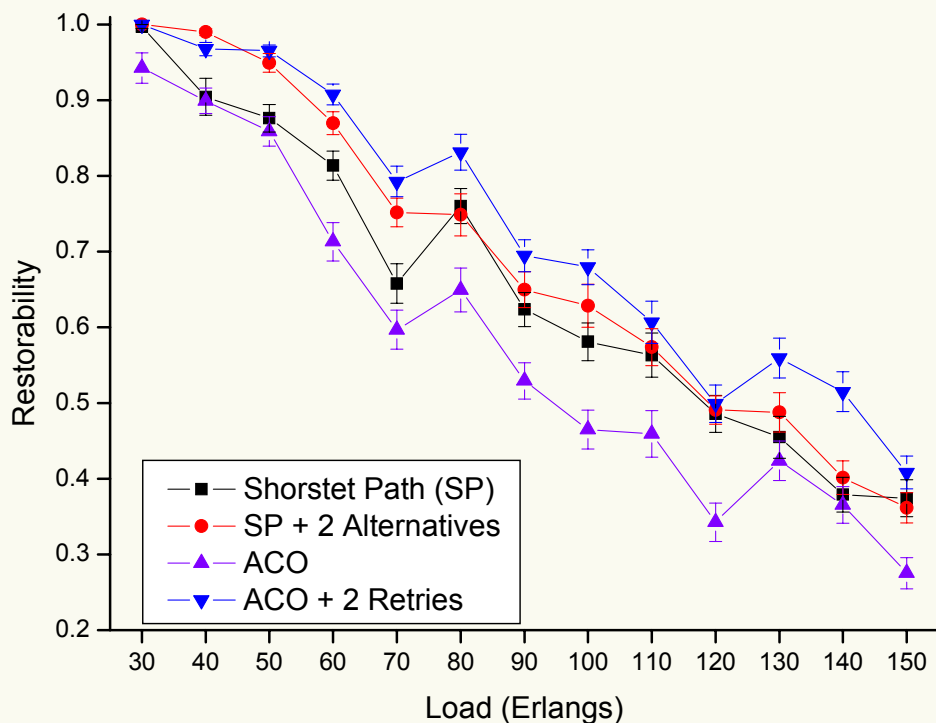
- The state of the previous simulation of the link 3-6 failure is used to process the failure of link 5-7.

# Mechanisms

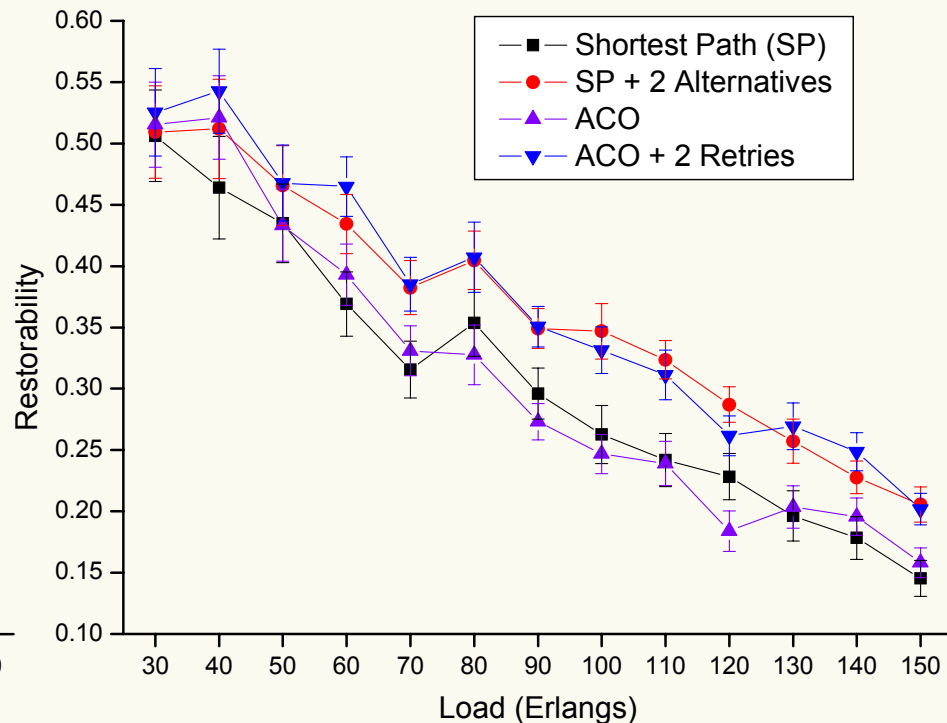
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- **Ant Colony Optimization (ACO)**
  - ACO is used to refer to the class of algorithms that are inspired in the process of foraging for food by natural ants for the optimization of hard-to-solve problems
  - It is characterized by ant-like mobile agents that cooperate and stochastically explore a network, iteratively building solutions based on their own memory and on the traces (pheromone levels) left by other agents
- **K-shortest paths**
  - Traditional routing in optical networks
  - Use of an ordered list of a number of fixed routes to each destination node. For instance, these routes may include the shortest-path route, the second-shortest path and so on.

