CRESCO Project

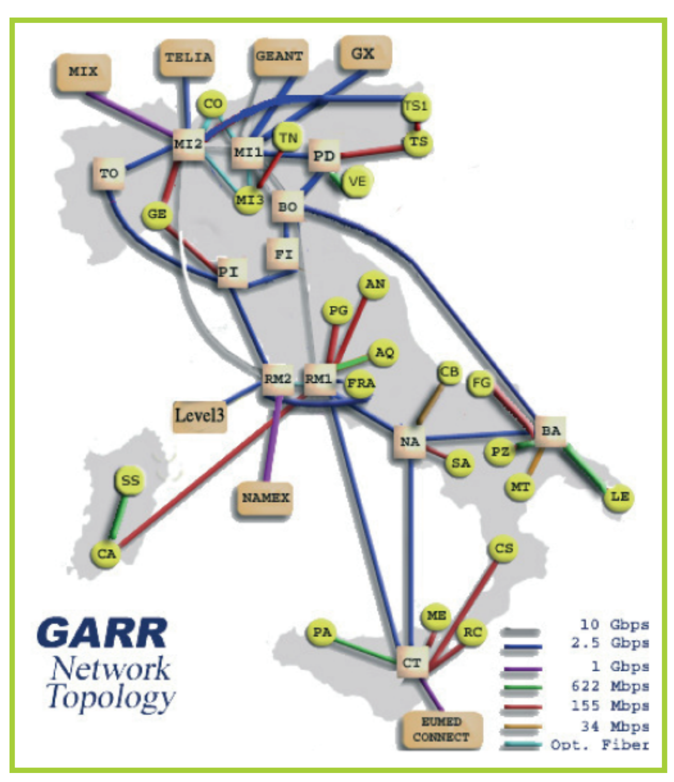
ENTE PER LE NUOVE TECNOLOGIE, L'ENERGIA E L'AMBIENTE

Modelling Interdependent Infrastructures Using Interacting System Simulators

TARGET

Complex infrastructures display relevant "interdependencies"; a loss of functionality in one of them has a severe impact on the functionality of the others. In some cases (electrical and telecommunication networks), there is a bi-directional "functional" interdependency: a lack of power supply reduces the functionality of telecommunication network whose function is, in turn, vital for the healing the electrical system.

