IPv6 Deployment and Migration of WLCG TEIR-2 site resources on Private Cloud

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Agenda

- Introduction of National Centre for Physics (NCP)

- NCP IT infrastructure

- IPv6 deployment status at NCP

- Private Cloud Deployment at NCP

Technology updates @ NCP

- Conclusion

About NCP

- The National Centre for Physics, Pakistan has been established to promote research in Physics & applied disciplines in the country and the region.

- NCP has collaboration with many in international organizations including **CERN**, **SEASME**, **ICTP**, **TWAS**…

- Major Research Programs:

  - Experimental High Energy Physics, Theoretical and Plasma Physics, Nano Sciences and Catalysis, Laser Physics, vacuum Sciences and technology, Earthquake studies.

CP IT Overview

P is maintaining a large IT infrastructure, which is mainly categorized into owing areas:

CORE COMPUTING SERVICES

- Hosted a WLCG TIER-2 Site, comprising of **524 CPU Cores**, and **~400 TB of Disk torage**

- Computing cluster of **84 CPU cores**, nstalled for local scientific community.

CORPORATE IT SERVICES

- Corporate Services, including Email, DNS, Public Web site, FTP , application databases etc... are hosted inside NCF data centre.

- All Of the Corporate Services are **Virtualized. ... 50 + VMs**

High Speed & fault tolerant network infrastructure is deployed to provide IT services

CP Campus Network

- **NCP has campus wide Wired and Wireless Network deployment.**

  - **~ 100 + active Network Devices (Switches, Routers, WAPs, Firewalls) installed.**

  - **Active Network follows layered Architecture.**

    - **Distribution & Core Network is operating at 10 Gb/s BW, while Access Network is 1 Gb/s.**

  - **~ 1500 Wired Network end points available.**

  - **~ 50 Wireless access points are installed for Wi-Fi coverage.**

  - **1 Gbps Connectivity with International NREN through TEIN**

Low Level Network Architecture

NETWORK ARCHITECTURE AT NATIONAL CENTRE FOR PHYSICS
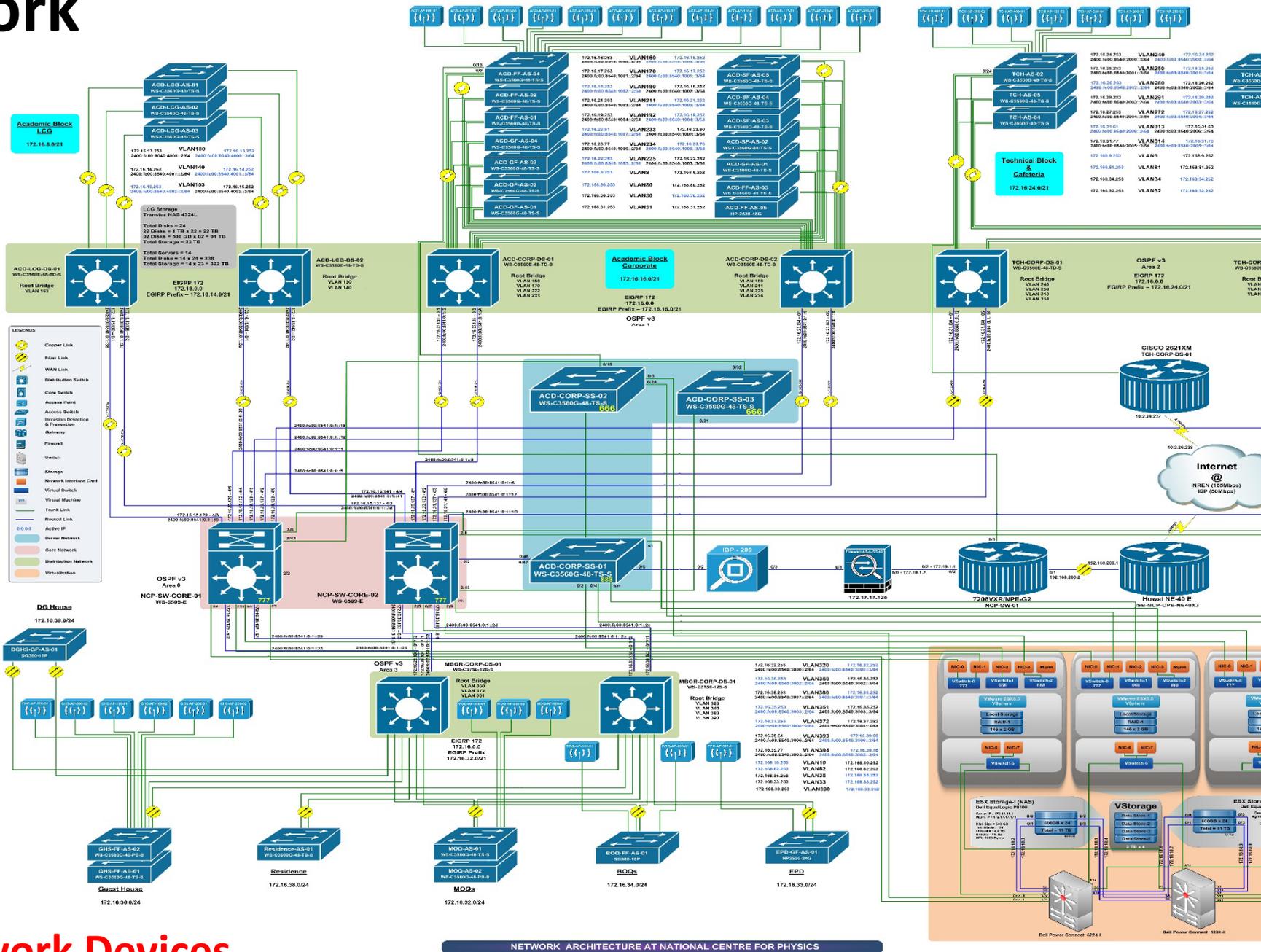
100 + active Network Devices

IPv6 Deployment @ NCP

- **Need for IPV6**

  - We are located in a Region, where IPv4 address space is near to depletion. Only last /8 Pool is available with APNIC. Not as such easy to obtain, public IPv4 addresses.