# Restorability for the NSFNet Network



(a) Single-link failure



(b) Single-node failure

- Comparison between k-shortest path and ACO restoration

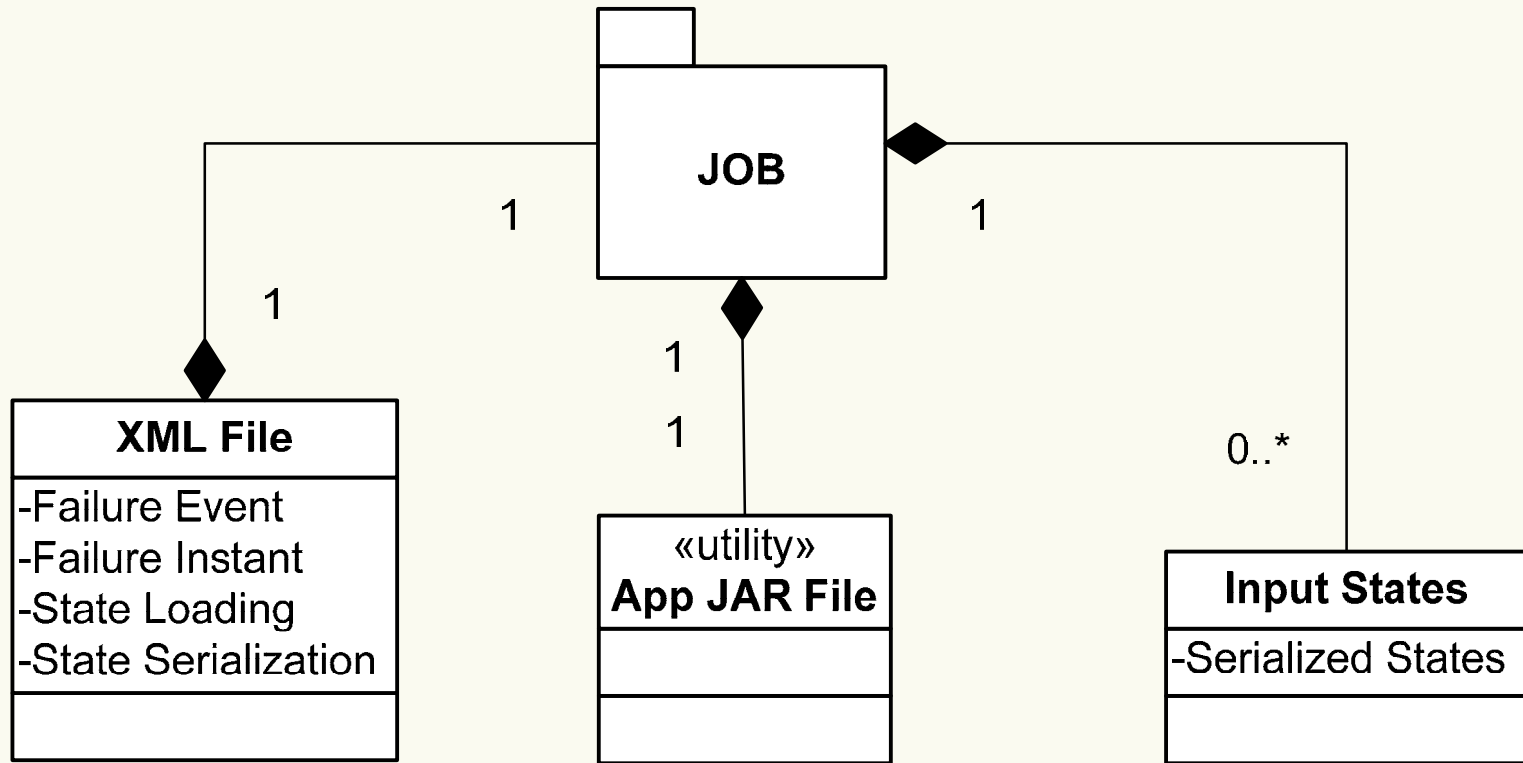


# Details about the application

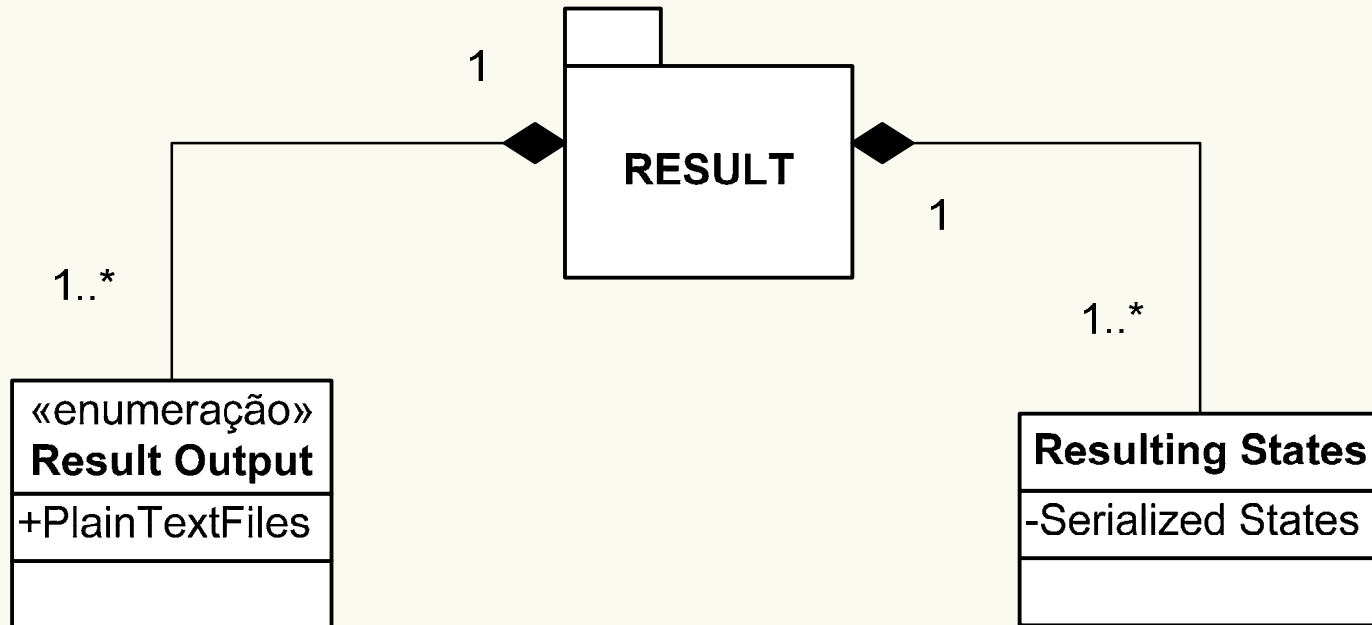
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- **Event-driven simulator written in Java (JDK 1.5)**
- **The input files for the simulator are well-formed XML files and, optionally, a serialized state. The output files, on the other hand, are plain text**
- **There is a tool for generating the XML files needed for a complete failure scenario**
- **To generate the restorability statistics these output files are parsed by a small Java application**
- **The simulator is capable of loading or recording a simulation at any specific simulation time by the use of the Java Serialization API**