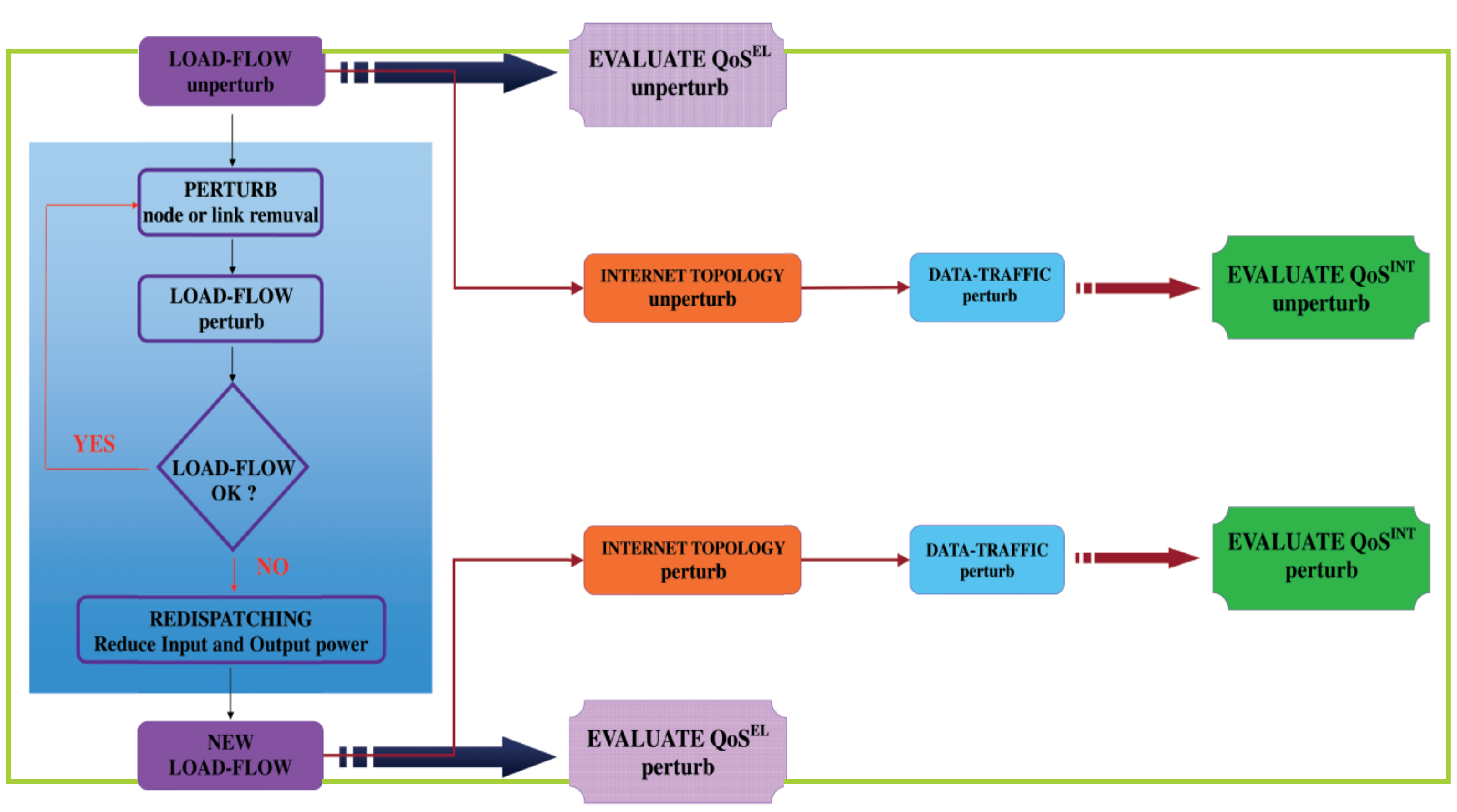
In order to estimate the interdependencies between an electrical grid and a data traffic network (the Internet), we studied how a perturbation affecting the electrical grid reduces the Internet functionalities. This is done by connecting the nodes of Italian internet high-bandwidth backbone (GARR) to the load nodes of the Italian high-voltage grid (HVIET); if these electrical load nodes are not loaded any more, the GARR node connected to them is switched off with a consequent repercussion on the network functionality.



WORKFLOW

The project workflow consists of evaluating the Quality of Service of the perturbed network (the electrical network, QoS^{EL}) and studying how it affects that of Internet network (QoS^{INT}).

After evaluating the QoS^{EL} in "normal conditions" we introduce a perturbation on the electrical network (such as node or link removal). If the load-flow is no longer satisfied, a power redispatching is performed which reduces the input and the output power flow. This reduces the QoS^{EL} defined as the difference between the expected and the received power. If the local QoS^{EL} reduces below a given threshold, the GARR node is switched off, a new simulation of data traffic is performed and a new QoS^{INT} evaluated. The correlation between QoS^{INT} and QoS^{EL} constitutes the final goal of the study.