  - Adoption of Cloud/Virtualization technologies resulted in increased number of VMs and Live applications... Thus more Network addresses are required.

  - Worldwide LHC Computing Grid (WLCG) Site hosted. Community is actively working on WLCG IPv6 migration **(HEPIX-IPv6 Working Group**) .

IPv6 Deployment @ NCP

Deployment of IPv6:

- NCP started **deployment of IPv6 in 2011** as a proactive transition strategy, Just after availability of IPv6 pool from our upstream provider (PERN2).

- IPv6 support was already available in Installed Network devices.
    - Gateway Routers
    - Core Switches
    - Distribution Layer Switches   **IPv6 supported**
    - Firewalls
    - Wireless Access Points

- NCP is among first, few public sector institutes in Pakistan, which has almost completely deployed dual stack i.e. IPv4/IPv6 in its campus network.
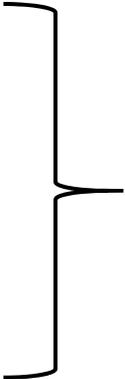
IPv6 usage Trend

Bandwidth Usage (Mbps)
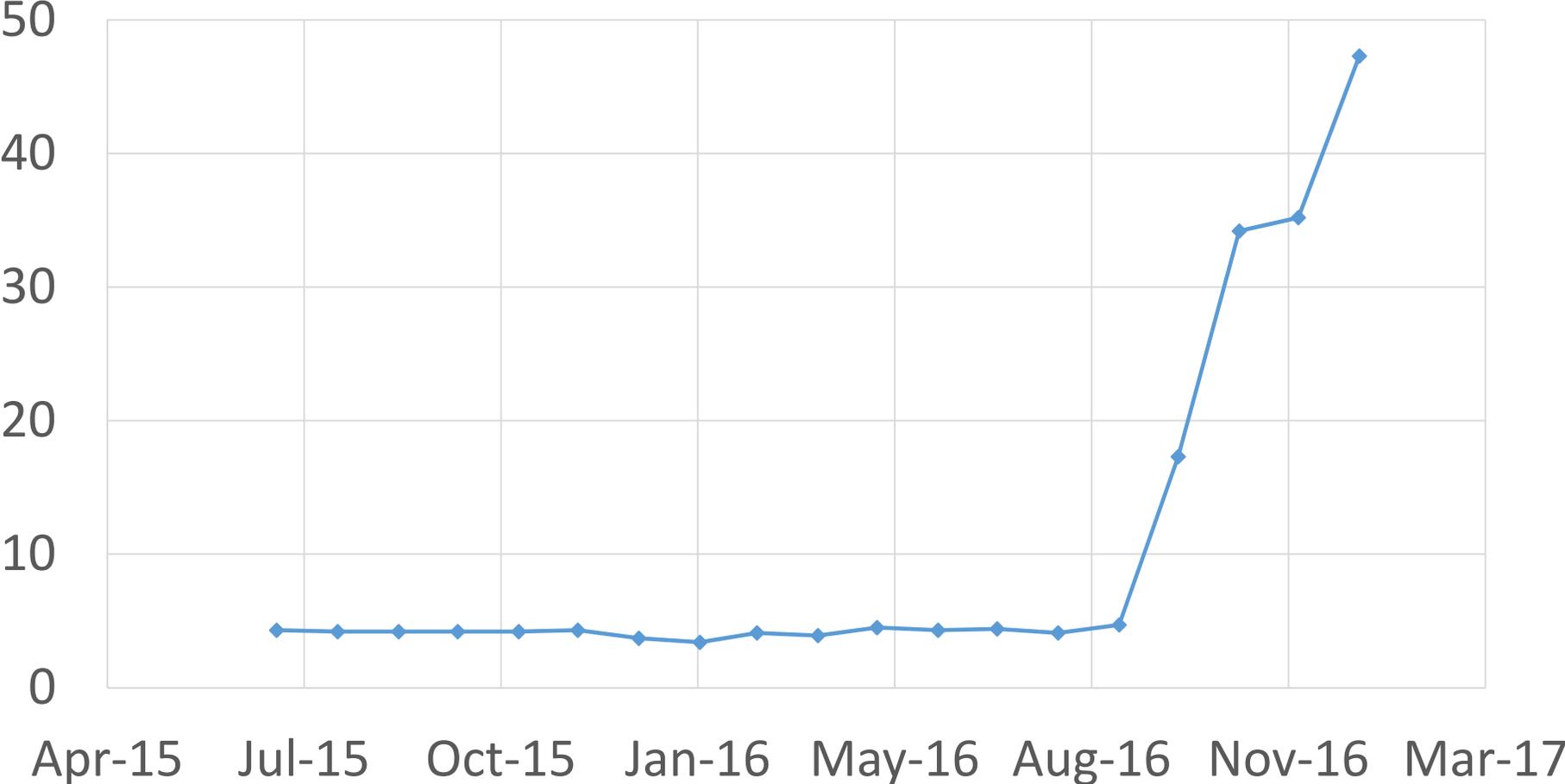
IPv6 usage Trend

NCP - GigabitEthernet2/0/0.60 - ******IPv6 Traffic NCP******
Last 3 Months
Last 3 Months

