Grid Status in India and National Knowledge Network (NKN)

P.S.Dhekne,

Scientific Consultant to PSA to Govt. Of India and Raja Ramanna Fellow, BARC
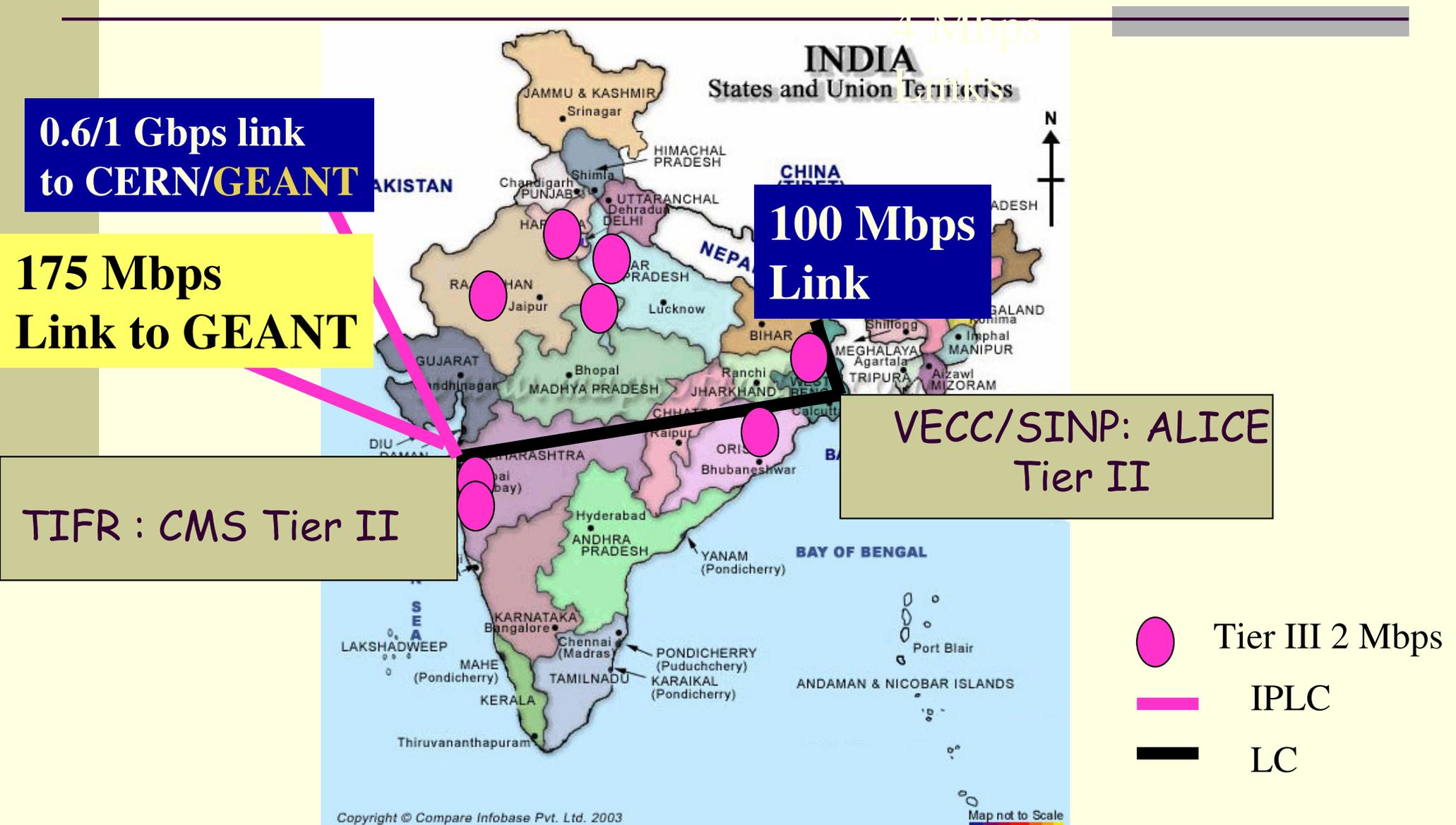
Mega Science Projects

•The LHC and Astro-particle physics experiments offer new glimpses beyond the current frontiers.

- LHC experiments will produce **10-15 million Gigabytes** of data each year (about 20 million CDs!)
- LHC data analysis requires a computing power equivalent to **~ 100,000 of today's fastest PC processors**.
- Requires many cooperating computer centres, CERN providing only ~20% of the CPU power

And the computing infrastructure to support such physics research needs to look beyond the cutting edge.

Regional WLCG Tier II Grid in India

0.6/1 Gbps link to CERN/GEANT

175 Mbps Link to GEANT

100 Mbps Link

VECC/SINP: ALICE Tier II

TIFR : CMS Tier II

Tier III 2 Mbps

IPLC

LC

Original Network started operating since 2007 and upgraded on regular basis

International Connectivity

- **Current status**
  - - **TIFR-CERN link (0.6/1Gbps)**
  - - **ERNET-GEANT link(175 Mbps)**
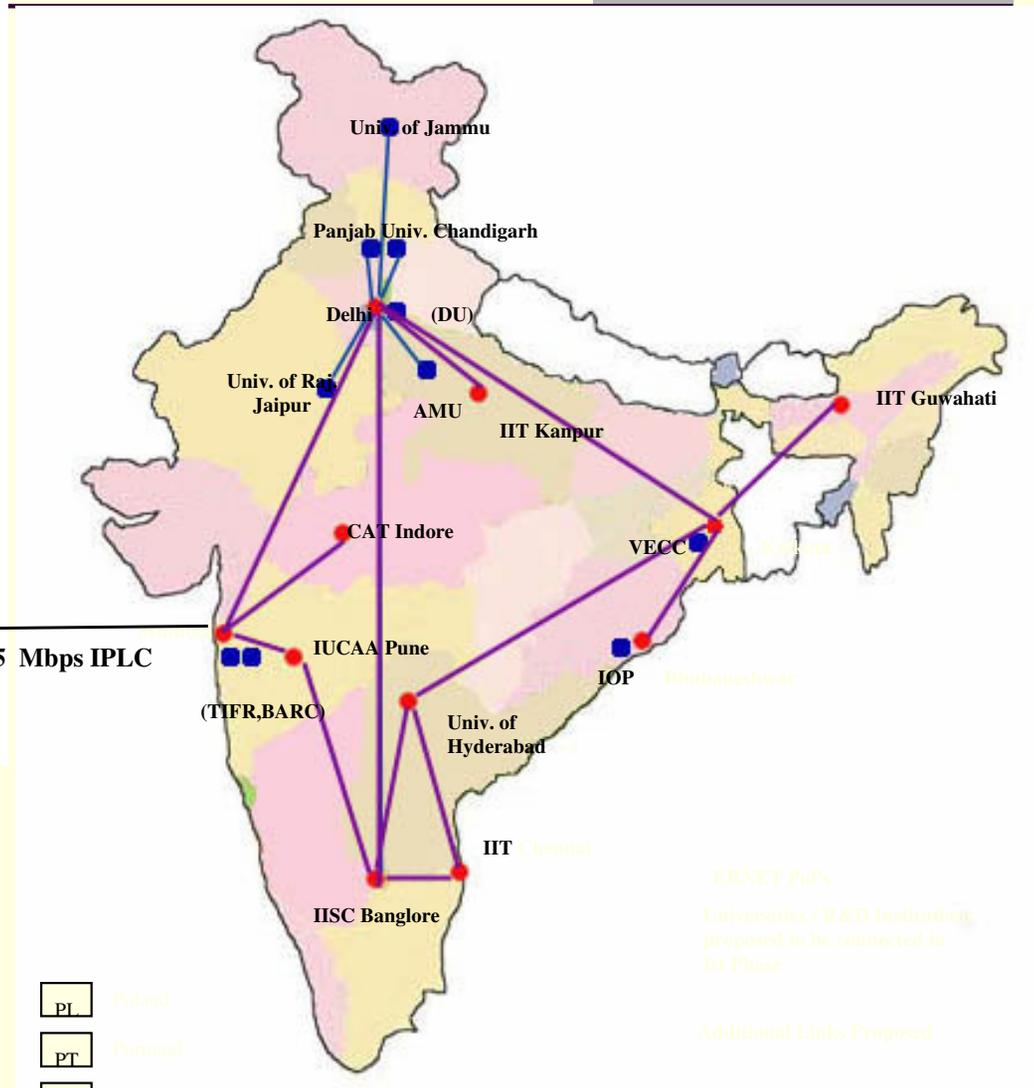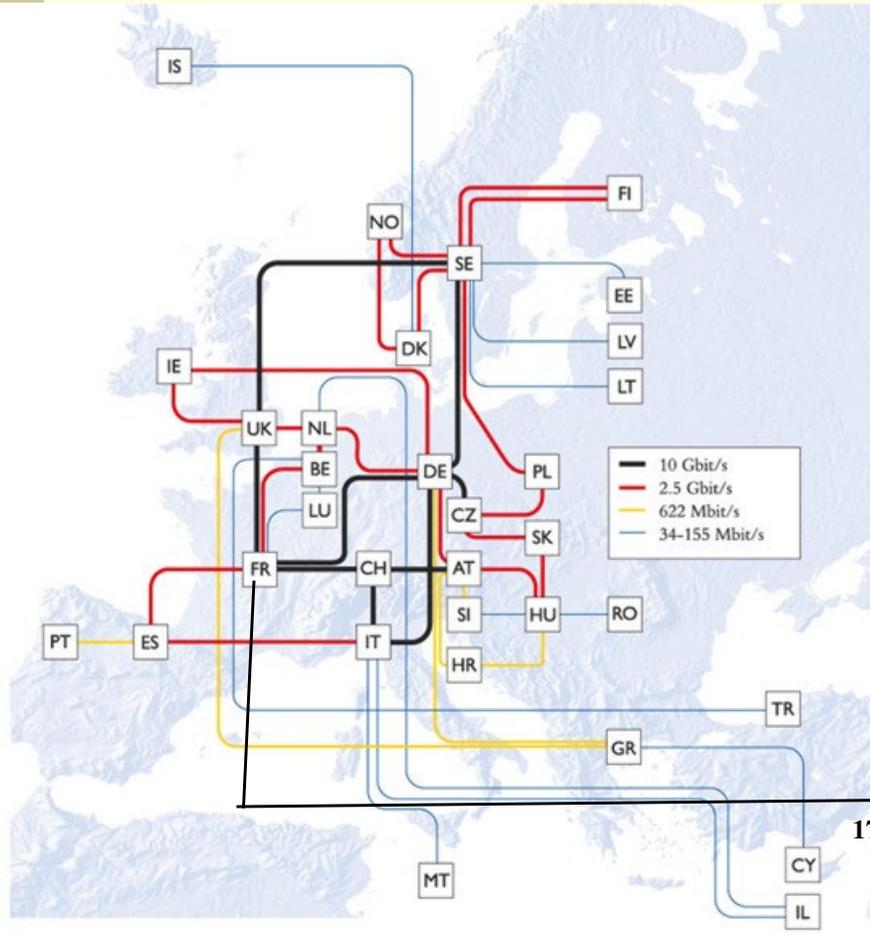
- **Participation in TEIN3**
  - From India, ERNET was nominated to participate in South Asia Feasibility Study(SAFS) meetings of TEIN3.
  - SAFS report accepted by EC
  - During SAFS meeting, we had projected 2.5 Gbps connectivity to India toward GEANT PoP in Europe and toward East Asia PoP of TEIN3
  - We are going to participate in network procurement phase of TEIN3 for South Asia