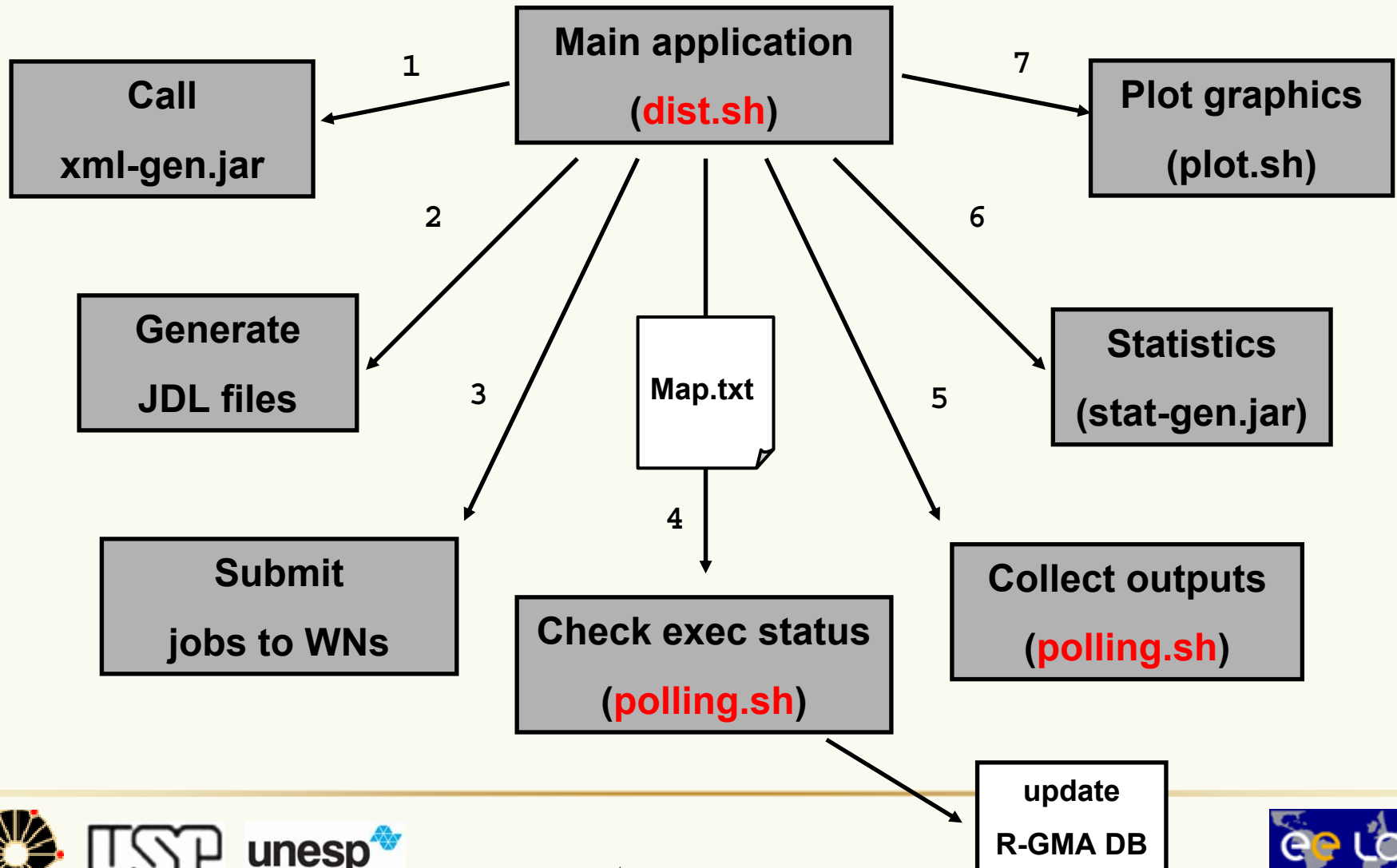
# Job schematics



# Result schematics



# Main application behavior



# Two-Level Simulation

**First level:**

**Single Failure**  
**Copy serialized states to SE**

**Results**

**Second level:**

**Double Failure**  
**Retrieve serialized states from SE**

**Results**

# XML Configuration Files (First Level)

1. config\_RWA\_NSF\_SP\_LinkFailure\_10-13\_time30000.xml
2. config\_RWA\_NSF\_SP\_LinkFailure\_3-6\_time30000.xml
3. config\_RWA\_NSF\_SP\_LinkFailure\_10-14\_time30000.xml
4. config\_RWA\_NSF\_SP\_LinkFailure\_4-10\_time30000.xml
5. config\_RWA\_NSF\_SP\_LinkFailure\_11-13\_time30000.xml
6. config\_RWA\_NSF\_SP\_LinkFailure\_4-5\_time30000.xml
7. config\_RWA\_NSF\_SP\_LinkFailure\_11-14\_time30000.xml
8. config\_RWA\_NSF\_SP\_LinkFailure\_5-6\_time30000.xml
9. config\_RWA\_NSF\_SP\_LinkFailure\_12-13\_time30000.xml
10. config\_RWA\_NSF\_SP\_LinkFailure\_5-7\_time30000.xml
11. config\_RWA\_NSF\_SP\_LinkFailure\_12-14\_time30000.xml
12. config\_RWA\_NSF\_SP\_LinkFailure\_6-12\_time30000.xml
13. config\_RWA\_NSF\_SP\_LinkFailure\_1-2\_time30000.xml
14. config\_RWA\_NSF\_SP\_LinkFailure\_6-9\_time30000.xml
15. config\_RWA\_NSF\_SP\_LinkFailure\_1-3\_time30000.xml
16. config\_RWA\_NSF\_SP\_LinkFailure\_7-8\_time30000.xml
17. config\_RWA\_NSF\_SP\_LinkFailure\_1-8\_time30000.xml
18. config\_RWA\_NSF\_SP\_LinkFailure\_8-11\_time30000.xml
19. config\_RWA\_NSF\_SP\_LinkFailure\_2-3\_time30000.xml
20. config\_RWA\_NSF\_SP\_LinkFailure\_9-11\_time30000.xml
21. config\_RWA\_NSF\_SP\_LinkFailure\_2-4\_time30000.xml



# JDL Files (First Level)

1. job\_config\_RWA\_NSF\_SP\_LinkFailure\_3-6\_time30000.xml.jdl
2. job\_config\_RWA\_NSF\_SP\_LinkFailure\_10-13\_time30000.xml.jdl
3. job\_config\_RWA\_NSF\_SP\_LinkFailure\_4-10\_time30000.xml.jdl
4. job\_config\_RWA\_NSF\_SP\_LinkFailure\_10-14\_time30000.xml.jdl
5. job\_config\_RWA\_NSF\_SP\_LinkFailure\_4-5\_time30000.xml.jdl
6. job\_config\_RWA\_NSF\_SP\_LinkFailure\_11-13\_time30000.xml.jdl
7. job\_config\_RWA\_NSF\_SP\_LinkFailure\_5-6\_time30000.xml.jdl
8. job\_config\_RWA\_NSF\_SP\_LinkFailure\_11-14\_time30000.xml.jdl
9. job\_config\_RWA\_NSF\_SP\_LinkFailure\_5-7\_time30000.xml.jdl
10. job\_config\_RWA\_NSF\_SP\_LinkFailure\_12-13\_time30000.xml.jdl
11. job\_config\_RWA\_NSF\_SP\_LinkFailure\_6-12\_time30000.xml.jdl
12. job\_config\_RWA\_NSF\_SP\_LinkFailure\_12-14\_time30000.xml.jdl
13. job\_config\_RWA\_NSF\_SP\_LinkFailure\_6-9\_time30000.xml.jdl
14. job\_config\_RWA\_NSF\_SP\_LinkFailure\_1-2\_time30000.xml.jdl
15. job\_config\_RWA\_NSF\_SP\_LinkFailure\_7-8\_time30000.xml.jdl
16. job\_config\_RWA\_NSF\_SP\_LinkFailure\_1-3\_time30000.xml.jdl
17. job\_config\_RWA\_NSF\_SP\_LinkFailure\_8-11\_time30000.xml.jdl
18. job\_config\_RWA\_NSF\_SP\_LinkFailure\_1-8\_time30000.xml.jdl
19. job\_config\_RWA\_NSF\_SP\_LinkFailure\_9-11\_time30000.xml.jdl
20. job\_config\_RWA\_NSF\_SP\_LinkFailure\_2-3\_time30000.xml.jdl
21. job\_config\_RWA\_NSF\_SP\_LinkFailure\_2-4\_time30000.xml.jdl



