Project Number: 031834

Project Acronym: EU-IndiaGrid

Project Title: Joining European and Indian Grids for e-Science Network Community

Instrument: Specific Support Action

Activity: Research Infrastructures

D3.2 – Proposed Network connectivity roadmap

Due on: 31/05/2007

Submitted on: 14/07/2007

Start date of project: 1 October 2006

Duration: 24 months

Organisation name of lead contractor for this deliverable: GARR

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	**Public**	X
PP	**Restricted to other programme participants (including the Commission Services)**	
RE	**Restricted to a group specified by the consortium (including the Commission Services)**	
CO	**Confidential, only for members of the consortium (including the Commission Services)**	

Document Identifier:	**EU-IndiaGrid-Deliverable D3.2**
Date:	**14/07/07**
Work Package:	**WP3: Network Planning Support**
Lead Partner:	**GARR**
Document Status:	**Final**
Document Link:	

Abstract:

Delivery slip

	Name	partner/activity	date	Signature
From:	Marco Marletta	GARR	10/7/2007	
Reviewed by:	Moderator and reviewers			
Approved by:	TB			

Document log

Issue	Date	Comment	Author
0- 1	3/7/2007	First draft	Marco Marletta
0- 2	10/7/2007	First version, including comments from Alberto Masoni and Dipak Singh	Marco Marletta
0- 3	12/7/2007	Second version, , including further comments from Alberto Masoni and Dipak Singh	Marco Marletta
0- 4			
0- 5			

Document change record

Issue	Item	Reason for change

Contents

1. INTRODUCTION

1.1. Purpose of the document

The purpose of this document is to give an overview of the perspectives of research networking in India, as long as its interconnection with GEANT2, the pan-European research network, focusing on a network connectivity roadmap to enhance the status of the networking in India.

1.2. Application area

This document is an EU-IndiaGrid Deliverable related to the work package WP3 – Network planning and support.

This document is addressed to project partners and to the involved community interested to the project activity.

2. EXECUTIVE SUMMARY

WP3 activity supports the Grid infrastructure from the networking point of view, and pursues all the technical and political solutions to improve it. Current status of research networking in India does not allow extensive use of Grid resources in cooperation with Europe and the rest of the world. One of the main advantages of the Grid paradigm is the possibility of use of computing resources regardless of their geographical localization. But without a broadband, capillary, flexible and reliable network infrastructure, it is virtually impossible to exchange huge amounts of data in limited time, which is especially crucial in case of applications with tight time constraints. One of the main requirements of the project is therefore to describe a roadmap to establish a reliable, effective and state-of-the-art broadband network infrastructure. Such requirement should be satisfied both at the levels of the international connectivity and of the national backbone, in order to achieve the best results and to avoid bottlenecks.

3. ASSESSMENT OF PRESENT RESEARCH NETWORK INFRASTRUCTURES

ERNET is the Indian Academic Education and Research Network while GARUDA embodies the Indian National Grid infrastructure together with DAE-Grid (the Department of Atomic Energy Grid) represent the main Grid (and research network) Infrastructures in the Country.

In this document we will focus on these three entities.

3.1. ERNET

ERNET is the Indian National Education and Research Network, and was built according to some main architectural choices.

- The network is composed of circuits leased from several commercial telecom suppliers. This fosters the competition between the commercial suppliers and allows to choose the cheaper supplier depending on the geographical placement.
- The routers interconnecting these circuits are centrally managed and configured by ERNET, that handles autonomously all routing and performance monitoring policies. This enables autonomous choices on where and how the network traffic flows, as long as allowing in-house service testing and delivery.
- The backbone interconnects several Points of Presence, all established in academic and research entities. This enables a cheaper and more effective interconnection of traffic centre of mass, such as research districts or campuses with several different academic entities. This enables also a bigger flexibility on service delivering, and a neutral point where different suppliers can install their transmission equipments.
- ERNET has connections with the commercial Internet in all of its Point of Presence and several interconnections with the National Internet Exchange of India (NIXI) are established in selected ERNET PoPs. This allows for efficient traffic management, since commercial traffic doesn't flow massively on the backbone and domestic traffic doesn't travel outside India.
- Since the network is run autonomously, it allows research and development in the area of data communication and of applications that make use of it.

3.2. GARUDA

GARUDA is the Indian National Grid Computing Initiative, and has an underlying network infrastructure to serve the communication needs of several Grid Computing centres across India. The network was built as a Proof of Concept with a finite duration, and was fully outsourced to a commercial supplier, namely Sify.