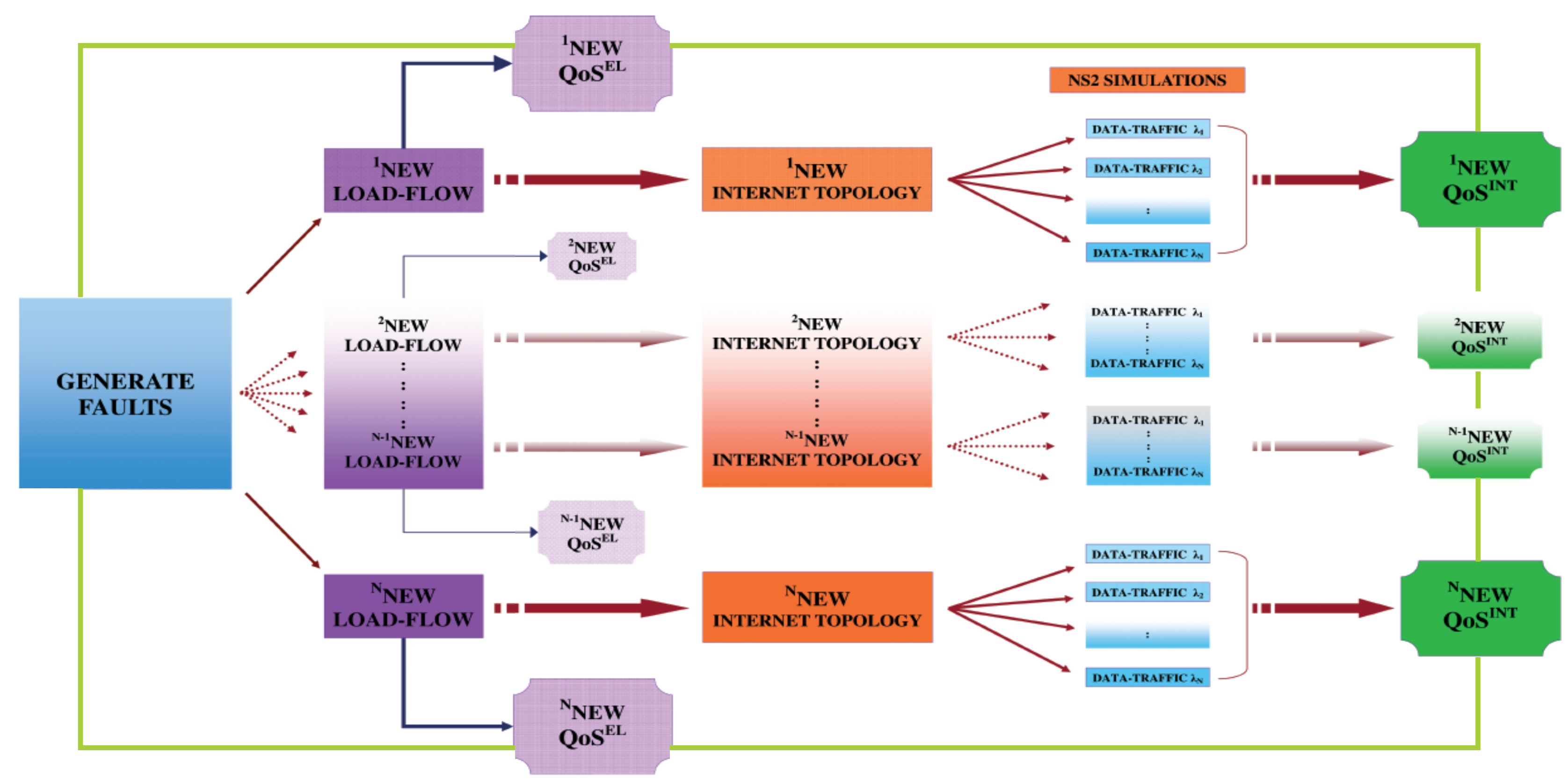
IMPLEMENTATION

The implementation consists of generating a set of faults on the electrical network (link removal) and evaluating (for each fault) a new power flow conditions of the electrical network (new load-flow). The new power flow conditions are determined by evaluating , for all nodes, the power iput/power output conditions as close as possible to those occurring before the fault and compatible with the new network topology. Upon power redispatching the electrical power received by each node is evaluated; if this is lower of a given threshold, the internet router connected to that electrical node is switched off and a new internet traffic simulation is restarted to evaluate the impact of the new Internet topology (without the off node) on the average time of packet delivery and then the new QoS.

For each 'new internet topology', we start N data-traffic simulations varying the amount of traffic to be dealt with by the network.

The workflow has been implemented on the ENEA-GRID structure. Each specific electrical fault (and the subsequent power redispatching) is performed on a given computational node. On the basis of the redispatching results, different data traffic simulations (each on a different computational node) are performed to test the efficiency of the faulted network under different traffic conditions.