# Script for First Level

```
#!/bin/sh
# env vars
LFC_HOST=egris196.eela.ufrj.br
LFC_HOME=/grid/gilda/distsim
LCG_GFAL_VO=gilda
LCG_GFAL_INFOSYS=egris195.eela.ufrj.br:2170
LCG_CATALOG_TYPE=lfc
VO_GILDA_DEFAULT_SE=egris204.eela.ufrj.br
export LFC_HOST LFC_HOME LCG_GFAL_VO
LCG_GFAL_INFOSYS \
VO_GILDA_DEFAULT_SE
export PATH=/usr/java/jdk1.5.0_10/bin:$PATH

# shell vars
GREP="/bin/grep"
LCG_CMD="/opt/lcg/bin"
UPLOAD="lcg-cr"
COPY="lcg-cp"
DEL="lcg-del"
GET_GUID="lcg-lg"
LIST="lfc-ls"
ROOT_DIR="`pwd`"
```

```
echo "Start running the application at:" `date`
java -server -Xmx256m -jar $1 $2
# Now zip the output text files
tar -cf - ./RWA*.txt | gzip -9 > output_txt.tgz
# Generate list of serialized objects $3 -> prefix
ls ${3}*.obj > ./list_obj_level1.txt
# Send the serialized objects to SE
while read got_line;
do
    $LCG_CMD/$UPLOAD -l lfn:$got_line \
        file://$ROOT_DIR/$got_line 2>&1 > /dev/null
done < ./list_obj_level1.txt
# done
echo "Finishing running the application at:" `date`
```





# Recorded Serialized States in SE

- For instance, for link 1-2 we have:

```
RWA_NSF_SP_LinkFailure_1-2_load_100.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_1-2_load_110.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_1-2_load_120.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_1-2_load_130.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_1-2_load_140.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_1-2_load_150.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_1-2_load_30.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_1-2_load_40.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_1-2_load_50.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_1-2_load_60.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_1-2_load_70.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_1-2_load_80.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_1-2_load_90.0_t30000.0.obj
```

- Total recorded states: 273 (95 MB)

# Script for Second Level

```
echo "Start running the application at:" `date`  
# get the previous failed link  
link=`ls *.xml | sed -e  
\ "s%config_RWA_NSF_SP_LinkFailure2_%g\" | awk -F_  
'{print $1}'`  
echo  
"RWA_NSF_SP_LinkFailure_${link}_load_30.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_${link}_load_40.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_${link}_load_50.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_${link}_load_60.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_${link}_load_70.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_${link}_load_80.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_${link}_load_90.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_${link}_load_100.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_${link}_load_110.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_${link}_load_120.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_${link}_load_130.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_${link}_load_140.0_t30000.0.obj  
RWA_NSF_SP_LinkFailure_${link}_load_150.0_t30000.0.obj"  
> ./filelist.txt
```

```
# get the files  
while read got_line;  
do  
    $LCG_CMD/$COPY lfn:$got_line \  
    file://${ROOT_DIR}/${got_line} 2>&1 > \  
    /dev/null  
done < ./filelist.txt  
# run the app  
java -server -Xmx256m -jar $1 $2  
# Now zip the output text files  
tar -cf - ./RWA*.txt | gzip -9 > \  
output_txt.tgz  
echo "`ls -l`" > ./ls.txt  
echo "Finishing running the application \  
at:" `date`
```



# Polling

Browser window: <https://egris198.eela.ufrj.br:8443/R-GMA/>

Query: `SELECT jobID, configXMLFile, status, MeasurementDate, MeasurementTime FROM DistSimMonitor`  
 Properties: Continuous[1000 days]

jobID	configXMLFile	status	MeasurementDate	MeasurementTime
<a href="https://egris195.eela.ufrj.br:9000/4eh-o06uZ_z9AY4zFITsIQ">https://egris195.eela.ufrj.br:9000/4eh-o06uZ_z9AY4zFITsIQ</a>	config_RWA_NSF_SP_LinkFailure_10-13_time30000.xml	Running	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/sMMSYrwFFOjVar_7kAgY9Q">https://egris195.eela.ufrj.br:9000/sMMSYrwFFOjVar_7kAgY9Q</a>	config_RWA_NSF_SP_LinkFailure_10-14_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/aAcXM_N2ggwheK6GvWV3Fg">https://egris195.eela.ufrj.br:9000/aAcXM_N2ggwheK6GvWV3Fg</a>	config_RWA_NSF_SP_LinkFailure_11-13_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/YtcDvdI5O_jMhbrVky_CZg">https://egris195.eela.ufrj.br:9000/YtcDvdI5O_jMhbrVky_CZg</a>	config_RWA_NSF_SP_LinkFailure_11-14_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/yipiSpup3Z6sEL86DRgg">https://egris195.eela.ufrj.br:9000/yipiSpup3Z6sEL86DRgg</a>	config_RWA_NSF_SP_LinkFailure_12-13_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/dH-NV4d6EMjWU4z1MAwh9A">https://egris195.eela.ufrj.br:9000/dH-NV4d6EMjWU4z1MAwh9A</a>	config_RWA_NSF_SP_LinkFailure_12-14_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/2WY8TSDi7ZN5ZLw8Sibvw">https://egris195.eela.ufrj.br:9000/2WY8TSDi7ZN5ZLw8Sibvw</a>	config_RWA_NSF_SP_LinkFailure_1-2_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/LNU5PWXzI-oELdbFFHrAIA">https://egris195.eela.ufrj.br:9000/LNU5PWXzI-oELdbFFHrAIA</a>	config_RWA_NSF_SP_LinkFailure_1-3_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/XhzmjK5FaMqWB0GXkqzQ">https://egris195.eela.ufrj.br:9000/XhzmjK5FaMqWB0GXkqzQ</a>	config_RWA_NSF_SP_LinkFailure_1-8_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/kgrOJFvLT3o-8U3ElzxQ">https://egris195.eela.ufrj.br:9000/kgrOJFvLT3o-8U3ElzxQ</a>	config_RWA_NSF_SP_LinkFailure_2-3_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/VORWHBjJKmUfMtdnrTasQ">https://egris195.eela.ufrj.br:9000/VORWHBjJKmUfMtdnrTasQ</a>	config_RWA_NSF_SP_LinkFailure_2-4_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/XrSnFsBmQDy3ZDV8cnjzQ">https://egris195.eela.ufrj.br:9000/XrSnFsBmQDy3ZDV8cnjzQ</a>	config_RWA_NSF_SP_LinkFailure_3-6_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/zV4zSmOm75oOz7K-haBmbw">https://egris195.eela.ufrj.br:9000/zV4zSmOm75oOz7K-haBmbw</a>	config_RWA_NSF_SP_LinkFailure_4-10_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/rxUF5-QHqleIDssQwEySWA">https://egris195.eela.ufrj.br:9000/rxUF5-QHqleIDssQwEySWA</a>	config_RWA_NSF_SP_LinkFailure_4-5_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/RBT5fVf1tVGEQhdQAihWxA">https://egris195.eela.ufrj.br:9000/RBT5fVf1tVGEQhdQAihWxA</a>	config_RWA_NSF_SP_LinkFailure_5-6_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/QwcIqXYcT1xVHvKzWQE_Sw">https://egris195.eela.ufrj.br:9000/QwcIqXYcT1xVHvKzWQE_Sw</a>	config_RWA_NSF_SP_LinkFailure_5-7_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/DzG3rx7J1awV2VsKE375gQ">https://egris195.eela.ufrj.br:9000/DzG3rx7J1awV2VsKE375gQ</a>	config_RWA_NSF_SP_LinkFailure_6-12_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/VyLRT3YcBeqZKu_uzuuP4g">https://egris195.eela.ufrj.br:9000/VyLRT3YcBeqZKu_uzuuP4g</a>	config_RWA_NSF_SP_LinkFailure_6-9_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/hFLEQdwbM4_YVSYec26J-Q">https://egris195.eela.ufrj.br:9000/hFLEQdwbM4_YVSYec26J-Q</a>	config_RWA_NSF_SP_LinkFailure_7-8_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/pj2EXw91zbKvHoce9KXB5Q">https://egris195.eela.ufrj.br:9000/pj2EXw91zbKvHoce9KXB5Q</a>	config_RWA_NSF_SP_LinkFailure_8-11_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/R1egG2vps3UDE27DQFMq9w">https://egris195.eela.ufrj.br:9000/R1egG2vps3UDE27DQFMq9w</a>	config_RWA_NSF_SP_LinkFailure_9-11_time30000.xml	Scheduled	2006-12-13	21:03:12
<a href="https://egris195.eela.ufrj.br:9000/4eh-o06uZ_z9AY4zFITsIQ">https://egris195.eela.ufrj.br:9000/4eh-o06uZ_z9AY4zFITsIQ</a>	config_RWA_NSF_SP_LinkFailure_10-13_time30000.xml	Running	2006-12-13	21:05:45
<a href="https://egris195.eela.ufrj.br:9000/sMMSYrwFFOjVar_7kAgY9Q">https://egris195.eela.ufrj.br:9000/sMMSYrwFFOjVar_7kAgY9Q</a>	config_RWA_NSF_SP_LinkFailure_10-14_time30000.xml	Running	2006-12-13	21:05:45
<a href="https://egris195.eela.ufrj.br:9000/aAcXM_N2ggwheK6GvWV3Fg">https://egris195.eela.ufrj.br:9000/aAcXM_N2ggwheK6GvWV3Fg</a>	config_RWA_NSF_SP_LinkFailure_11-13_time30000.xml	Running	2006-12-13	21:05:45
<a href="https://egris195.eela.ufrj.br:9000/YtcDvdI5O_jMhbrVky_CZg">https://egris195.eela.ufrj.br:9000/YtcDvdI5O_jMhbrVky_CZg</a>	config_RWA_NSF_SP_LinkFailure_11-14_time30000.xml	Running	2006-12-13	21:05:45