Received Transmitted — Trend

12.0 Gbytes

10.0 Gbytes

8.0 Gbytes

6.0 Gbytes

4.0 Gbytes

2.0 Gbytes

0 bytes

Dec

2017

Feb
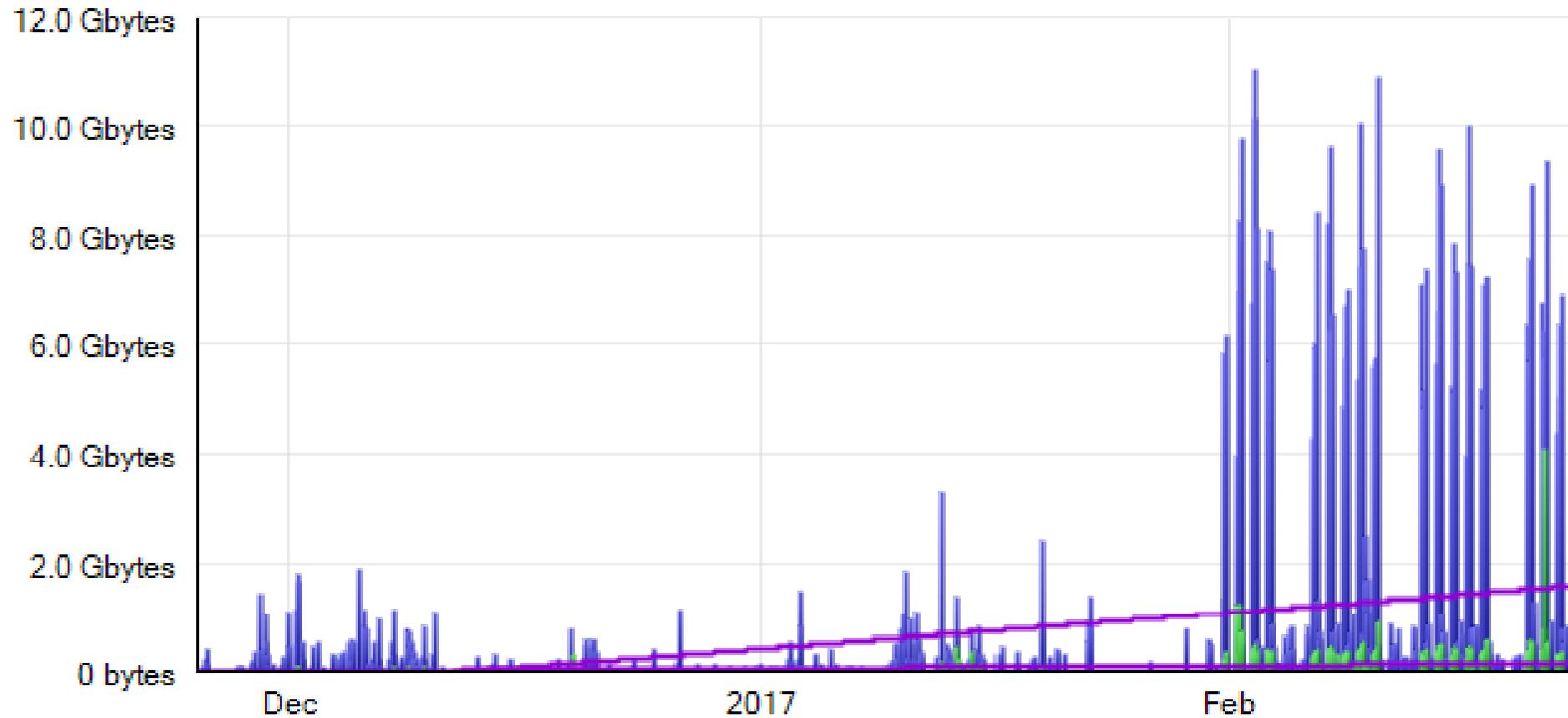
2016

Application Service on IPv6
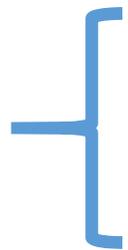
APPLICATION /SERVICE	DNS name	IPv6 Status
NCP official Website	www.ncp.edu.pk	Yes
FTP Server	ftp6.ncp.edu.pk	Yes
DNS Server	ns1.ncp.edu.pk	Yes
Mail server	mailserver.ncp.edu.pk Smtp.ncp.edu.pk Webmail.ncp.edu.pk	Yes
Edge Transport Servers	Et1.ncp.edu.pk Et2.ncp.edu.pk	Yes
NTP server	ntp6.ncp.edu.pk	Yes
Conference management system	Indico.ncp.edu.pk	yes