- **Connectivity to Internet2**
  - To connect to TEIN3 PoP at Singapore at 622 Mbps from India

- **Proposal from Japan for PoP in Chennai**

Spread of ERNET in India

Legend (European map):
- ▬ 10 Gbit/s
- ▬ 2.5 Gbit/s
- ▬ 622 Mbit/s
- ▬ 34–155 Mbit/s

175 Mbps IPLC

India map labels:
Univ. of Jammu, Panjab Univ. Chandigarh, Delhi (DU), Univ. of Raj Jaipur, AMU, IIT Kanpur, IIT Guwahati, CAT Indore, VECC, IUCAA Pune, (TIFR,BARC), Univ. of Hyderabad, IOP, IIT, IISC Banglore

- Multi-Gigabit pan-European Research Network
- Connecting 32 European Countries and 28 NRENs
- Backbone capacity in the range of: 34Mb/s-10Gb/s

|									
AT	Austria	DK	Denmark	HR	Croatia	LT	Lithuania	PL	
BE	Belgium	EE	Estonia	HU	Hungary	LU	Luxembourg	PT	
CH	Switzerland	ES	Spain	IE	Ireland	LV	Latvia	RO	
CY	Cyprus	FI	Finland	IL	Israel	MT	Malta	SE	Sweden
CZ	Czech Republic	FR	France	IS	Iceland	NL	Netherlands	SI	Slovenia
DE	Germany	GR	Greece	IT	Italy	NO	Norway	SK	Slovakia
								TR	Turkey
								UK	United Kingdom

# Traffic Analysis

(ERNET –GEANT 175 Mbps link)
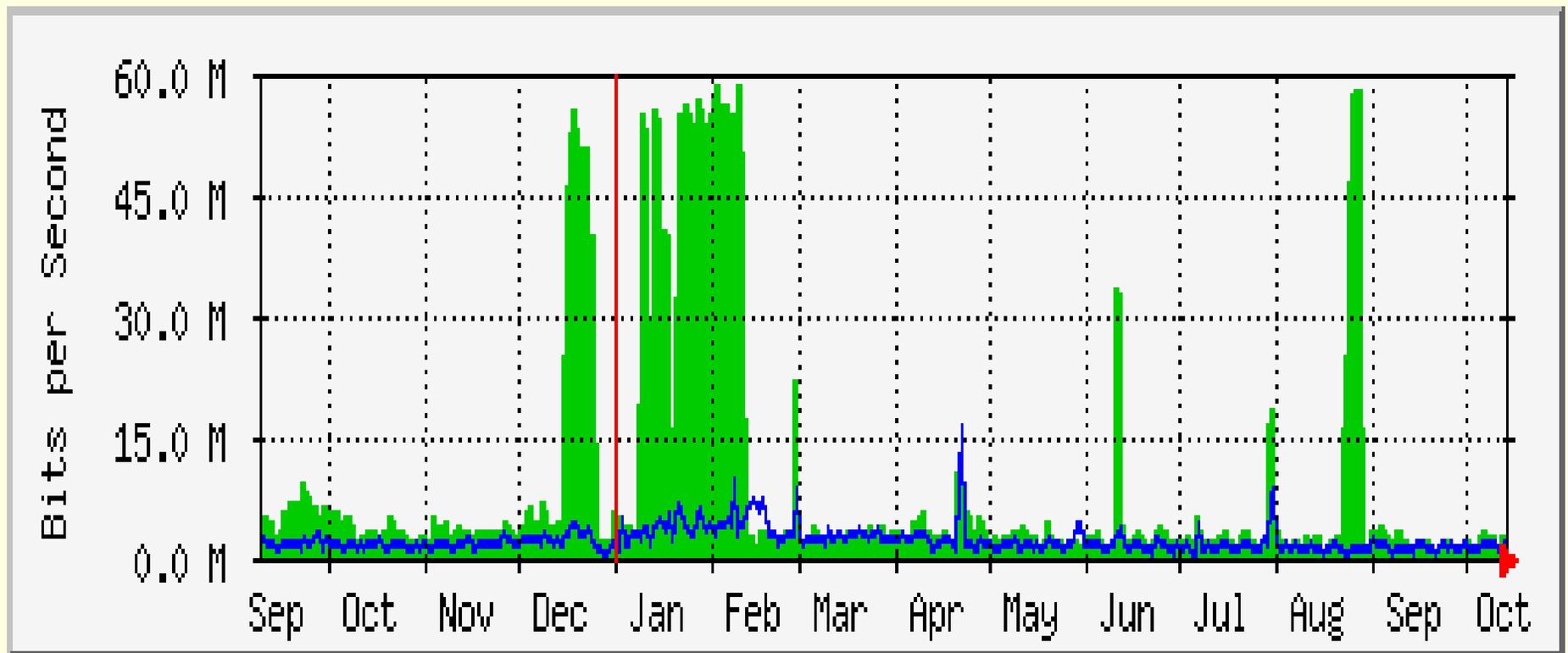
TIFR – CERN 1 Gbps link
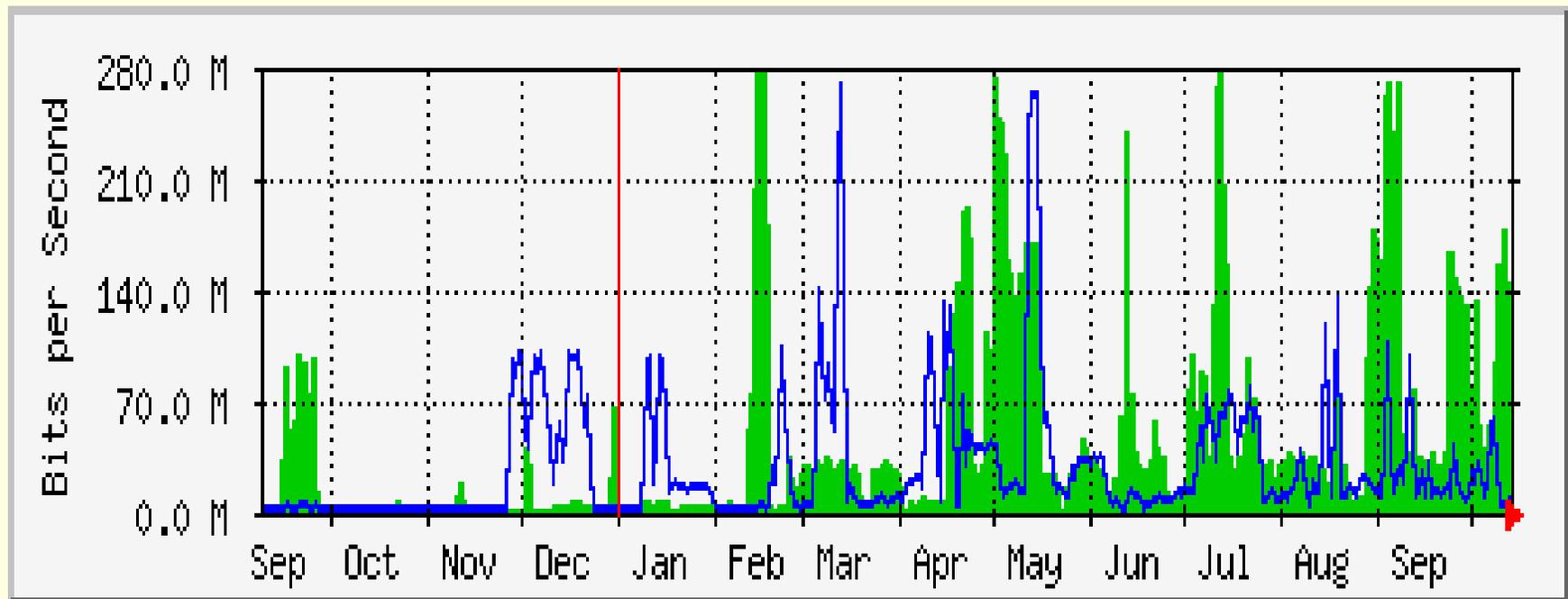
National Grid: Garuda by C-DAC