# Getting Results from Output Sandbox

\*\*\*\*\* Polling session for querying job status finished. \*\*\*\*\*

```
Getting results from egris__2WY8TSDi7ZN5ZLw8Sibvw
Getting results from egris_4eh-o06uZ_z9AY4zFITslQ
Getting results from egris_aAcXM_N2ggwheK6GvWV3Fg
Getting results from egris_dH-NV4d6EMjWU4z1MAwh9A
Getting results from egris_DzG3rx7J1awV2VsKE375gQ
Getting results from egris_hFLEQdwBM4_YVSYec26J-Q
Getting results from egris__kgrOJFyILt3o-8U3ElzxQ
Getting results from egris_LNU5PWXxI-oELdbFFHrAlA
Getting results from egris_pj2EXw91zbKvHoce9KXB5Q
Getting results from egris_pZ1ywnHxOy9Owke60Q1h2w
Getting results from egris_QwcIqXYcT1xVHvKzWQE_Sw
Getting results from egris_R1egG2vps3UDE27DQFMq9w
Getting results from egris_RBT5fvf1tVGEQhdQAihWxA
Getting results from egris_rxUf5-QHqIeIDssQwEySWA
Getting results from egris_sMMSYrwFfOjVar_7kAgY9Q
Getting results from egris_VORWHBiJKmUfMtIdnrTasQ
Getting results from egris_VyLRT3YcBeqZKu_uzuuP4g
Getting results from egris_XhznjjK5FaJMqWB0GXkgzQ
Getting results from egris_XrSnFsBmQDy3ZDV8cnjznQ
Getting results from egris_yjpiSpup3Z61sEIL86DRgg
Getting results from egris_YtcDvd150_jMhbrVkY_CZg
Getting results from egris_zV4zSmOm75oOz7K-haBmbw
```



# Doing Restorability Statistics

Doing statistics...

```
Adding: RWA_NSF_Failure_SP_t30000_1-8.txt
Adding: RWA_NSF_Failure_SP_t30000_11-13.txt
Adding: RWA_NSF_Failure_SP_t30000_4-10.txt
Adding: RWA_NSF_Failure_SP_t30000_1-2.txt
Adding: RWA_NSF_Failure_SP_t30000_10-13.txt
Adding: RWA_NSF_Failure_SP_t30000_5-6.txt
Adding: RWA_NSF_Failure_SP_t30000_12-14.txt
Adding: RWA_NSF_Failure_SP_t30000_2-4.txt
Adding: RWA_NSF_Failure_SP_t30000_11-14.txt
Adding: RWA_NSF_Failure_SP_t30000_8-11.txt
Adding: RWA_NSF_Failure_SP_t30000_6-12.txt
Adding: RWA_NSF_Failure_SP_t30000_2-3.txt
Adding: RWA_NSF_Failure_SP_t30000_1-3.txt
Adding: RWA_NSF_Failure_SP_t30000_7-8.txt
Adding: RWA_NSF_Failure_SP_t30000_12-13.txt
Adding: RWA_NSF_Failure_SP_t30000_9-11.txt
Adding: RWA_NSF_Failure_SP_t30000_10-14.txt
Adding: RWA_NSF_Failure_SP_t30000_4-5.txt
Adding: RWA_NSF_Failure_SP_t30000_3-6.txt
Adding: RWA_NSF_Failure_SP_t30000_6-9.txt
Adding: RWA_NSF_Failure_SP_t30000_5-7.txt
```