mail ervices

NCP official web site on IPv6

Email Exchange over IPv6 Network

Received: **from ET2.ncp.edu.pk ([2400:fc00:854a:aaaa::164])** by mx.google.com with ESMTPS id 72si1823271wmr.49.2017.02.22.01.12.29 for <saqib.haleem@gmail.com> (version=TLS1 cipher=ECDHE-RSA-AES128-SHA bits=128/128); Wed, 22 Feb 2017 01:12:30 -0800 (PST) Received-SPF: pass (google.com: domain of saqib.haleem@ncp.edu.pk designates 2400:fc00:854a:aaaa::164 as permitted sender) **client-ip=2400:fc00:854a:aaaa::164**; Authentication-Results: mx.google.com; spf=pass (google.com: domain of saqib.haleem@ncp.edu.pk designates **2400:fc00:854a:aaaa::164 as permitted sender**) smtp.mailfrom=saqib.haleem@ncp.edu.pk Received: from mailserver.ncp.edu.pk (111.68.96.168) by et2.ncp.edu.pk (111.68.96.164) with Microsoft SMTP Server (TLS) id 14.3.235.1; Wed, 22 Feb 2017 14:12:09 +0500

Email from NCP to Gm...

...mail from ...mail to NCP

Received: from ET-2010.ncp.edu.pk (111.68.96.167) by mailserver.ncp.edu.pk (111.68.96.168) with Microsoft SMTP Server (TLS) id 14.3.319.2; Wed, 22 Feb 2017 14:10:59 +0500

Received: from **mail-oi0-x22b.google.com (2607:f8b0:4003:c06::22b)** by **et1.ncp.edu.pk (2400:fc00:854a:aaaa::167)** with Microsoft SMTP Server id 14.3.319.2; Wed, 22 Feb 2017 14:09:52 +0500

Received: by mail-oi0-x22b.google.com with SMTP id 65so2357673oig.1 for <saqib.haleem@ncp.edu.pk>; Wed, 22 Feb 2017 01:10:09 -0800 (PST)

PK-GRID-CA CRL is available on IPv6
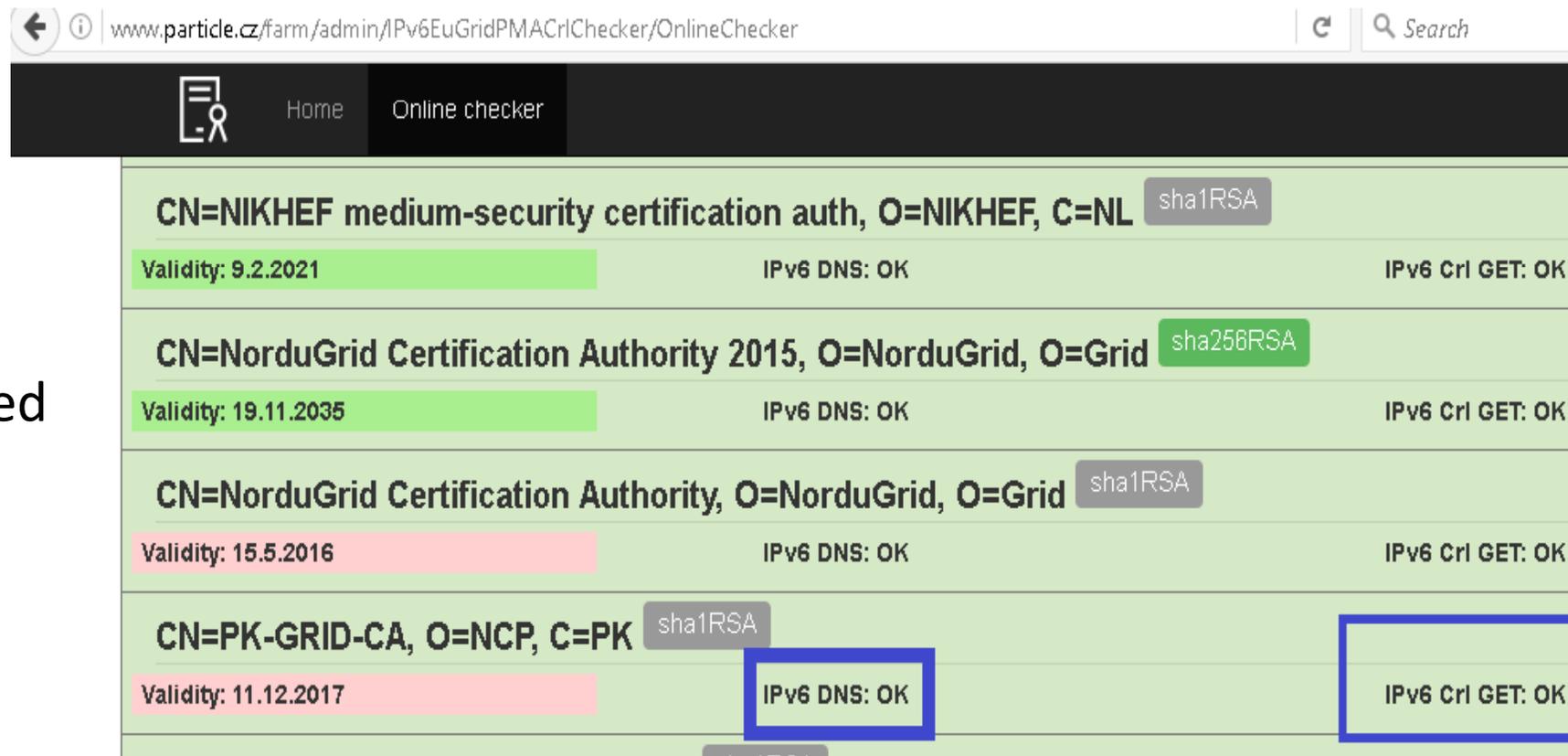
is Certification
hority (CA), accredited
U-GRID-PMA

Application Service on IPv6

- NCP DNS Server is configured on IPv6, and can be used by IPv6 only end clients for name resolution.