- The Proof of Concept network was established in collaboration with ERNET

- The MPLS Virtual Private Network (VPN) connects 22 institutions at 100 Mbps and 23 institutions at 10 Mbps across 17 Indian cities with SLA agreements

- Collaborative environment enabled through Video Conferencing over IP at the following centres of C-DAC : Bangalore, Pune, Chennai, Hyderabad, Mumbai and Trivandrum
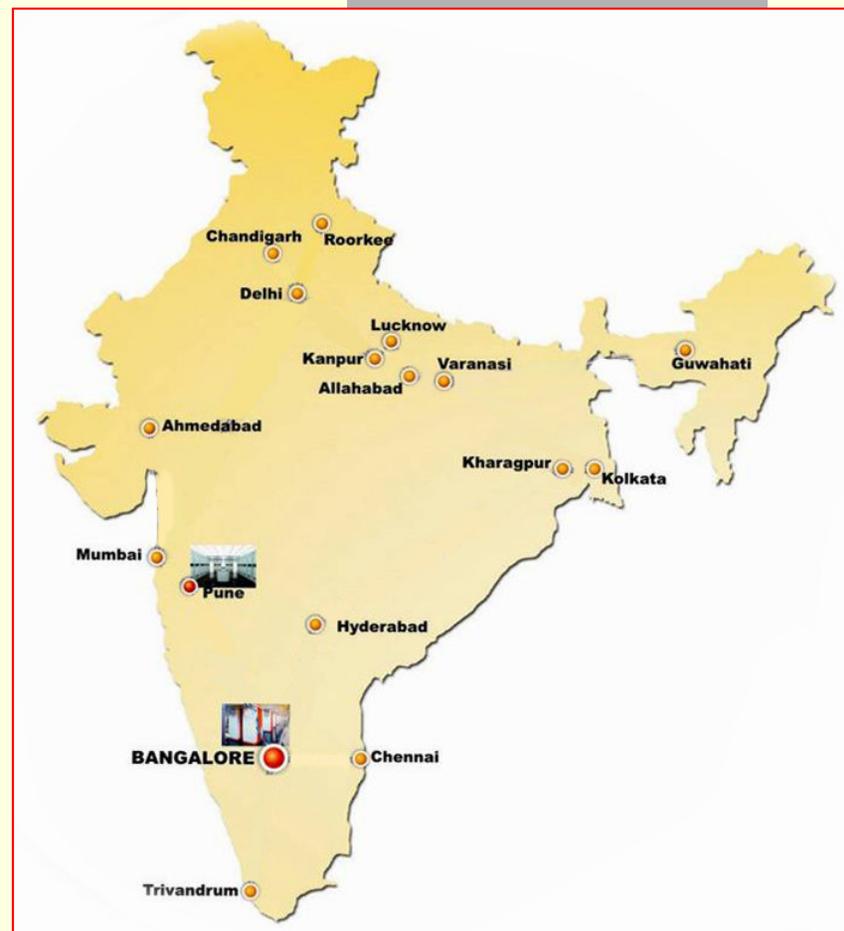
This project passed successfully from proof-of concept to foundation phase and now a phase 3 (Grid Technology services for operational phase of Garuda) has been approved.

The EU-IndiaGrid Project Joining European and Indian grids for e-science

- **To support the interconnection and interoperability of the prominent European Grid infrastructure (EGEE) with the Indian Grid infrastructure for the benefit of eScience applications**

- **Two year project started from Oct 2006 with BUDGET of 1208 k-EUR total fund out of which 1015.9 k-EUR from European Commission (5 Europe & 8 Indian partners)**

- **Person months**
  - **353.3 PM total**
  - **226.4 PM funded from European Commission**

PARTICIPANTS

EUROPE

- **Italian National Institute of Nuclear Physics, INFN (project coordinator),**
- **Metaware SpA,**
- **Italian Academic and Research Network (GARR)**
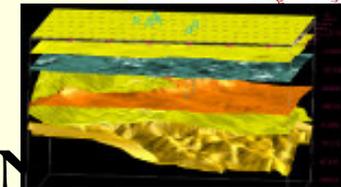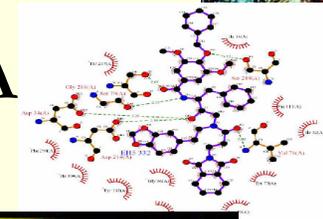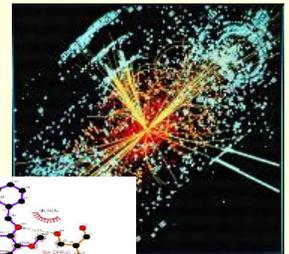- **Cambridge University**