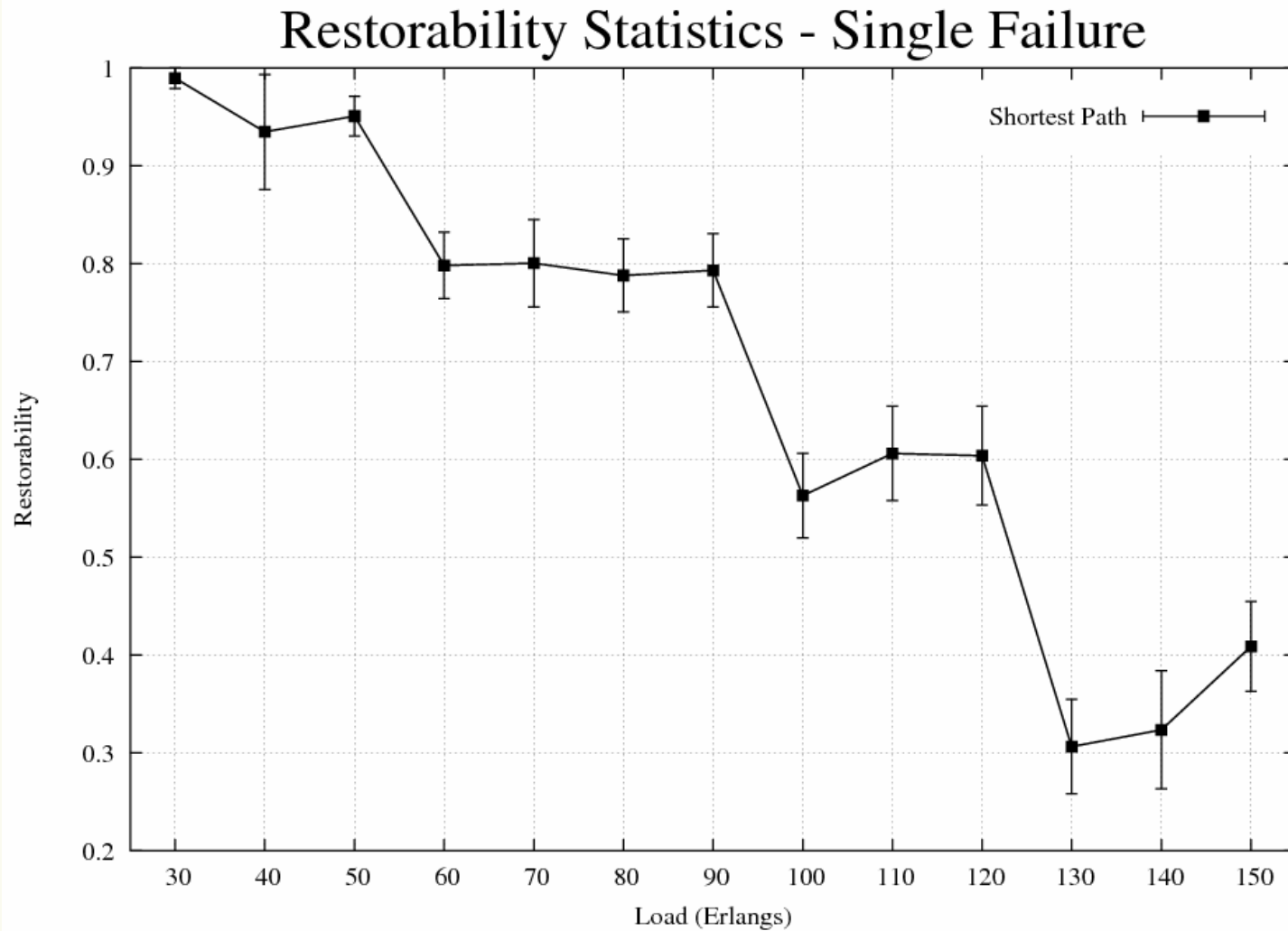
# Plotting script

---

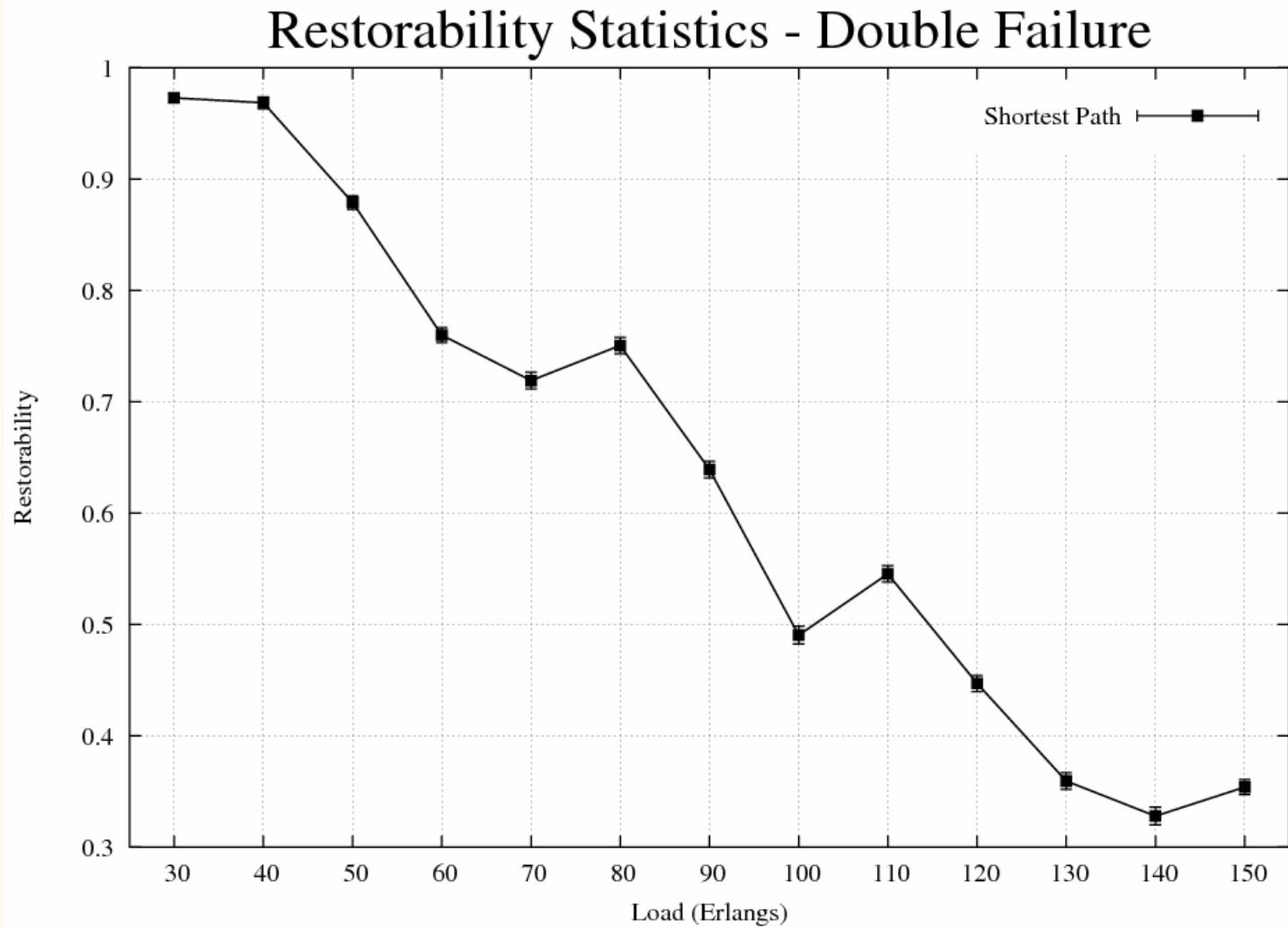
```
#!/usr/bin/gnuplot -persist
set terminal postscript enhanced color solid "Times-Roman" 14
set output "output.ps"
set title "Restorability Statistics" font "Times-Roman,30"
set xlabel "Load (Erlangs)"
set ylabel "Restorability"
set xrange[25:155]
set pointsize 5
set linestyle 1 lt -1 lw 1 pt 5 ps 1
set linestyle 2 lt -1 lw 1 pt 3 ps 2
set xtics 30,10
set grid
# set data style linespoints
plot "/home/egris/results/RWA_NSF_Failure_SP_stat.txt" ind 0:0
usi 1:3:4 ti "Shortest Path" w yerr ls 1, \
"/home/egris/results/RWA_NSF_Failure_SP_stat.txt" ind 0:0 usi
1:3 notit w lines ls 2
```