- However, DNS queries for ncp.edu.pk domain, is not fully supported over IPv6, because ccTLd (.pk) registrar PKNIC is not supporting IPv6 glue record.

Query from IPv6 DNS server (ns1.ncp.edu.pk)


```
ers\saqib>nslookup
ult Server:  UnKnown
ss:   2400:fc00:854a:aaaa::166

ilserver.ncp.edu.pk
er:  UnKnown
ss:   2400:fc00:854a:aaaa::166

      mailserver.ncp.edu.pk
sses:  2400:fc00:854a:aaaa::168
       111.68.96.168
```

**DNS query
Reverse lookup**


```
C:\Users\saqib>nslookup
Default Server:  dns.sinica.edu.tw
Address:  140.109.1.10

>  2400:fc00:854a:aaaa::168
Server:  dns.sinica.edu.tw
Address:  140.109.1.10

Name:     mailserver.ncp.edu.pk
Address:  2400:fc00:854a:aaaa::168
```

Application Service on IPv6

- **DHCP v6** is running for IPv6 address allocation.

- **Open stack Cloud (Juno)** is configured to allocate IPv6 address to VM instances.

- IPv6 enabled on of Most of the WLCG Application Services on NCP-LCG2 tier 2 Site.

    - BDII
    - CREAM CE
    - DPM (Storage)

IPv6 Routing

- OSPFv3 is being used in Campus Network
- All IPv6 addresses are routable, within the campus and outside.

```
IPv6 Routing Table - Default - 34 entries
Codes: C - Connected, L - Local, S - Static, U - Per-user Static route
       B - BGP, R - RIP, I1 - ISIS L1, I2 - ISIS L2
       IA - ISIS interarea, IS - ISIS summary, D - EIGRP, EX - EIGRP external
       O - OSPF Intra, OI - OSPF Inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
S    ::/0 [1/0]
      via 2400:FC00:8540::1
C    2400:FC00:8540::/64 [0/0]
      via Vlan999, directly connected
L    2400:FC00:8540::2/128 [0/0]
      via Vlan999, receive
OI   2400:FC00:8540:16::/64 [110/2]
      via FE80::223:ACFF:FED3:51C1, TenGigabitEthernet4/2
      via FE80::223:ACFF:FED3:5342, TenGigabitEthernet4/1
OI   2400:FC00:8540:33::/64 [110/2]
      via FE80::221:A0FF:FE89:5FC3, GigabitEthernet6/2
C    2400:FC00:8540:50::/64 [0/0]
      via Vlan777, directly connected
L    2400:FC00:8540:50::1/128 [0/0]
      via Vlan777, receive
S    2400:FC00:8540:70::/64 [1/0]
      via 2001:DB8:100:F101::2
      via 2001:DB8:100:F101:5054:FF:FEAA:4824
```

IPv6 Traffic Monitoring

- Net flow v9 is enabled on Gateway routers, Cisco ASA Firewalls, and flows are exported, to Net flow Analyser application.
- All IPv6 traffic statistics logged.

1 Minute Average
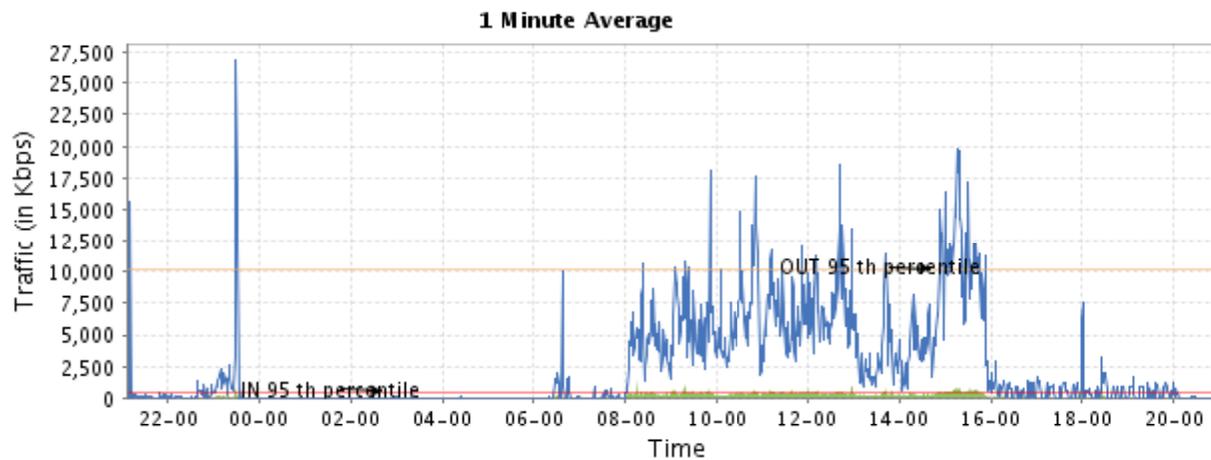
Category	Total	Max	Min	Avg	Standard Deviation	95th Percentile
IN	1.3 GB	1.39 Mbps	44.40 bps	120.55 Kbps	175.58 Kbps	475.68 Kbps
OUT	25.09 GB	26.85 Mbps	9.60 bps	2.32 Mbps	3.66 Mbps	10.18 Mbps