INTERNATIONAL

- **Abdus Salam International Centre for Theoretical Physics (ICTP)**

INDIA
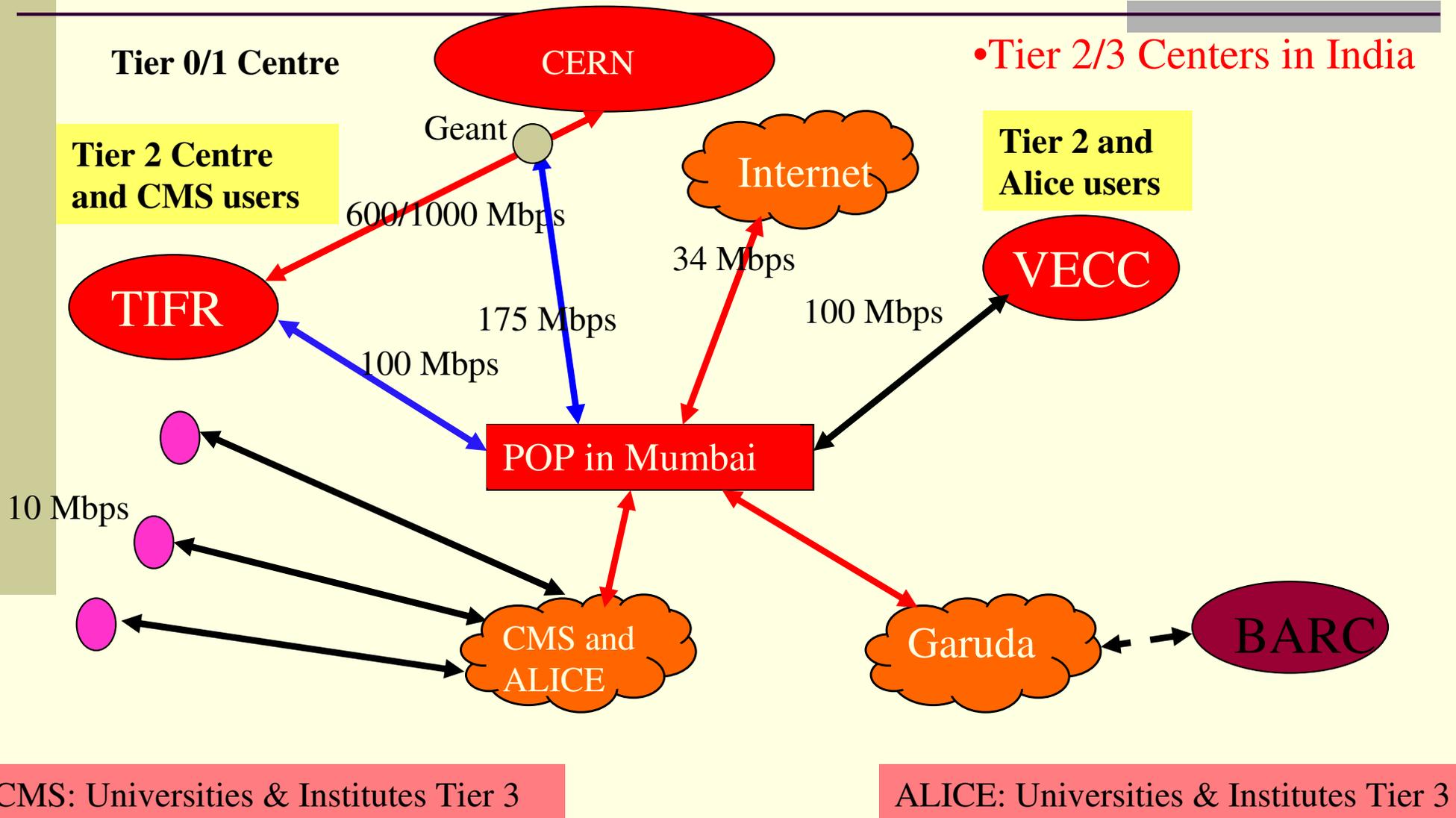
- **Indian Education and Research Network (ERNET),**
- **University of Pune,**
- **SAHA Institute of Nuclear Physics, Kolkata,**
- **Centre for Development of Advanced Computing (C-DAC),**
- **Bhabha Atomic Research Centre, Mumbai**
- **TATA Institute for Fundamental Research (Mumbai) National Centre for Biological Sciences (Bangalore)**
- **Variable Energy Cyclotron Centre (VECC) Kolkata**

EU-IndiaGrid Mission

- **Quickly set up Grid Infrastructure**
  - Use production Grid-WLC and connect GARUDA
  - Interoperate with EGEE Euro-Grids
  - Contribute to Grid standardisation efforts
- **Support applications from diverse communities**
  - High Energy Physics…………. DAE units
  - Condense Matter Physics …Pune Univ, TIFR, BA
  - Bio-Sciences……………………… NCBS
  - Climate/Earth Sciences …. MOES
- **Business**
  - E-governance interested business partners… N

+ Disseminate knowledge about the Grid through training
+ Prepare for sustainable European Grid Infrastructure

WLCG, GARUDA & EU-IndiaGrid

Tier 0/1 Centre

CERN

•Tier 2/3 Centers in India

Geant

Tier 2 Centre and CMS users

Internet

Tier 2 and Alice users

600/1000 Mbps

34 Mbps

VECC

TIFR

175 Mbps

100 Mbps

100 Mbps

POP in Mumbai

10 Mbps

CMS and ALICE

Garuda

BARC

CMS: Universities & Institutes Tier 3

ALICE: Universities & Institutes Tier 3

Operational since Feb 2008

Indian Grid Certification Authority

- ASGC played the role of Grid CA for India till recently

- First Grid CA in India was established at C-DAC, Banglore; Indian Grid Certification Authority (IGCA) accredited by APGridPMA

- C-DAC presented IGCA in APGridPMA Face to Face meeting on 16th Sep 2008 @ OGF24, Singapore.

  - Reference: http://www.ogf.org/OGF24

    http://www.apgridpma.org/meetings/index.html

- IGCA formally inaugurated on Jan 14, 2009 by Dr. R Chidambaram , PSA to Govt. of India and presided by Secretary, DIT

- IGCA is fully operational now and issuing user and host certificates

Non-HEP applications

- A new VO called euindia was setup to support non-HEP applications

- WP5 provided a quick gLite HOW-TO for EU-IndiaGrid users:

  - how to get personal certificates, register to euindia VO, download and use UIPnP, simple glite-* commands, references to gLite official Users Guides and API documentation
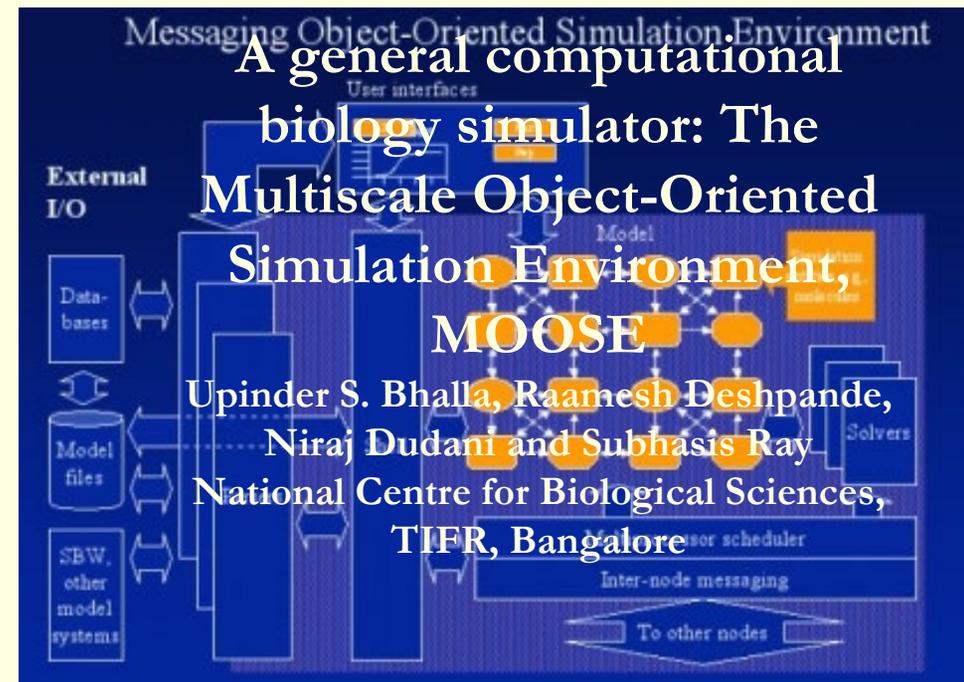
  http://grid-it.cnaf.infn.it/cresti/euindiagrid/wiki/index.php?n=WP5.0EuindiaVOQuickUserGuide

- The VO has currently 28 members (12 European and 16 Indian)