# Results - First Level



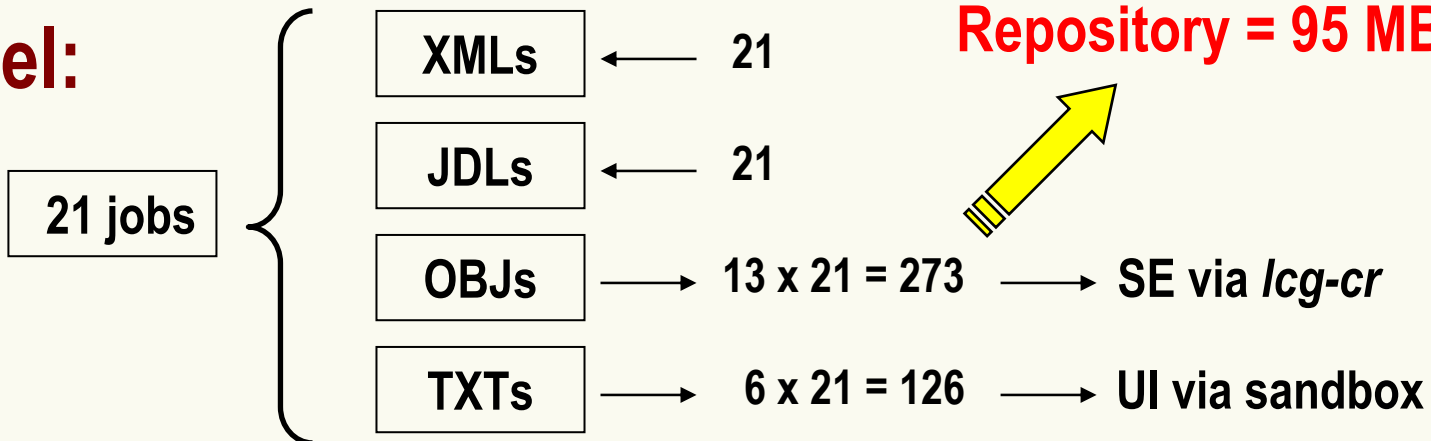
# Results - Second Level



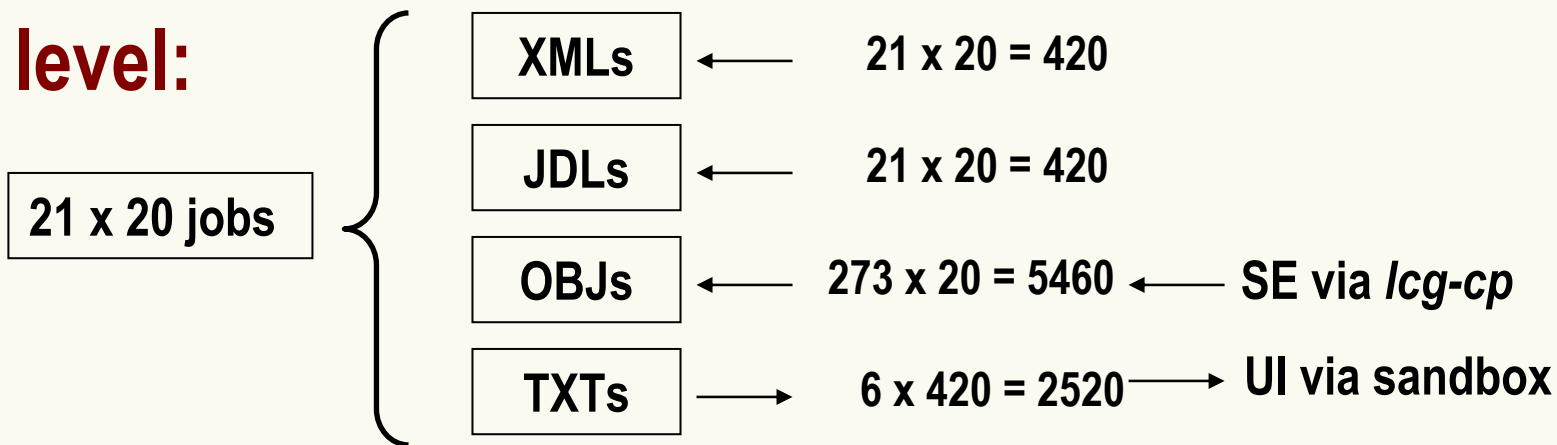


# Some Figures

## 1<sup>st</sup> level:



## 2<sup>nd</sup> level:



# Genius Web Portal – Introduction

Introduction

Failure recovery is a very important aspect in optical networks. A single link failure may affect thousand or even millions of users, thus stressing the need for high reliability. Unexpected events occur frequently in complex optical networks, and many of them result in failure situations where a management mechanism is required to interfere and restore the network to a new working state. The motivation of this work is to study the restorability for single and multiple failure events under different loads and network topologies of different dynamic Routing and Wavelength Assignment (RWA) algorithms with survivability. Restorability is the average fraction of failed connections that can be restored within the spare capacity provided in the network.

In order to get the restorability of a single link or node failure event for a given network topology, under a specific load and traffic, it is necessary to simulate a single failure of each component (link or node) of the network and repeat this process at different time intervals. Thus, the simulation of each failure must be repeated many times to be statistically significant.

Let  $N$  be the number of nodes,  $L$  the number of links of a network, and  $F$  the number of simulated failure events at a different time. The total number of simulations needed is equal to  $N \cdot F$  (for single node failure) or  $L \cdot F$  (for single link failure). For a double sequential failure, the total number of simulations needed is equal to  $N \cdot (N - 1) \cdot F^2$  or  $L \cdot (L - 1) \cdot F^2$ , respectively. And a simulation of a triple failure sequential event would require a number of simulations of  $N \cdot (N - 1) \cdot (N - 2) \cdot F^3$  or  $L \cdot (L - 1) \cdot (L - 2) \cdot F^3$ , respectively.

In general, current research works do not simulate double or higher-order failures due to the huge amount of processing needed to achieve consistent results. A large Grid infrastructure can be the answer to this problem. Thus, the goal of this project is to simulate double and triple failures using different restoration mechanisms.

The NSFNet Network, which is used in this application, is shown in the figure below:

If you want more information about the application visit the following web page <http://www.optinet.fee.unicamp.br/~pavani>

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# Genius Web Portal – Level

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DISTSIM

Services

- Introduction
- Proxy
- Select the level
- Submit Jobs
- Polling and Retrieval
- Generate Statistics
- Plot
- Back home

Select the level

Select a Level

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# Genius Web Portal - Generation of XML & JDL Files

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DISTSIM

Services

- Introduction
- Proxy
- Select the level
- Submit Jobs
- Polling and Retrieval
- Generate Statistics
- Plot
- Back home