- The network is built as a Layer3 VPN, overlying on the supplier IP network infrastructure. This enables a huge reduction of costs, since no dedicated, long-distance backbone circuits are needed, and only interconnection from each site to the provider's PoP is provided.

- The customer's edge equipment installed in each GARUDA site needs only few implemented functionalities. This is again a reduction of costs.
- No direct management of large scale network resources is needed, all routing and configuration is handled directly by the provider. Thus no personnel is to be hired to manage the network core.
- The GARUDA traffic flows alongside with the traffic of all other Sify customers, but on a separate routing instance, so IP packets from other customers don't reach GARUDA sites, although they travel mixed on the provider's backbone.
- While eight GARUDA institutions participating in the Eu-Indiagrid project are already connected using public IP addressing, the rest of the GARUDA network use private IP addressing, thus these machines are unreachable from outside and communication in this direction is still impossible.

3.3. The gateway between ERNET and GARUDA

One of the main computing research sites in India, namely C-DAC Mumbai, is either an ERNET Point of Presence and a GARUDA site. Equipments of both network infrastructures were installed in the same campus not far from each other. In the same site, present 45Mbit/s circuit connecting Mumbai-Milan that interconnects ERNET with GEANT2 also terminates. Thus the C-DAC Mumbai site is the natural gateway between the two network infrastructures, allowing in principle all Indian research institutions connected via GARUDA (not only the ones participating in the Eu-Indiagrid project) to use the Mumbai-Milan link, together with all the Indian institutes connected via ERNET. This operation implies some changes:

1. The interconnection link between C-DAC Mumbai and GARUDA infrastructure was to be upgraded from 10Mbit/s to 100Mbit/s since it had to transport not only the traffic between C-DAC Mumbai and the rest of GARUDA, but also the traffic between GARUDA and the whole system of the academic networks throughout the world. This operation is so far (July, 2007) overdue.
2. On the Milan-Mumbai link, approximately 10.000 BGP routes are announced from GEANT2 to ERNET. These BGP routes represent all the academic and research network IP addresses, and allow the reachability of these destination by the routers that receive them. To extend this reachability up to all GARUDA sites, all these routes must be announced to the GARUDA network, using one of the two following approaches (the choice depends on the current setup of the L3VPN and on the feasibility of the changes):

- All GARUDA customer edge routers must have an IP-over-IP tunnel up to ERNET router in Mumbai. Public addresses are to be routed over this tunnel, and a BGP session is established between each GARUDA router and the ERNET router. This solution requires mainly software changes but might imply some hardware or software release changes on GARUDA sites border routers if those are not enabled to use BGP. Since these changes cannot be funded by the GARUDA project, it is possible that some users refuse to accept these changes.
- The commercial provider (Sify) must implement a Layer3 VPN functionality called "carrier supporting carrier". This will allow to exchange all the internal routes between GARUDA

and ERNET crossing the Sify backbone, thus resulting in direct reachability of next-hops between the two networks that otherwise wouldn't have been guaranteed because of the unawareness of the Sify backbone of ERNET next-hops. Then, a BGP session between all GARUDA sites and the ERNET router in Mumbai will propagate the GEANT2-received routes, and allow their reachability from GARUDA. This solution is more efficient since it does not requires the IP-over-IP encapsulation, but requires the exchange of routing informations and MPLS labels between the carrier and ERNET.

Currently the situation is that all the routes learnt from GEANT by ERNET router in Mumbai are announced to the neighbouring GARUDA router in Mumbai, and then propagated by Sify via the L3VPN to some selected GARUDA sites. This arrangement can be extended to all GARUDA partners to provide connectivity between them and the rest of the research community throughout the world.

3.4. DAENet

The Department of Atomic Energy of the Government of India has promoted a Grid network infrastructure between 4 major sites, namely

- BARC Mumbai (Computing with shared controls)
- VECC Kolkata (real-time data collection)
- IGCAR (wide-area data dissemination)
- CAT (archival storage)

Each site has Grid resources and tools deployed and made available to the others via the communication network. The infrastructure is composed of 4Mbit/s links and represents a private network, thus with no communication with the outside world. It is operational since April 2006.

4. A ROADMAP TO A NEW NETWORK

India's tremendous development in either scientific, industrial and human fields of knowledge requires an adequate development of the network infrastructure.

The present situation of networking in India doesn't allow the big expansion of requirements that such a huge country will require in the next years. It is thus required a new network paradigm to take place in the future.

The Government of India is working hard to set up a new high speed network (see the National Knowledge Network initiative described in section 5). The establishment of a new network in India would be a challenging project, since it will require a lot of human and economic effort.