- >8000 jobs executed and >10 CPU.years consumed

Biology

■ Focused on porting to grid the Multiscale Object-Oriented Simulation Environment (MOOSE)

- Work lead by NCBS team in Bangalore, collaborating with University of Cambridge
- Compute intensive application
- Some models partitionable in loosely coupled sub-models which can run independently
- boosted from Bangalore workshop in Apr.07
- Results achieved:
  - code optimization
  - devel. of simulation code for bacterial chemotaxis with MOOSE
  - porting to GARUDA completed
  - tests on gLite based grid started
  - presentation at eScience07

A general computational biology simulator: The Multiscale Object-Oriented Simulation Environment, MOOSE

Upinder S. Bhalla, Raamesh Deshpande, Niraj Dudani and Subhasis Ray
National Centre for Biological Sciences, TIFR, Bangalore

Condensed Matter Physics

- Many different research groups within University of Pune and ICTP (+ SISSA and Democritos researchers)

- Different applications/porting approaches: from trivial parameter-sweep computational tasks to tightly coupled MPI parallel programs

    - Real Space Density Function Code for Quantum dots (University of Pune)

    - Equilibrium geometries of atomic clusters using VASP code (University of Pune)

    - Quantum-Espresso suite for electronic-structure calculations and materials modeling at the nanoscale (ICTP)

    - Biased Exchange Metadynamics algorithm based on Gromacs MD package (ICTP)
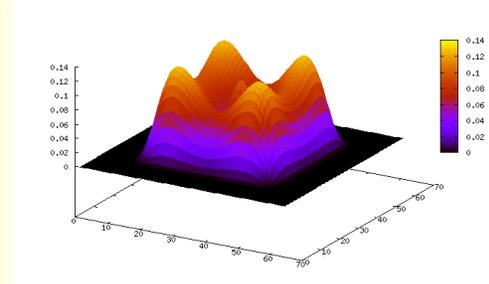
Physics of Quantum Dots

$$H\Psi = [T + V + U]\Psi = \left[\sum_i^N -\frac{\hbar^2}{2m}\nabla_i^2 + \sum_i^N V(\vec{r}_i) + \sum_{i<j} U(\vec{r}_i, \vec{r}_j)\right]\Psi = E\Psi \qquad V_{imp} = Ae^{-B(x^2+y^2)}$$
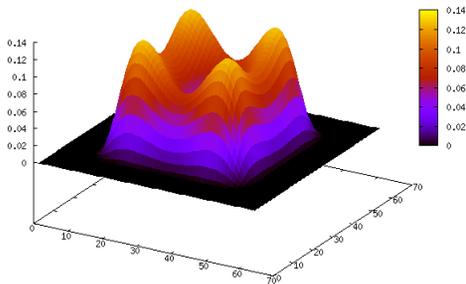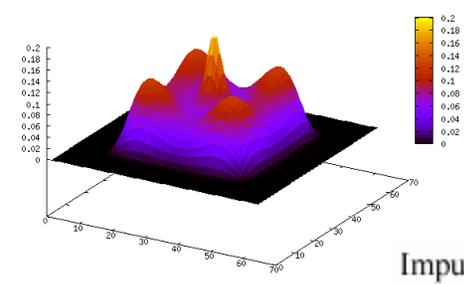

QD with N=5, Spin Sz=1/2;

Area=125.44 X 125.44 nanometer

Impurity strength- A = -0.5 (weak)

Impurity strength- A = -1.5

(Other parameters remaining same)

Observe the formation of small peak at impurity location *i.e.* at the center.

Impurity strength- A = -2.5

(Other parameters remaining same)
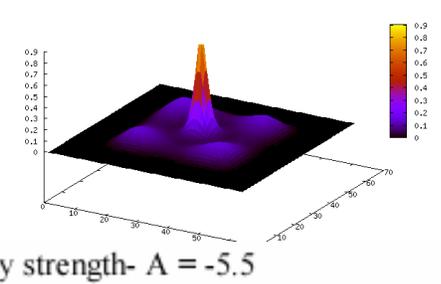
Impurity strength- A = -5.5

Observe the strengthening of the central peak with strengthening of impurity.

Many iterations with many initial guesses, each with different spin and impurity parameters → thousands of independent jobs

Quantum-Espresso suite porting

- Tightly coupled MPI parallel program

- Doesn't fit with MPICH over Ethernet implementation typical of gLite based resources (latency and bandwidth limitations)

- New approach : use most recent multicore WNs to run small parallel jobs exploiting shared memory for communication

- Python utility developed to reserve a full WN on a CE, more details at:

  http://partners.euindiagrid.eu/deliverables/D5.2.html

Biased Exchange MD algorithm

- BEM is a new approach to the protein folding problem

- Parallel code but loosely coupled (low communication/computation ratio)

- Asynchronous client/server communication mechanism developed to overcome poorly MPI support on gLite

- First results presented at eScience07:

Approaching protein folding problem using EU-IndiaGRID infrastructure

Stefano Cozzini(1,2), Riccardo Di Meo(1,2), Alessandro Laio(3), Fabio Pietrucci(1)
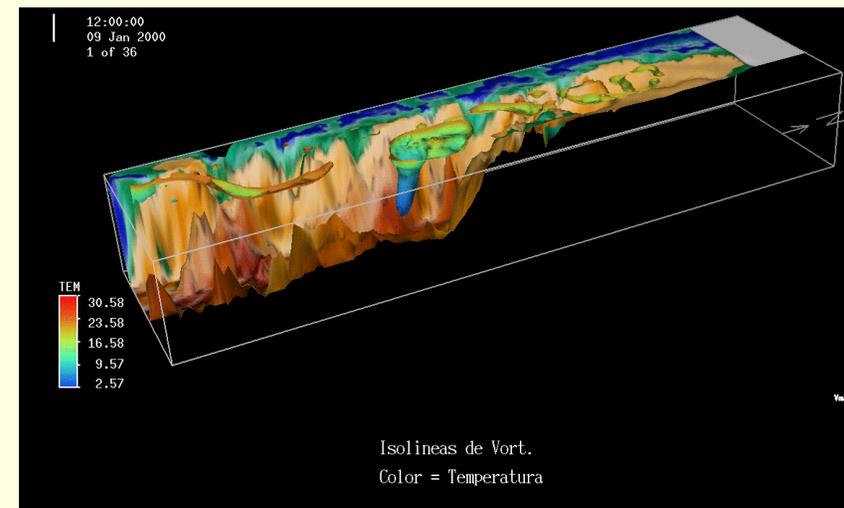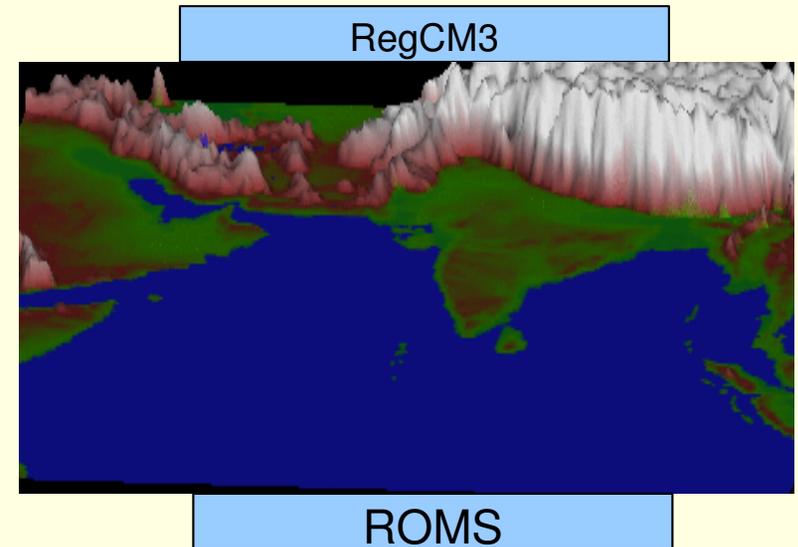
1.International School for Advanced Studies (SISSA), Italy