IPv6 Traffic Monitoring

IN ◯ OUT   Last Hour ⌄   From: 2017-03-09 04:41   To: 2017-03-09 05:41

Resolve DNS | Group by None ⌄   ◀ Showing 1 to 50 ▶   View per pa

Src IP	Dst IP	Application	Port	Dst Port	Protocol	DSCP	Traffic
2600:1417:75::687c:3	2400:fc00:8540:1005:8088	http	80	50486	TCP	Default	115.2 KB
2400:fc00:8540:2001:	2001:4998:44:204::100c	https	54759	443	TCP	Default	93.99 KB
2600:1417:75::687c:3	2400:fc00:8540:1005:8088	http	80	60035	TCP	Default	86.4 KB
2400:fc00:8540:2001:	2001:4998:44:204::100c	https	63710	443	TCP	Default	85.75 KB
2400:fc00:8540:2001:	2a03:2880:f10d:83:face:b0	https	64246	443	TCP	Default	80.16 KB
2400:fc00:8540:2001:	2a00:1288:80:800::7000	https	64392	443	TCP	Default	67.33 KB
2400:fc00:8540:2001:	2001:4998:44:204::100b	https	61729	443	TCP	Default	56.17 KB
2400:fc00:8540:2001:	2001:4998:44:204::100b	https	59375	443	TCP	Default	54.42 KB
2400:fc00:8540:1002:	2001:4998:44:204::100c	https	52170	443	TCP	Default	51.02 KB
2400:fc00:8540:2001:	2a00:1288:80:800::7001	https	59387	443	TCP	Default	36.5 KB
2400:fc00:8540:2001:	2a03:2880:f009:8:face:b00	https	64104	443	TCP	Default	35.52 KB

Net Flow traces of WLCG Application Traffic on IPv6

Top Destination IN Report - 2400:fc00:8540:5000::141 From: 2017-03-07 19:25 To: 2017-03-07 20:25

Resolve DNS | Group by None

Showing 1 to 16   View per page

Src IP	Dst IP	Application	Port	Dst Port	Protocol	DSCP	Traffic(48.88 KB)	Percent
2001:638:700:10df	2400:fc00:8540:5000::1	BDII	53712	2170	TCP	Default	10.0 KB	20%
2001:630:12:580:2	2400:fc00:8540:5000::1	BDII	59986	2170	TCP	Default	5.76 KB	12%
2001:630:12:580:2	2400:fc00:8540:5000::1	BDII	41094	2170	TCP	Default	5.76 KB	12%
2001:630:12:580:2	2400:fc00:8540:5000::1	BDII	60856	2170	TCP	Default	4.48 KB	9%

Top Destination IN Report - 2400:fc00:8540:5000::134 From: 2017-03-08 19:36 To: 2017-03-08 20:36

Resolve DNS | Group by None

Showing 1 to 16   View per page

Src IP	Dst IP	Application	Port	Dst Port	Protocol	DSCP	Traffic(21.53 KB)	Percent
2001:1458:201:e3:	2400:fc00:8540:5000::1	VOMS	44284	8443	TCP	Default	11.68 KB	54%

IPv6 Deployment to End users

- Campus Network is divided into multiple subnets/VLANs.

- Each VLAN interface has been assigned IPv4 and IPv6 addresses.

- Stateless Auto configuration (SLAAC) is Disabled.

- DHCPv6 is implemented
  - End device is assigned Fixed IPv6 address, using static binding of mac.
  - As, a convention last octet of end node is assigned same number in IPv4 and IPv6 . E.g.
    - IPv4 address-----172.16.16.**37**
    - Ipv6 Address ----2400:fc00:8540:1000::**37**

Cloud Deployment @ NCP

- **Need for Cloud Deployment**

  - NCP IT is hosting multiple Computing Environments. We have ~12 TeraFlops of, accumulative computing capacity.

  - Dedicated Physical Servers, for **WLCG site** and **General purpose high   performance computing**, which results in wastage of computing resources.

    - **86 % of the Computing capacity is dedicated to WLCG, EHEP community.**
    - **~14 % of the computing resources are dedicated to cluster for other scientific computing.**

      ISSUES:
      Inflexible Architecture.
   Inefficient Utilization of computing resources.
      Difficult to manage, configure.

  - **On the other side, CPU requirement for non-GRID computing, is increasing…. Community is growing**

