# PHOSPHORUS

Information Society Technologies

LAMBDA USER CONTROLLED INFRASTRUCTURE FOR EUROPEAN RESEARCH

## WP5: Supporting Studies

The main goals of this workpackage is to form a bridge between the research community and the other workpackages in Phosphorus. This lead us to identify a number of highly challenging research problems in the context of optical Grids, and through close collaboration with other Phosphorus partners, to propose solutions and perform studies for the next generation of Grid infrastructures. In particular, this workpackage has developed a simulation environment and performed studies to support the experimental activities of the project. Our simulation environment supports a wide range of optical Grid functionality, such as advanced routing strategies, QoS-aware resource scheduling algorithms, advance reservations, and resiliency techniques. Furthermore, we have developed various models for job demands in optical Grids, and proposed a number of algorithms to optimally design Grid architectures, incorporating specific optical Grid-related parameters, including impairment-aware design, anycast services and differentiated resiliency techniques.

WP5's main contribution is its highly advanced optical Grid simulator, released under the open-source GPL license

## Objectives

- To study and design resource management and job scheduling algorithms, addressing network-awareness, constraint-based routing and advance reservation techniques.
- To document and analyze recommendations for the design of an optical grid control/service plane.
- To develop a simulation environment to study and analyze advanced optical Grid architectures.
- To study and propose algorithms for the design and planning of optical Grid infrastructures, while taking different optical switching paradigms into consideration.
- To study and propose algorithms and strategies for providing resilient Grid operation, using both protection and restoration approaches.

## Developments

- In order to obtain accurate and useful results from simulations, it is important that a realistic grid job load is used as input for the simulation. We have detailed several of these **analytical job submission models**, and the process to extract the model parameters from actual grid log traces.
- We have proposed and evaluated **Quality of Service-aware** (QoS) and **fair scheduling algorithms** for Grid networks. These algorithms are capable of optimally or near-optimally assigning tasks to resources, taking into account the task characteristics, QoS requirements, and communication constraints.
- We have proposed **enhanced routing algorithms** capable of calculating optimal network paths considering a number of constraints such as the Grid user requirements and the physical layer characteristics. These algorithms aim to offer improved overall network performance and efficiency, optimize QoS levels and increase user satisfaction in service level agreements (SLAs).

- We have identified models of **network-based advance reservations** and embedded these in a broader context of advance reservations of various Grid resources. Subsequently, detailed studies on particular topics have been performed that cover topics such as resource management for advance reservations, comparison of centralized and distributed advance reservations architectures, and malleable advance reservations.

- We have developed a **simulator** that allows to make comparisons between different architectural and algorithmic proposals, and assists in evaluating them in a rapid and straightforward way. It supports a multi-domain, optical Grid network and both a detailed application model (to represent a wide range of service requirements) and an easily extensible resource (computing, storage, network) model. Furthermore, we have developed extensions that support the evaluation of scheduling and fault-tolerance algorithms in Grid environments, and implemented physical layer parameters in order to study constraint-based routing algorithms.

- We have studied the **design** of long-reach, high-capacity computational **lambda Grids**. In particular, we investigated two fundamental design areas: the optimization of the location and capacity of computational/network resources (dimensioning), and the architectural aspects of selecting an appropriate optical switching scheme.

- We studied **resiliency schemes** applicable to both Grid computational and network resources. Novel approaches for supporting reliable network design and resilient traffic engineering against network resource failures were proposed and evaluated through simulations. Furthermore, novel scheduling approaches that incorporate different fault-tolerance schemes against Grid resource failures have been proposed. Finally, a joint resilience study for combined optimization of both network and Grid resources has been presented.