2. DEmocritos MOdelling Center for Research In ATOmistic Simulation (Democritos), Italy

3. International Center for Theoretical Physics (ICTP), Italy

Earth & Atmospheric Sciences

- Physic of Weather and Climate group at ICTP and Computational Atmospheric Science group of C-DAC/Pune
- Focus on developing a Regional coupled atmosphere-ocean model system for the prediction of the Indian summer monsoon
- Regional Climate Model (RegCM3)
- Regional Ocean Modeling System (ROMS)
- Results achieved (some presented at EGEE User Forum in May 2007):
  - RegCM3 and ROMS ported to both GARUDA and gLite
  - Prove of concept with limited problem size (few MBs, one CE only)
  - Coupled system tested on gLite
- Next steps: implementing adequate data management, increasing problem size to enable realistic simulations

RegCM3

ROMS

12:00:00
09 Jan 2000
1 of 36

TEM
30.58
23.58
16.58
9.57
2.57

Isolineas de Vort.
Color = Temperatura

Earth & Atmospheric Sciences

- Very recently, at Pune Workshop of September, the Seismology group of C-DAC Pune successfully ported to both GARUDA and EU-IndiaGrid infrastructures a Travel Time Tomography application

- Loosely coupled parallel code, good for MPI-enabled resources

- Proof of concept carried out with limited problem size

- Plan for the next period:
  - run TTT with bigger problem size and hence larger exploration space
  - exploit a larger number of processors

New Projects with Europe

• The EU-IndiaGrid project fully achieved its objectives and technical goals and even exceeded expectations

• As a results of excellent achievements, two year second phase Eu-IndiaGrid2 project - Sustainable e-Infrastructures across Europe and India, funded by EC, was approval, with start date 1/1/2010

• New proposal for Co-ordination and Harmonization of Advanced e-INfrastructures (CHAIN) is expected to reinforce coherent synergy between India & Europe and would help in consolidating India's multi-gigabit, low latency, e-infrastructure: National Knowledge Network (NKN).

National Knowledge Network: Objective

- The objective of the National Knowledge Network is to bring together all the stakeholders in Science, Technology, Higher Education, Research and Development, GRID Computing, e-governance with speeds scalable eventually up to the order of 10s of gigabits per second coupled with extremely low latencies.

- NKN will interconnect all the research, higher education and scientific institutions in the country, over a period of three years.

- The joint proposal for the establishment of NKN was initiated by the PSA's Office and the National Knowledge Commission and then taken up by the Department of IT.

Action Taken

- NKN was first announced in the budget/2008 - 100 Cr. initial allocation
- High Level Committee (HLC) was formed
- Technical Advisory Committee was set up for designing NKN
- NIC will manage the implementation of the project and prepare the DPR
- HLC decided to implement the same in two phases
    - Initial Phase
    - Final Phase
- Initial Phase: By augmenting NIC's Points of Presence at 15 locations (2.5 gbps) and to provide 1 Gbps links to 57 institutions
- NKN will enable Sectoral Overlay Network
- Agreement with PSU's (BSNL/PGCIL/Railtel) for supporting fiber for 10 years

NKN Design Philosophy

- Common National e-infrastructure like national highway, wherein different categories of users shall be supported

- To build a scalable network, which can expand both in Reach (spread across the entire country) and Speed (capacity)

NKN Features

- High Capacity, Highly Scalable Backbone

- Provide Quality of Service (QoS) and Security

- Wide Geographical Coverage

- Bandwidth from many NLD's

- Highly Reliable & Available by Design

- Test beds (for various implementation)

- Dedicated and Owned.

- Connectivity for International & other global R&D Networks

NKN TOPOLOGY

Srinagar
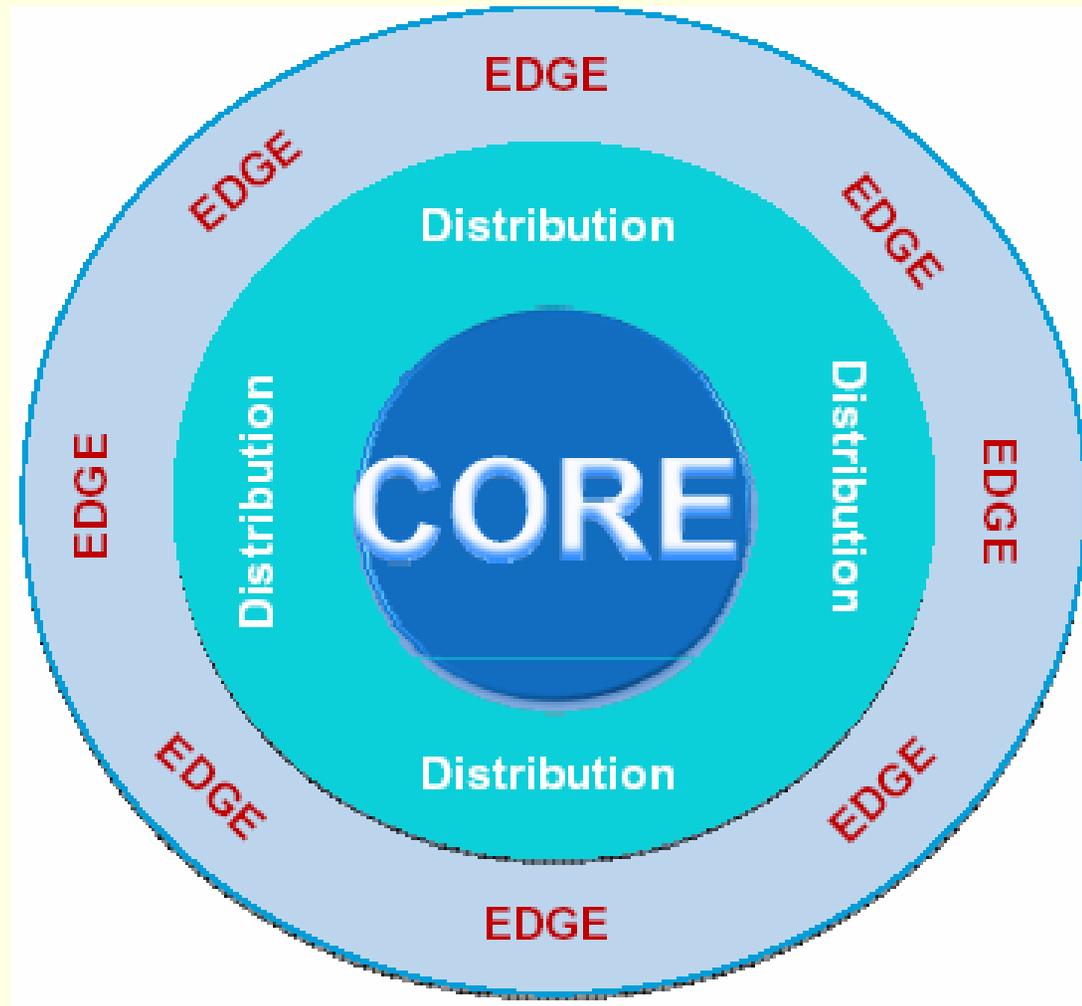Jammu
Amritsar
Shimla
Chandigarh
Dehradun
New.Delhi
Jaipur
Kanpur
Lucknow
Gangtok
Itanagar
Guwahati
Shillong
Kohima
Silchar
Imphal
Patna
Ahmedabad
Bhopal
Indore
Ranchi
Kharagpur
Kolkata
Agartala
Aizwal
Raipur
Nagpur
Mumbai
Bhubaneswar
Pune
Hyderabad
Vizag
Vijayawada
Panaji
Mangalore
Bengaluru
Chennai
Salem
Puducherry
Kochi
Trichy
Thiruvananthapuram

- ● PoP Level 1
- ■ PoP Level 2 (State Capital)
- ● PoP Level 2
- = = = = = Dark Fiber
- ⬡ Network Operations Centre (NOC)
- ▨ Disaster Recovery NOC (DRNOC)

27

NKN of INDIA

Implementation of Initial Phase of NKN

- **Core links of 2.5 gbps created by various NLD on an experimental basis for 6 months.**

- **Equipment at NIC Backbone upgraded to cater to multiples of 2.5 Gbps**

- **57 institutions / organizations to be connected (42 already connected)**

- **Creation of 48 virtual Class Rooms at various Mentoring & Mentored IITs. (16 Already in place)**

Status on NKN (initial phase)

➢ **Design of the NKN is complete (including final phase)**

➢ **The Backbone of the initial Phase is ready and operational**

➢ **42 Institutes have been connected so far. 50 more will be connected in the next 6-8 months**