The network design should be an optimal compromise between what is available on the market and a foresight of future technologies and requirements. Several elements and building blocks must be considered in the design of a digital communications network, and will be examined in the following paragraphs..

4.1. Dark fibre

Owned dark fibre is definitely the enabling substrate of any modern network infrastructure. Current technologies allow for multiple high speed channels to be transmitted over several hundreds (and even thousands) of kilometres without regeneration of the signal, simply adding amplification sites in the middle, resulting in a virtually infinite network bandwidth availability.

Dark fibre is often extensively available from commercial providers, that lay cables with multiple optical fibres in them. It is somehow difficult to find capillary availability of fiber cables in less developed regions, where the public intervention is needed to remove the "digital divide" problem.

It is often preferable not to lay or to buy long fiber spans when possible. This is mainly due to the fact that it is often difficult to share the enormous costs of laying a large dark fiber infrastructure, and to the fact that fiber may become obsolete after some tenths of years. Commercial carriers themselves often trade fiber spans between them. It is thus recommended to acquire the dark fiber using "indefeasible right of use" contracts for multiple years, to benefit from lower prices and contractually guaranteed availability of the resource for a long time.

4.2. DWDM

Dense Wave Division Multiplexing technologies currently allow for 64 up to 192 10Gbit/s or 40Gbit/s channels to be multiplexed on a single pair of dark fibres. This gives an idea of what amount of bandwidth can be made available to the bandwidth-hungry scientific applications that run nowadays on academic and scientific networks.

Building an own network based on this technology require a firm knowledge of the implementation details and on physical phenomenons that rule the transmission of optical power on optical fibres, but allows also an unprecented flexibility in deploying new services and adding more bandwidth in case of need. Several scientific applications require huge communications channels without big intelligence added to them, and using DWDM it is possible to supply these channels (often called "lightpaths") to a limited number of "big users" without the need of crossing several expensive router or switch interfaces in the middle. DWDM can be a considerably cheaper solution because of the lower cost of interfaces on this type of equipment. In fact, IP routers and switching equipment will have similar transmission and switching components, but the latter do not have nor need the ASICs and software required for advanced IP services.

New products add protection mechanisms and switching capabilities to the optical layer, resulting in a completely new set of features and services that can be made available to the Indian scientific community.

4.3. Points of Presence

The Points of Presence of the network are the place where the network and the users meet each other. Establishing points of presence inside the bigger academic and research campuses allows these institutions to be “on the network”, and interconnecting most of the others using short fiber spans or metropolitan ring fiber networks is a strategical choice that enables them to use all the new services.

The network points of presence can be also collection points for circuits or MPLS services from local service providers that can reach other institutions not reached by the owned dark fiber. In any case, all services must be supplied by the owned network infrastructure, using the providers’ infrastructures only to reach and collect geographically sparse institutions.

4.4. Geographical spread

It is a simpler task to build a completely owned network in a small country. Reaching Indian geographically sparse institutions with owned dark fiber will be for sure a technical and economical challenge.

Lower speed circuits or shared technologies such as MPLS can be used to collect these sparse users only up to the closest network point of presence, where it will be possible to use immediately the services of the scientific network without having to cross the service provider’s network.

4.5. Public IP addressing

It is crucial to provide as many as needed public IP addresses to all the machines connected to the network. Grid applications, as long as videoconferencing applications or collaboration tools need public IP addresses to work.

NAT and strict firewall security policies reduce the ability of the scientific applications to work at full speed, exploiting the capacity made available by the new transmission technologies. Of course this means that firm security procedures must be carried out to cope with modern threats without compromising the performances. The introduction of large scale IPv6 usage is most suited for this requirement.

4.6. Access to commercial networks

The ability to access resources outside of the academic worldwide network with no bandwidth restrictions is also important for the researchers everydays’ work, to download software as long as hardware documentation, and to be able to participate in the development of the worldwide information and communication society.

High bandwidth gateways to commercial carriers' networks can be contracted effectively by one unique entity on behalf of all academic and research organizations as a whole instead than having a double connection for each site, one for research and one to reach the commercial internet.

The traffic can travel on the academic network together with the research traffic, possibly with lower priority in order that it can be discarded in favor of the research traffic in case of congestion.

The connection of the gateways can happen in the most commercial cities such as Mumbai, Chennai, Cochin (where are submarine cables landing points), or Delhi, where competition between carriers can lead to lower prices, so that institutions placed in less developed areas can benefit from the overall contractual power of the Indian research institutions.