Generating files for level 1.  
Generated XML files:

```
config_RWA_NSF_SP_LinkFailure_10-13_time30000.xml
config_RWA_NSF_SP_LinkFailure_10-14_time30000.xml
config_RWA_NSF_SP_LinkFailure_11-13_time30000.xml
config_RWA_NSF_SP_LinkFailure_11-14_time30000.xml
config_RWA_NSF_SP_LinkFailure_12-13_time30000.xml
config_RWA_NSF_SP_LinkFailure_12-14_time30000.xml
config_RWA_NSF_SP_LinkFailure_1-2_time30000.xml
config_RWA_NSF_SP_LinkFailure_1-3_time30000.xml
config_RWA_NSF_SP_LinkFailure_1-8_time30000.xml
config_RWA_NSF_SP_LinkFailure_2-3_time30000.xml
config_RWA_NSF_SP_LinkFailure_2-4_time30000.xml
config_RWA_NSF_SP_LinkFailure_3-6_time30000.xml
config_RWA_NSF_SP_LinkFailure_4-10_time30000.xml
config_RWA_NSF_SP_LinkFailure_4-5_time30000.xml
config_RWA_NSF_SP_LinkFailure_5-6_time30000.xml
config_RWA_NSF_SP_LinkFailure_5-7_time30000.xml
config_RWA_NSF_SP_LinkFailure_6-12_time30000.xml
config_RWA_NSF_SP_LinkFailure_6-9_time30000.xml
config_RWA_NSF_SP_LinkFailure_7-8_time30000.xml
config_RWA_NSF_SP_LinkFailure_8-11_time30000.xml
config_RWA_NSF_SP_LinkFailure_9-11_time30000.xml
```

Generation of XMLs done!  
starting jdl generation...

```
Generating jdl for config file: config_RWA_NSF_SP_LinkFailure_10-13_time30000.xml
Generating jdl for config file: config_RWA_NSF_SP_LinkFailure_10-14_time30000.xml
Generating jdl for config file: config_RWA_NSF_SP_LinkFailure_11-13_time30000.xml
Generating jdl for config file: config_RWA_NSF_SP_LinkFailure_11-14_time30000.xml
Generating jdl for config file: config_RWA_NSF_SP_LinkFailure_12-13_time30000.xml
Generating jdl for config file: config_RWA_NSF_SP_LinkFailure_12-14_time30000.xml
Generating jdl for config file: config_RWA_NSF_SP_LinkFailure_1-2_time30000.xml
Generating jdl for config file: config_RWA_NSF_SP_LinkFailure_1-3_time30000.xml
Generating jdl for config file: config_RWA_NSF_SP_LinkFailure_1-8_time30000.xml
```

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# Genius Web Portal – Job Submission

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DISTSIM Services

- Introduction
- Proxy
- Select the level
- Submit Jobs
- Polling and Retrieval
- Generate Statistics
- Plot
- Back home

### Job Submission

Submitting jobs... This operation may take several minutes!

Selected Virtual Organisation name (from proxy certificate extension): gilda  
Connecting to host egris195.eela.ufrj.br, port 7772  
Logging to host egris195.eela.ufrj.br, port 9002

```
===== edg-job-submit Success =====  
The job has been successfully submitted to the Network Server.  
Use edg-job-status command to check job current status. Your job identifier (edg_jobId) is:  
  
- https://egris195.eela.ufrj.br:9000/snMu4zqSreD83Zx1jcsHTA  
  
The edg_jobId has been saved in the following file:  
/home/distsim/jd11/jobs.id  
=====
```

Selected Virtual Organisation name (from proxy certificate extension): gilda  
Connecting to host egris195.eela.ufrj.br, port 7772  
Logging to host egris195.eela.ufrj.br, port 9002

```
===== edg-job-submit Success =====  
The job has been successfully submitted to the Network Server.  
Use edg-job-status command to check job current status. Your job identifier (edg_jobId) is:  
  
- https://egris195.eela.ufrj.br:9000/ML_IZFLYGu9bhNYxyt7hYA  
  
The edg_jobId has been saved in the following file:  
/home/distsim/jd11/jobs.id  
=====
```

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# Genius Web Portal – Polling & Output Retrieval

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DISTSIM

- Services
  - Introduction
  - Proxy
  - Select the level
  - Submit Jobs
  - Polling and Retrieval**
  - Generate Statistics
  - Plot
  - Back home

**Polling**

Polling jobs... This operation may take several minutes!

\*\*\*\*\* Verifying Status \*\*\*\*\*

Getting status of job https://egris195.eela.ufrj.br:9000/snMu4zqSreD83Zx1jcsHTA  
status = Running

Getting status of job https://egris195.eela.ufrj.br:9000/ML\_IZFLYGu9bhNYxyt7hYA  
status = Running

Getting status of job https://egris195.eela.ufrj.br:9000/vakpcYSRTPCoxRpkHp7YvW  
status = Running

Getting status of job https://egris195.eela.ufrj.br:9000/1B9hgW9WR19-blyZt23LWQ  
status = Running

Getting status of job https://egris195.eela.ufrj.br:9000/mQmEXmOCqAO\_LQ01njoYjQ  
status = Running

Getting status of job https://egris195.eela.ufrj.br:9000/cgNuXnZmXeMyAVqBq-txrg  
status = Scheduled

Getting status of job https://egris195.eela.ufrj.br:9000/JqYb-F0VvvdFQ5fBr2rr7Q  
status = Scheduled

Getting status of job https://egris195.eela.ufrj.br:9000/90pkoJf1AtQkNhr1uv31Cg  
status = Running

Getting status of job https://egris195.eela.ufrj.br:9000/MibQvKacs11r7Qzx1eWpuw  
status = Scheduled

Getting status of job https://egris195.eela.ufrj.br:9000/OVawFlk5VqgvYnWkbrIN4A  
status = Scheduled

Getting status of job https://egris195.eela.ufrj.br:9000/ffC4YqjxkFyHVesK4VOX\_g  
status = Scheduled

Getting status of job https://egris195.eela.ufrj.br:9000/bz7uAhybCz0u1A0YPD7ZCA  
status = Scheduled

Getting status of job https://egris195.eela.ufrj.br:9000/19Nqn2yKIVFBer9GcfWSKA  
status = Scheduled

Getting status of job https://egris195.eela.ufrj.br:9000/ig3iQQGSPocufcsUowcjkq  
status = Scheduled

Getting status of job https://egris195.eela.ufrj.br:9000/soifavzsvhLNF8WPI0968A  
status = Scheduled

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# Genius Web Portal – Statistics Generation

The screenshot shows a Mozilla Firefox browser window with the address bar displaying `https://egris216.eela.ufrj.br/`. The page content includes logos for INFN, egee (Enabling Grids for E-science), and NICE. The main text area displays a list of job results, each starting with "Getting results from" followed by a unique identifier. Below this list, the text "Doing statistics..." is followed by a list of files being added, such as "RWA\_NSF\_Failure\_SP\_t30000\_12-13.txt". At the bottom of the page, a copyright notice reads: "Copyright © 1998 - 2005 Nice S.r.l. All trademarks and logos on this page are owned by NICE s.r.l. or by their respective owners." The browser's status bar at the bottom shows "Done" and the URL `egris216.eela.ufrj.br`.



# Genius Web Portal – Postscript Download

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DISTSIM

- Services
  - Introduction
  - Proxy
  - Select the level
  - Submit Jobs
  - Polling and Retrieval
  - Generate Statistics
  - Plot
  - Back home

**Graph Plotting**

Generating postscript file output1.ps for single failure scenario!

[Postscript file for the simulation of Level 1](#)

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