➢ **16 Class rooms have been equipped with the Virtual Class Room facilities**

➢ **Rest are getting ready for Mentoring/Mentored IIT's**

NKN Initial Phase – Core Link Status
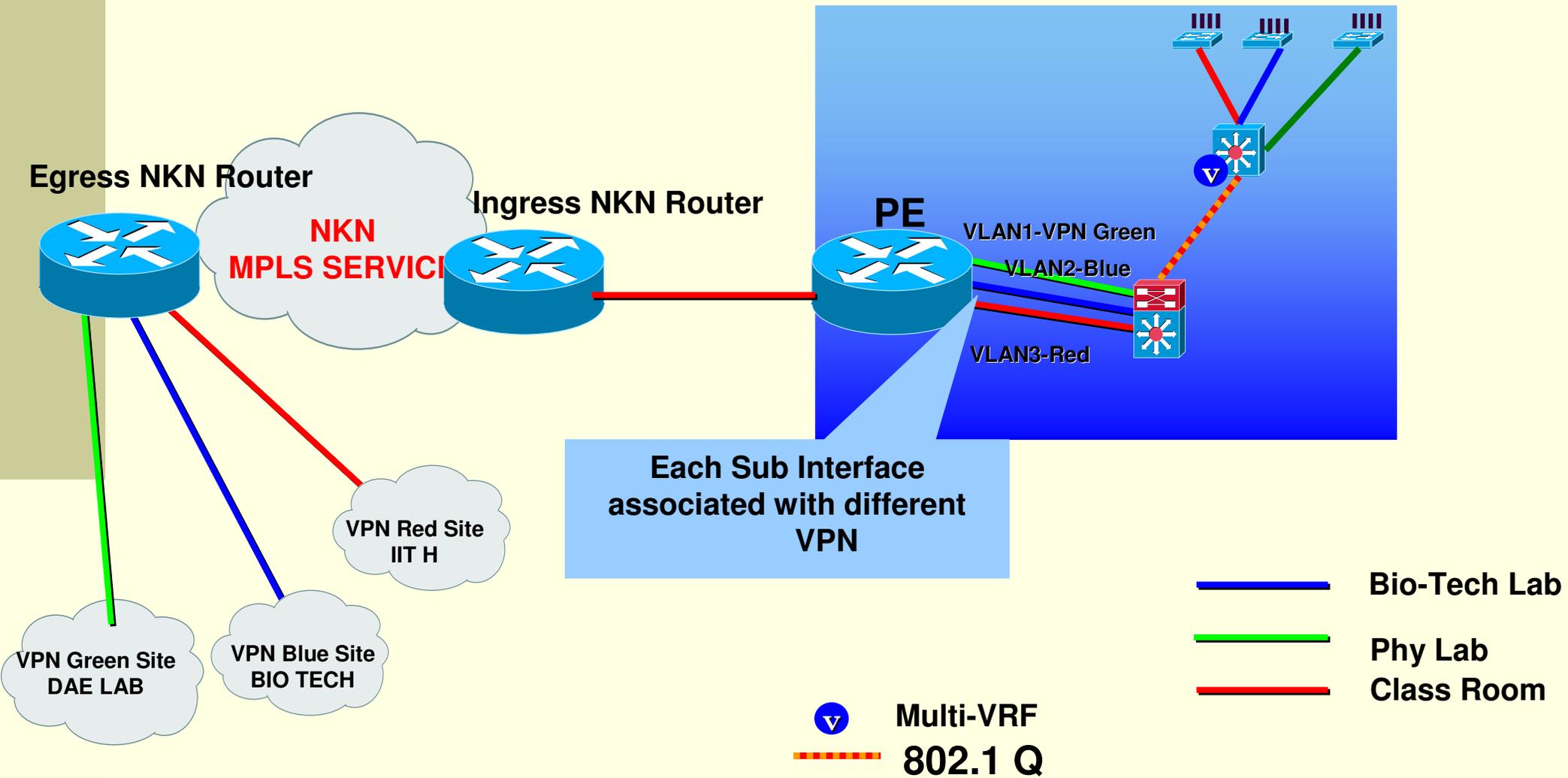
Inaugurated by President of India on April 9, 2009
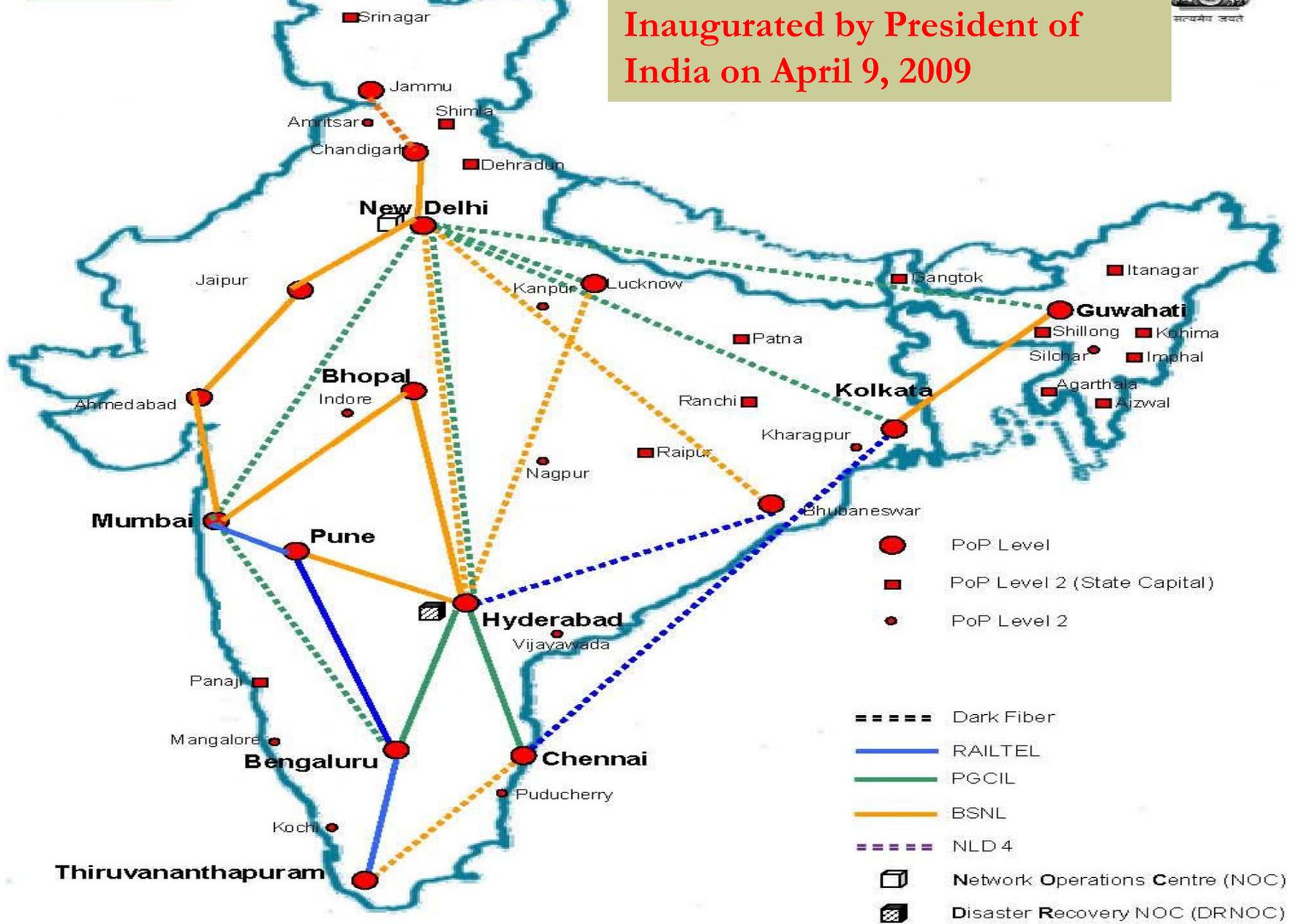
NKN connectivity

- **NKN Highway will have minimum of 100mbps connectivity (1gbps for large institutes). Hence all the nodes that hook on to NKN will be on that speed**

- **All the colleges and Polytechnics needs to be aggregated and brought on to NKN**