Cloud Deployment @ NCP

WLCG-Tier-2 site

WN 01 · WN 02 · WN 03 · WN 04 · WN 05 · · · · · WN # N

Local Computing Cluster

Compute 01 · Compute 02 · Compute 03 · · · · · Compute # N
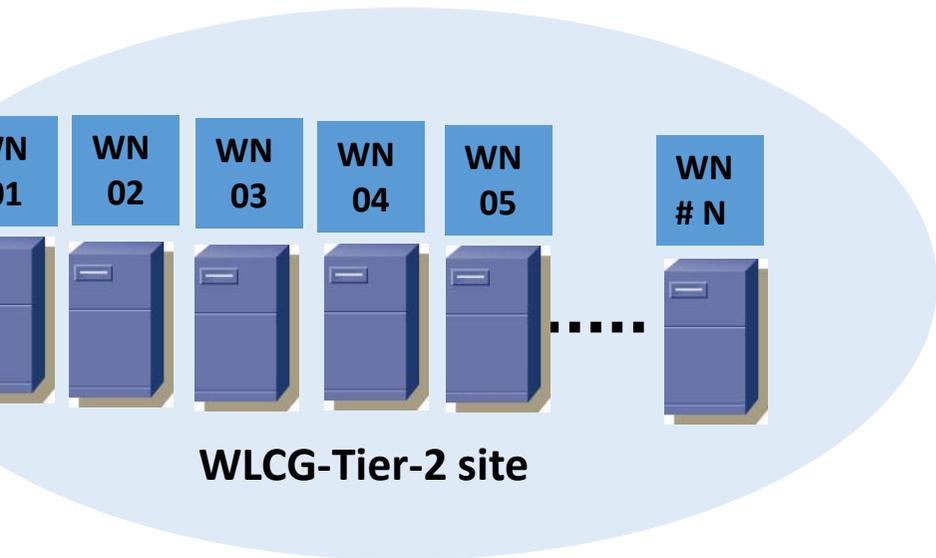
Traditional Computing Model

Virtual Machines

Worker node VM-01 · Worker node VM-02 · Worker node VM-03

Worker node VM-04 · · · Worker node VM #N · Compute VM-01

Compute VM-02 · Compute VM-03 · · · Compute VM- N

Physical Hardware

Openstack Private Cloud
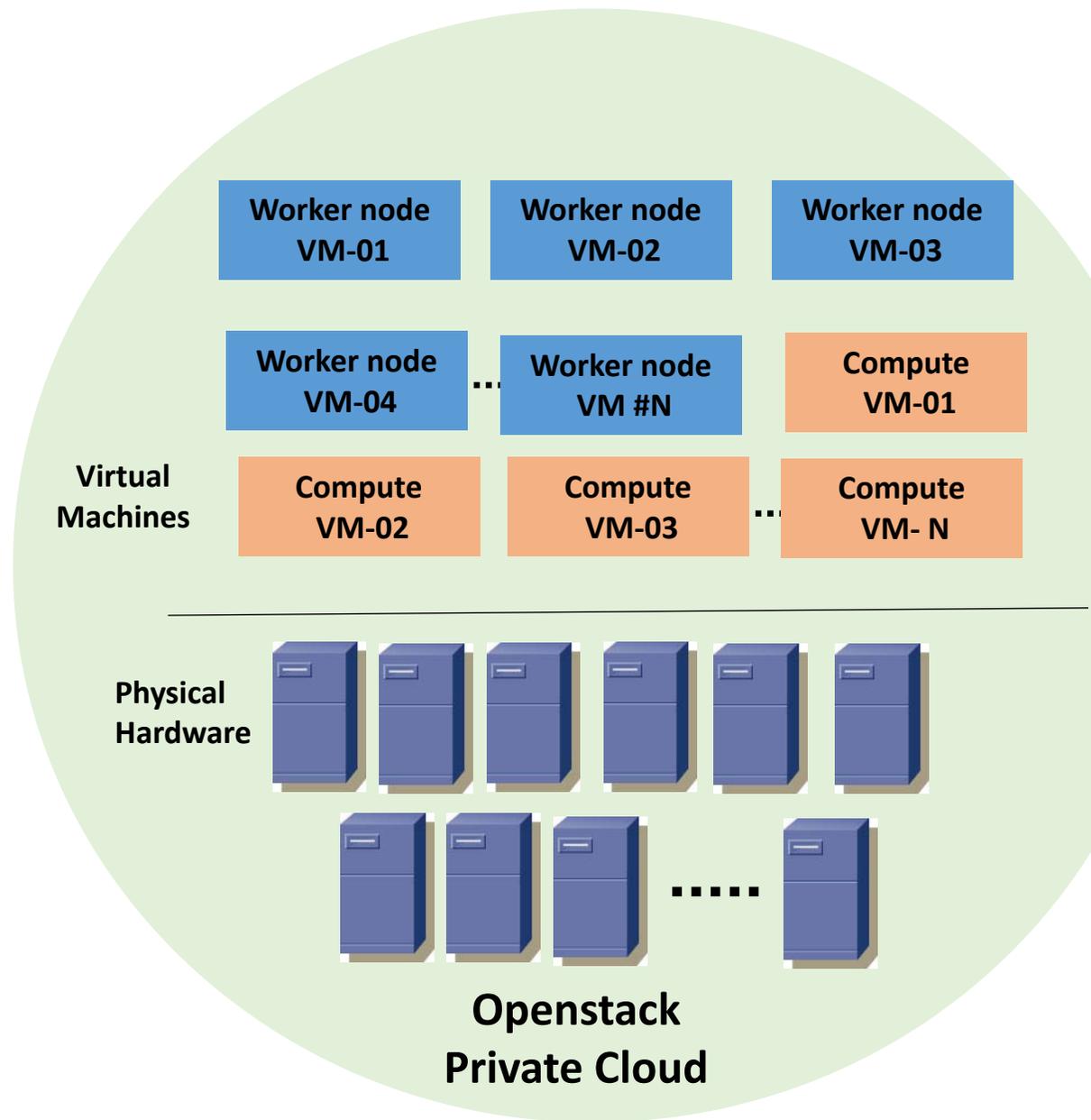
Migration on new Computing Model