From another point of view, the creation of Internet eXchange Points (IXP), where commercial, research and government networks exchange traffic between them, is another great incentive for the development of the information society. In several countries worldwide, such IXPs are often hosted by research entities for their intrinsic neutral and non-commercial nature. All the participants install their equipments in their premises, and establish BGP peerings to exchange the traffic of their own connected users for no cost. This way national or regional traffic does not cross expensive long distance or international links, and can reach much faster the desired destinations.

Within this perspective, The National Internet eXchange of India (NIXI) centres are in operation at Noida (Delhi), Mumbai, Chennai, Kolkata to allow exchange of routes for domestic traffic. ERNET as long as all the commercial service providers are connected to NIXI in all these cities. New NOCs of NIXI are coming up at Bangalore, Hyderabad, Ahmedabad, Lucknow and Chandigarh.

4.7. Collecting the efforts

It is really strategic that all research institutions act together to build a new infrastructure. The network can fulfil the needs of many different user types, from the bandwidth-hungry high energy physics experiment, to the videoconferencing user, up to the single researcher browsing the internet. All of them can find a fast and reliable work instrument in a new and modern general purpose network infrastructure. There is no need to build, procure and operate separate network for different research projects, provided that it is possible to provide overlay networks on a general purpose infrastructure owned by all the involved institutions.

5. THE NATIONAL KNOWLEDGE NETWORK

In December 2006, the Indian National Knowledge Commission (NKC), after consultations of a group of network experts, potential users, telecom service providers and government officials, submitted to the Government of India a proposal to create an integrated National Knowledge Network, to connect all research laboratories, universities and education institutions via an high speed network. It was identified that research and development activities require increasing computing power, live collaboration and data and resource sharing, and was recommended that all of these were to be provided via broadband (100Mbit/s and more) connectivity.

The main challenge is that the number of institutions to be connected all across India is approximately 5000, but starting with a first phase where 500 or 1000 are to be chosen. The priority, according to NKC, is to be given to institutions able to use immediately the new network, and able to show the benefits of the high available capacity.

The strategic options for the new infrastructure, include the hiring of long distance dark fibres and the acquisition of the equipments needed to light them. Other options include leasing lit fibres or lambdas (not requiring investments in transmission equipments) from commercial network operators. A mixed approach where the high bandwidth core is entirely owned, and the capillary access network is provided by commercial operators is also taken into account.

Various phases are envisaged to reach the proposed goal. A very first phase, where the utilisation of the commercial operators to provide leased circuits is considered, presents the undeniable advantage that no capital cost is involved to build the infrastructure. Afterwards, the mixed approach is recommended, where a central core is fully owned and the outer circuits are built over the operators' networks.

The foreseen architecture is recommended to be built using IP/MPLS technologies, with well defined hierarchical levels: a core layer, an aggregation layer and an access layer, to provide the same fast and reliable services to all users.

Concerning the congruence between the National Knowledge Network and the government agencies and office connection needs, it is suggested that the two networks to remain uncorrelated, since the e-government network should be based on a much higher geographical spread and a much lower bandwidth. Such requirements are well suited by VPNs built over commercial networks.

The National Knowledge Network should be chaired by a group of professional experts, pooled from selected institutions to coordinate and manage the implementations. The property of the NKN is suggested to be taken by the stakeholders to allow the government to withdraw from direct operations activities in the informations technology sector, and to have the possibility to hire high profile network specialists that require high remuneration.

6. REFERENCES

R 1	Project website	http://www.euindiagrid.eu/
R 2	Project partners website	http://partners.euindiagrid.eu/
R 3	ERNET website	http://www.ernet.in/
R 4	EGEE website	http://public.eu-egee.org/
R 5	GARUDA website	http://www.garudaindia.in/
R 6	EC eInfrastructures website	http://www.einfrastructures.org/
R 7	CORDIS website	http://www.cordis.lu/ist/home.html
R 8	GEANT2 website	http://www.geant2.net/

7. TERMINOLOGY

Glossary

Term	Definition
GARUDA	India's National Grid Computing Initiative
VPN	Virtual Private Network
IISc	Indian Institute of Science
IIT	Indian Institute of Technology
C-DAC	Centre for Development of Advanced Computing, India
DIT	Department of Information Technology, Government of India
MIT	Ministry of Information Technology, Government of India
TIFR	The Tata Institute of Fundamental Research, India
DST	Department of Science & Technology, Government of India
DAE	Department of Atomic Energy, Government of India
BARC	Bhabha Atomic Research Centre, DAE, Government of India
VECC	Variable Energy Cyclotron Center, Calcutta
NKC	National Knowledge Commission
NKN	National Knowledge Network