- **Routers and switches to take connections from User Organizations**

Typical End Node Design

Egress NKN Router

NKN
MPLS SERVICE

Ingress NKN Router

PE

VLAN1-VPN Green
VLAN2-Blue
VLAN3-Red

Each Sub Interface associated with different VPN

VPN Red Site
IIT H

VPN Green Site
DAE LAB

VPN Blue Site
BIO TECH

Bio-Tech Lab

Phy Lab
Class Room

Multi-VRF

802.1 Q

Integrating existing networks on NKN

NICNET POPs are upgraded to implement initial phase of NKN

The major PoPs of ERNET are already a part of NKN - IISC, VECC, RRCAT, IIT(Chennai, Kanpur, Guwahati), IUCAA, University of Rajasthan

Out of 45 institutes participating on Garuda application 24 are already in the initial phase of NKN

Most of WLCG, EU-IndiaGrid and DAE Grid sites are included in the initial phase of NKN

Benefits of NKN

- **National Research & Education Network(NREN):** **e-infrastructure**

    - **Ultra High speed (OFC),** low latency network with scalability in terms of reach & capacity

- **Cost advantage due to consolidation and sharing -** virtualization

- **Central depository of software services & data bases for multidisciplinary applications** - effective usage

- **Foundation for seamless & secure collaboration over network**
  - uniform interfaces

Applications to show cased

- **Education & Research**
  - **Countrywide Real Time Classroom (IITs)**
  - **GRID Applications**
- **Agriculture**
- **Health Care**
- **Industry**
  - **e-governance**
  - **Knowledge content creation**

What is running on NKN?

- **Readiness during inauguration of NKN on 9th April 2009**

  - Virtual real-time Classrooms in IIT's (Chennai-Hyd, Mumbai-Gandhinagar and Guwahati- Patana)

  - Grid Computing using DAE Grid (BARC-IGCAR-RRCAT-VECC)

  - Weather Modeling on Garuda Grid of C-DAC (C-DAC-IISC)

  - Collab-CAD application for reactor component design from IGCAR-NIC-BARC

  - Open source Drug discovery from CSIR

NKN Events

- The initial phase of the NKN was inaugurated by the President of India on 9th April, 2009

- NKN workshop at NIC Delhi on 4th July 2009 to train network administrators on NKN

- NKN workshop at BARC, Mumbai on December 10-11 December 2008 for training users and systems people

- User Workshop on NKN Applications at NIC, Delhi during Nov 2008

Model Projects

Funds are allotted for implementing about 20-25 model projects (with unique application in each domain using NKN backbone) as a proof-of-concept to demonstrate the feasibility, capability and effective use of high bandwidth.
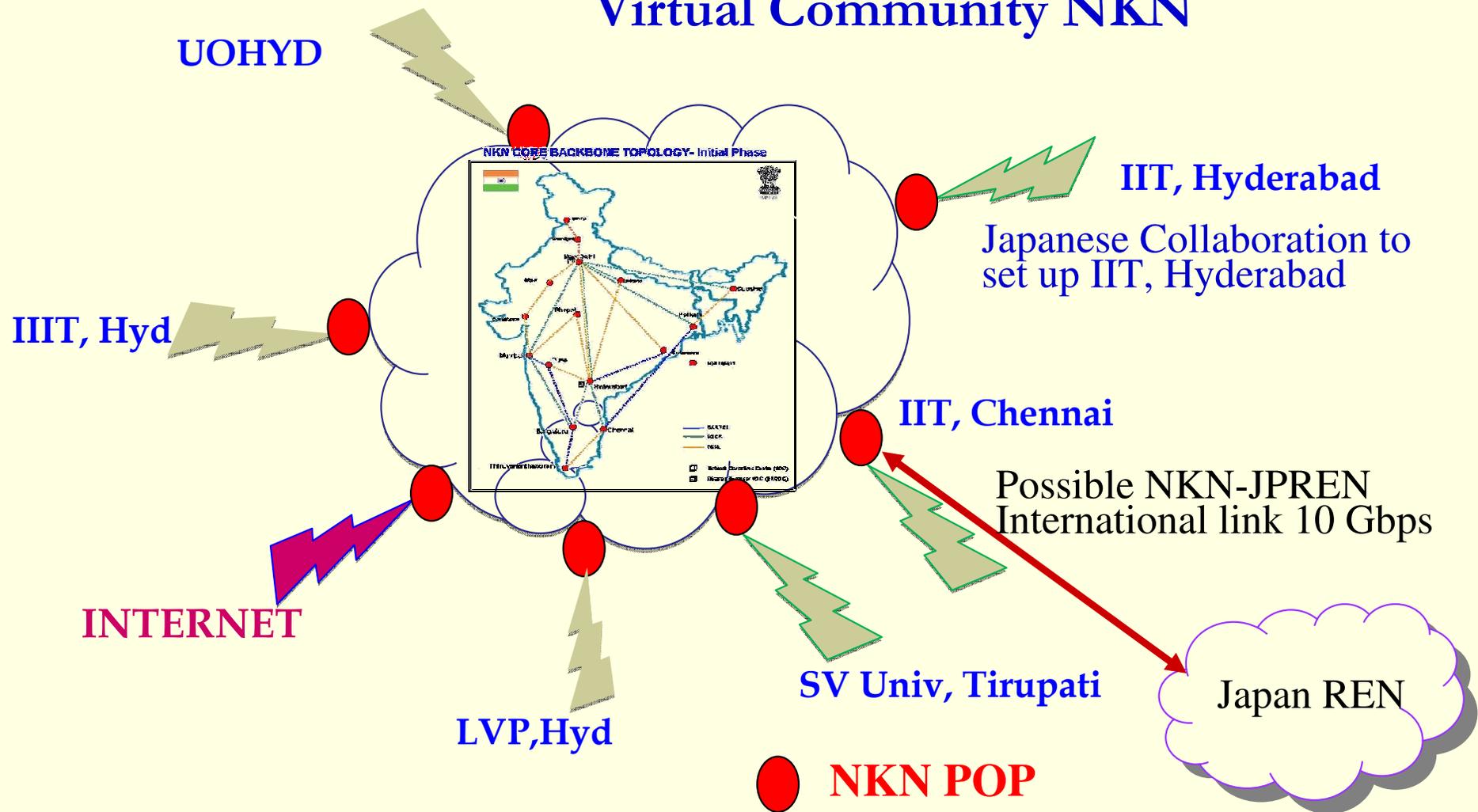
Some Example Projects:

- e_Mentoring in Maths Science (IISER, CBS, CMI, HBCSE, TIFR, BARC – Prof Sujatha Ramdorai)

- Cancer Research & Education (TMH- Dr. Badve)

- Grid for Eye Care (Shankar Netralaya -Dr. Lingam Gopal)

- Climate Modeling (MOES- Dr. Goswami)

- E_governance from Planning Commission (Dr. Pani)

- Public Health Education (Dr. Mohandas)

- Knowledge Hub at Hyderabad

NKN Connectivity for each Model project

Working as a Close User Group (CUG) of connected Institutions

Virtual Community NKN

UOHYD

IIIT, Hyd

INTERNET

LVP,Hyd

IIT, Hyderabad

Japanese Collaboration to set up IIT, Hyderabad

IIT, Chennai

Possible NKN-JPREN International link 10 Gbps

SV Univ, Tirupati

Japan REN

NKN POP

Foundation Technologies & Defining work packages

Services Framework for evolution of Knowledge Hub

Web Interface

Web Services (SOA)

API

Open source software & tools

Physical

Client Portal Interface
Open Services Framework
LAMP and open tools

OSS Based Security	OSS Based Workflow	OSS Based Database	OSS Based File Systems	OSS Based Directory	OSS Based Messaging

Servers	Storage	Network

NKN Grid brings Climate Change modelling for capacity building

IITM, Pune

LINUX

eka
Supercomputer
Fastest in Asia, 4th fastest in the world

CRL, Pune
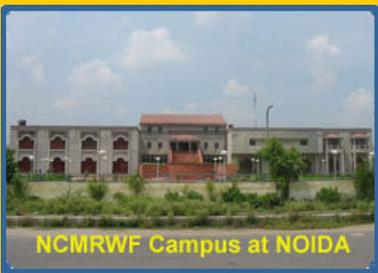
NCMRWF Campus at NOIDA

IMD, Delhi

High Speed NKN Grid Links

IISC, Banglore

IIT Delhi

LINUX

PARAM, C-DAC

Researcher

Thanks for your attention