Cloud Deployment @ NCP

Cloud Deployment @ NCP

Get Fresh Data

| hour | 2hr | 4hr | day | week | month | year | job |

or from [   ] 🗓 to [   ] 🗓 Go Clear

Physical View

cluster > --Choose a Node ⌄

Overview of cluster @ 2017-03-02 11:03

Total: **84**

up: **7**

down: **0**

t Load Avg (15, 5, 1m):

, 74%, 74%

tilization (last week):

o

rver Load Distribution

cluster Load last week

		Now:	Min:	Avg:	Max:
☐	1-min	71.8	24.0	44.6	85.
☐	Nodes	7.0	3.0	4.4	7.
☐	CPUs	84.0	36.0	53.0	84.
☐	Procs	70.9	24.0	44.4	85.

cluster Memory last week

		Now:	Min:	Avg:	Max:
☐	Use	4.4G	1.3G	2.3G	4.7G
☐	Share	0.0	0.0	0.0	0.0
☐	Cache	26.4G	5.0G	13.7G	31.4G
☐	Buffer	1.6G	660.7M	958.3M	1.6G
☐	Swap	43.3M	11.7M	22.5M	45.2M
☐	Total	100.9G	69.6G	80.7G	100.9G

cluster CPU last week

cluster Network last week
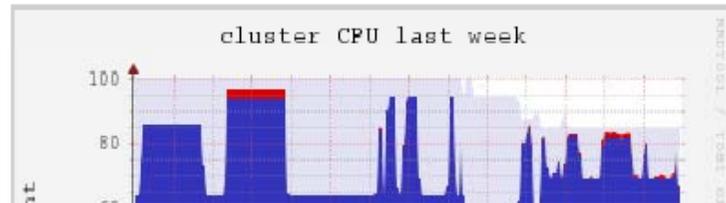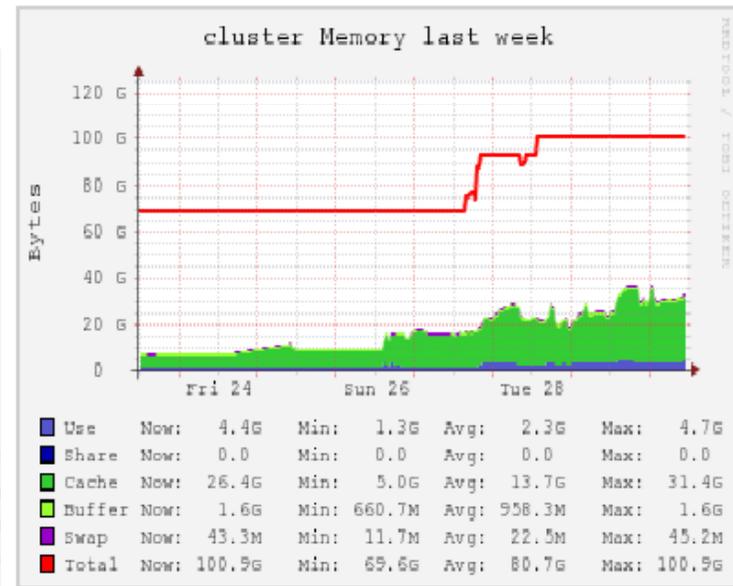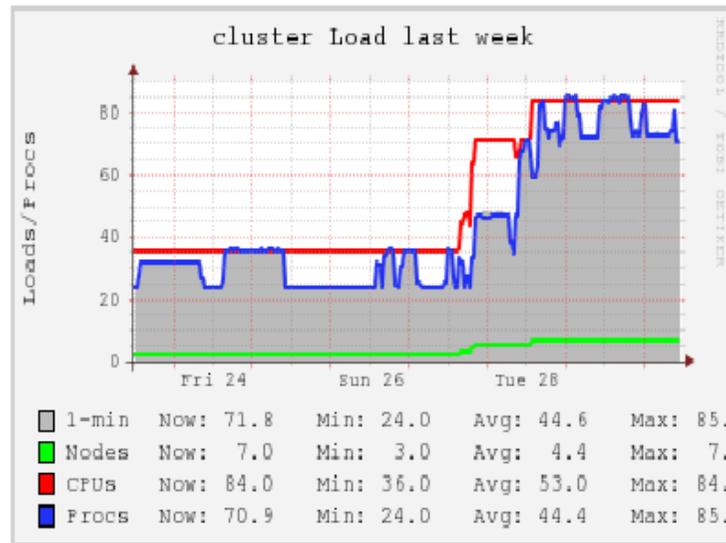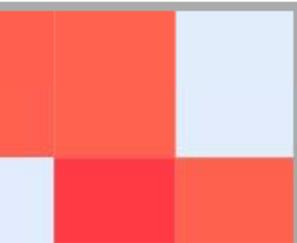
WLCG T2 site and Cloud Status update

- Currently GRID resources are provisioned manually on Openstack based cloud.

    - Worked node VMs, and Cluster compute node VMs have been created and launched according to our resource commitment, in WLCG project.

- Evaluated dynamic provisioning of GRID resources in cloud using GlideinWMS, but faced issue in launching jobs.

- Looking and discussing other possible approaches, to serve resources to CMS experiment from our private cloud, in a much flexible and dynamic way.

Thankyou For Your Attention