Research at LARC-USP

E-Science, Cloud & Big Data Projects

Fernando Redigolo

LARC – USP
Laboratory of Computer Architecture and Networks
Department of Computer and Digital System Engineering
USP University of São Paulo – Brazil
São Paulo

~ 12 Million inhabitants
University of São Paulo

• Created in 1934
  • 11 campi (4 – city of São Paulo).
  • 89 University Divisions.
• 92.064 students (undergrad, grad and extension).
  • 5.860 professors.
• 16.837 administrative staff.
• 249 undergraduation programs.
  • 239 graduation Programs

• Consistently the best-positioned Latin America institution on worldwide rankings (eg. 51-60 on The Times Higher Education World Reputation Ranking 2015)

Source: Anuário Estatistico 2013
LARC-USP

• Computer Networks and Architecture Lab
  • Created in 1993.
  • 8 professors
  • 50 collaborators, distributed among Doctorate, Master and Undergrad students and full-time researchers

• Main fields of interest
  • Security
  • High-Definition Networked Media & Visualization
  • Wireless and Sensor Networks
  • Advanced Internet & Applications
  • SDN (Software Defined Network)
  • High-Performance Hardware For Networking
  • Cloud Computing
Main Partnerships

- **RNP** (National Network for Research and Education)
- **ANSP** (Academic Network of the State of São Paulo)
- **FIU / AMPATH**
- **Ericsson Research** Sweden, Canada, Finland, Brazil
- **IBM Research** – T.J. Watson
- **Financial Institutions**: Bradesco & Itaú Banks, Scopus Tecnologia
- **Petrobras** (Brazilian Oil Company)
- **Incor** (Heart Institute)
E-Science, Cloud & Big Data Projects

• Characteristiscs
  – Usually Collaborative Projects involving multiple Partners
  – Usually infrastructure + Use Cases / Demos

• 4 Main Areas
  – New Network Architectures
  – High-Definition Networked Media & Visualization
  – Cloud Computing
  – Big Data
ESNet Vision: Scientific Progress should not be limited by physical location of instruments, people, computational resources and/or data.

- No longer possible to dissociate network from scientific research process.
<table>
<thead>
<tr>
<th>Institutions</th>
<th>Application</th>
<th>Data set</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>UFRJ</td>
<td>Images and videos Neurology</td>
<td>200GB/day</td>
<td>They can not perform the research because they have connection and bandwidth problems.</td>
</tr>
<tr>
<td>UFPE</td>
<td>DB Vegetal Genetics</td>
<td>18TB/experiment</td>
<td>Wget – 3 to 4 weeks scp - 4 to 6 weeks</td>
</tr>
<tr>
<td>INPE</td>
<td>Meteorological Data</td>
<td>240 MB/day</td>
<td>24 hours to transfer</td>
</tr>
<tr>
<td>USP</td>
<td>LHC Alice Experiment</td>
<td>-</td>
<td>They use practically only local simulated data, as the connectivity is deemed insufficient for real-time data transfer</td>
</tr>
</tbody>
</table>
Why?

Traditional Flows x Scientific Flows

**Traditional Flows**
- **Http**
- **Smtp**
- **http**
- **Imap**
- **VoIP**
- **erp**
- **p2p**
- **Http**
- **Imap**

Multiple applications, short-lived traffic, different endpoints

**Scientific Flows**

‘Single’ application, longer-lived traffic, constant endpoints

**Data Transfer**
## Why?

### Improper Data Transfer Tools

Source - [https://fasterdata.es.net/data-transfer-tools/](https://fasterdata.es.net/data-transfer-tools/)

<table>
<thead>
<tr>
<th>Data Transfer Tools</th>
<th>Disk Architecture</th>
<th>Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scp</td>
<td>1</td>
<td>140 Mbps (17.5 MB/s)</td>
</tr>
<tr>
<td>HPN-scp</td>
<td>1</td>
<td>760 Mbps (95 MB/s)</td>
</tr>
<tr>
<td>HPN-scp</td>
<td>RAID-0</td>
<td>1.2 Gbps (150 MB/s)</td>
</tr>
<tr>
<td>GridFTP com 1 fluxo</td>
<td>1</td>
<td>760 Mbps (95 MB/s)</td>
</tr>
<tr>
<td>GridFTP com 1 fluxo</td>
<td>RAID-0</td>
<td>1.4 Gbps (175 MB/s)</td>
</tr>
<tr>
<td>GridFTP com 4 fluxos</td>
<td>RAID-0</td>
<td>5.4 Gbps (675 MB/s)</td>
</tr>
<tr>
<td>GridFTP com 8 fluxos</td>
<td>RAID-0</td>
<td>6.6 Gbps (825 MB/s)</td>
</tr>
</tbody>
</table>

Disk-to-disk transfer from Berkeley, CA to Argonne, IL. RTT = **53 ms**, bandwidth > **10Gbps**, 4-disk RAID **0**. In order to go over 1 Gbps (125 MB/s) RAID was needed.
Traditional Flows x Scientific Flows: Firewalls

Traditional Flows

- http
- smtp
- http
- VoIP
- http
- imap
- http

Processors, buffers, etc. designed for multiple, short duration packets.