The potentials of ENEA-GRID has allowed us to subject the various jobs simultaneously (one for each simulation) and gain, in a short time, the all results. Electrical data of Italian 380kV networks have been treated by using a custom load-flow (and redispatching) simulator while data traffic simulations have been carried out by using the NS2 tool.



PRELIMINAR RESULTS

A suitable Quality of Service of the electrical network has been defined as a function of the perturbation strength, measured in term of removed lines:

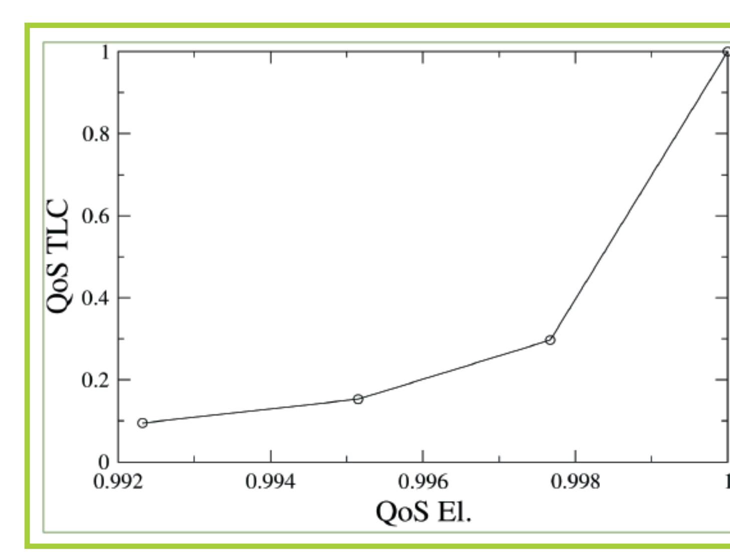
$QoS^{EL}=1-\sum[P_i-P^0_i]/\sum P^0_i$

Where P_i is the power flow perturbed of the node i and P^0_i the power flow in "normal condition".

The Quality of Service of Internet network has been defined as:

$QoS^{INT}=(m/M)/(\langle T\rangle/\langle T_0\rangle)$

Where m and M are respectively the number of generated and dispatched packets; $\langle T\rangle$ and $\langle T_0\rangle$ are the average delivery times in the perturbed and unperturbed phase. The preliminary results shows a strong non-linear dependence between the QoS^{INT} versus QoS^{EL}.



Variation of the QoS value for the telecommunication infrastructure with respect to the variation of QoS of the electrical networks.

V.Rosato, L.Issacharoff, F.Tiriticco, S. Meloni, S. De Porcellinis, R,Setola (2008) 'Modelling interdependent infrastructures using interacting dynamical models', Int. J. Critical Infrastructures, Vol.4, Nos. 1/2

NETWORK SIMULATOR NS2 AND ENEA-GRID

NS2 is a discrete event simulator that together with its companion Nam, the Network Animator, form a very powerful set of tools for study of the real networks. With NS2 it's possible to study e.g. wired and wireless (local and satellite) networks; create various routing algorithms; traffic sources like web, ftp, telnet, cbr, stochastic traffic; failures, including deterministic, probabilistic loss, link failure; various queuing disciplines. Nam is an animation tool for viewing network simulation traces and real world packet traces. It allows to visualize topology, packet level animation, and various data inspection tools.

We have implemented procedures within NS2 that allows us to study the performance of a data traffic network not only in terms of 'average delivery time' but also in term of number of active source or of the number of generated, dispatched or dropped packets. We can also analyze which link is a bottleneck.

To compute these parameters, we have used a unix script that allows us to launch several simulations on different Linux hosts of ENEA-GRID. Each job runs contemporaneously in batch mode.

The input parameters, used to vary source rate and source numbers, automatically change for each simulation. The output files are stored in a unique AFS (Andrew File System) volume and are visible from all hosts on which the distributed geographic file system is configured.

In the future we will try to integrate NS2 with other high level simulator to analyze the interdependent infrastructure.

Autori: E. Marchei, S. Di Blasi, V. Rosato
ENEA
www.cresco.enea.it