Scientific Flows

- http
- http
- imap
- p2p

Data Transfer

Normally, security equipments do not support large flows
What is a Science DMZ?

- **Specialized Network Architecture** for high-performance scientific computation, with differentiated policies and configuration in comparison to production network.
- Optimized machines for content transfer and monitoring.
- **Priviledged Connectivity**
- Concept created by DoE ESNet
Science DMZ @USP - 2015

- **Sc.DMZ Controller**
- **Data Transfer Node**
  - perfSONAR Bandwidth/Latency
- **Switch**
- **Sc.DMZ @USP**
- **shortcut for authorized traffic**

**Use Cases:**
- Physics Institute - LHC Alice Experiment
- AURA SOAR Telescope (Chile)

**Backbone USP**
- Border Router
- RNP
- ANSP NAP/Terremark
- USP Internal Network
- USP Internal Network

- 10G
- 10G
- 10G
- 10G
- 10G
- 10G
Sponsorship: RNP (Brazilian NREN)

Main goals:
- Develop and Deploy a Science DMZ Prototype with SDN/Openflow capability at Brazilian universities.
- Architecture Evaluation under Use Case Scenarios
  - Metereology
  - Astronomy
  - Genetics
  - High-Energy Physics
‘Research Network-as-a-Service’
  – Deploy a Web Portal for:
    • Schedule / initiate data transfer, using different data transfer tools
    • Setup monitoring rules for data transfer troubleshooting
    • Specify specific network requirements (eg. Layer 2 circuits)
    • Handle security (authentication, open/close TCP/UDP ports, etc.)

  – Web Services for mutual Science DMZ negotiations
    • Available Data Transfer Tools
    • Authorized/Unauthorized traffic
Other Networking Projects

• **USP – OSU (Ohio State University) – 2014**
  – Evaluating long-distance collaboration using Science DMZ

• **FIBRE -** Future Internet testbed for Brazilian Experimentation
  • Testbed for Future Internet & Software-Defined Networking, similar to GENI Project in US
  • 10 islands interconnected by means of RNP (Brazilian NRE)
  • Extensions for adding **Cloud Computing** and **IoT** (internet of Things) under evaluation
  • Integration with US & European projects (**ProtoGENI & Fed4FIRE**)
Visualization Portal – SAGE2

Environment for high-definition Collaborative Visualization

- Based on Univ. Illinois / Hawaii SAGE2 middleware
- Multiple simultaneous high-def content streamed through the network
- Interaction with users devices and portals from other institutions
- HTML/JS-based application development

3x1 Portal - WRNP 2015
RNP SAGE2 Project

• Goals
  – **Collaborative work** among Brazilian Research Entities with Tiled Displays
  – **Disseminate** this technology to Brazilian R&D community
  – **Evaluate/Adapt its** use for Scientific Applications (Use Case Analysis)
RNP SAGE2 Project

- Coordination:
  - Profa. Tereza Cristina Melo de Brito Carvalho
  - Fernando Frota Redigolo

- Sponsorship: RNP (Brazilian NREN)

- Use Case Scenarios
  - Telemedicine
  - Cinema / Video
  - Meteorology
  - Geoprocessing
  - Simulation

16 Mpixels 4x2 Portal – LASSU-USP
Video Streaming

• Projects involving **special audio/video transmissions**
  – Uncompressed Full HD Video
  – Compressed 4K Video

• Demos usually involving international Partners & Arts groups

• Pushing the boundaries on the networking
Previous Projects

• **4K Film transmission** – Brazil – US – Japan (2009) + Q&A session w/ compressed and uncompressed videoconferencing

• **Remote Master Class of Piano** – Brazil – Spain (2009) w/ compressed video and uncompressed audio
• Cinegrid
  – Community involving Digital Cinema, Arts and Scientific Visualization over networks

• Cinegrid Brasil – Aug/2014
  – 2nd Regional Meeting in Brazil
• Projects involving Cloud Computing Infrastructure
  – Credential Management
  – Secure Virtual Networking
  – Security SLA
  – Security Visualization
**Advanced Cloud Computing Services for Telecom**

**Goals:**

- Distributed Cloud Computing Framework for Telco Service offering
- FACE Framework Prototype – Speed Radar / Video Surveillance with Motion Detection
Network Traffic Modelling

• Model a Company-owned satellite network
  – Model based on real captured traffic - Identify applications & traffic patterns
  – Analyze ‘What-if’ Scenarios
  – 1-2 TB data (packet headers only) for a 1-week capture