Communications Regulatory Authority
State of Qatar
هيئة تنظيم الاتصالات
دولة قطر

جامعة قطر
QATAR UNIVERSITY

جامعة كارنيجي ميلون في قطر
Carnegie Mellon University Qatar

IPv6 TESTING LABS ACCESS PROCESSES AND PROCEDURES

This document was collaboratively produced by Communications Regulatory Authority, Qatar University and Carnegie Mellon University Qatar

TABLE OF CONTENT

Table of Contents

1. INTRODUCTION

The Communications Regulatory Authority of Qatar (CRA), Carnegie Mellon University in Qatar (CMU-Q), and Qatar University (QU) have collaborated to set up two IPv6 testing laboratories at the two universities. The IPv6 testing labs will:

- Show IPv6 in action so that institutions can see all the components that go into making such a network operational
- Provide an IPv6 environment so that institutions can bring their test systems and test them for IPv6 operation
- Focus the training to practical and fundamental aspects of IPv6

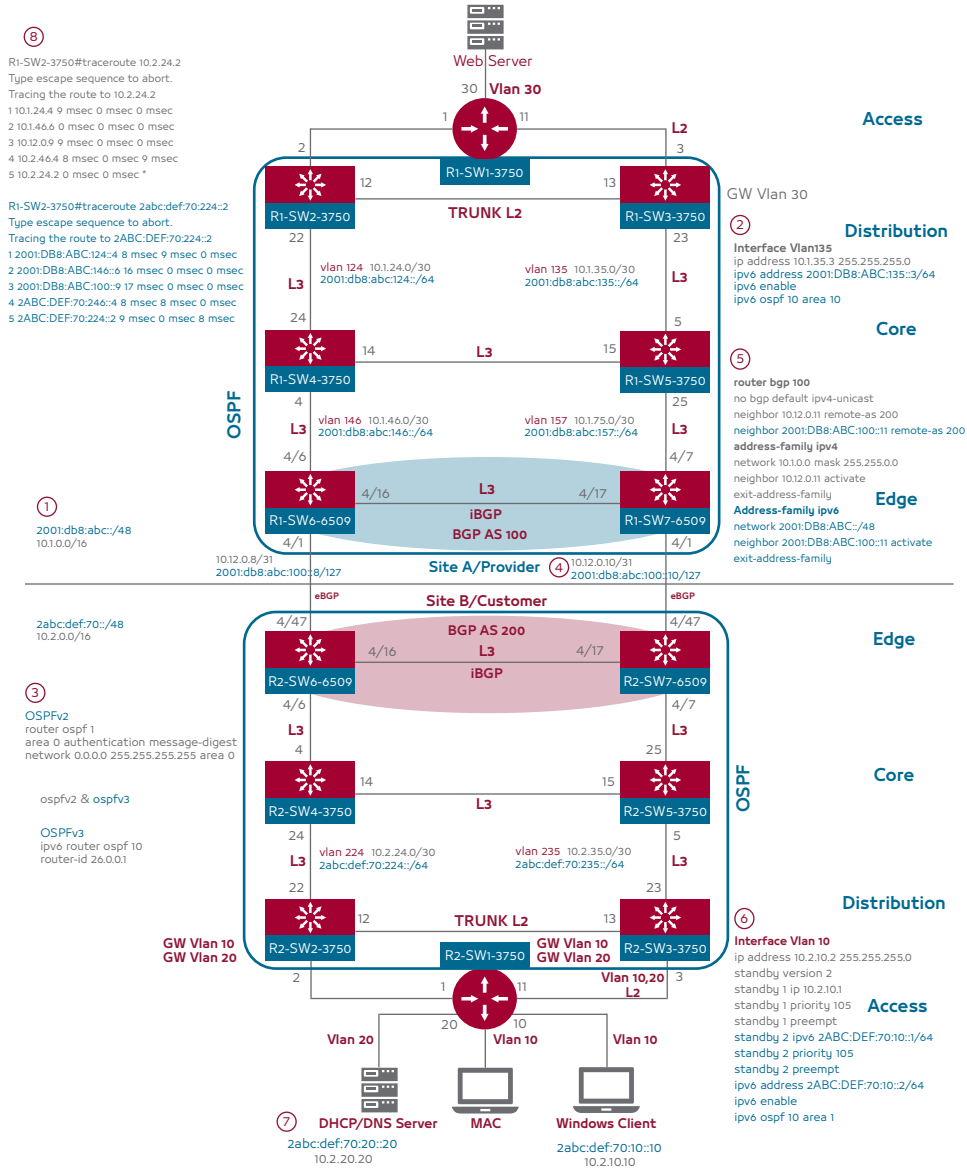
The labs are available to IPv6 Taskforce members, as well as government and private sectors entities that are interested in learning about IPv6 and testing situations. This document describes the IPv6 testing labs, how to request access, and the rules that govern the use of the labs.

2. CARNEGIE MELLON UNIVERSITY IN QATAR IPV6 TESTING LAB

The IPv6 testing lab at Carnegie Mellon University in Qatar is a dedicated and isolated environment that offers complete control for a variety of experiments. The lab consists of two sets of fully established networks, described as site A and site B. These two networks are identical in logical and physical setup. You can consider them as two enterprises communicating with each other, or a customer and a provider communicating with each other.

The standard network architecture consists of four layers: access, distribution, core and edge. These two networks are designed according to that principle. Although all devices are from Cisco and the setup follows standard Cisco guidelines, the setup can be easily recreated with equipment from other vendors.

The IP address ranges are different for the two networks, so it is easy to follow which prefix belongs to which site. We are running OSPF as IGP and BGP for Inter AS communication.



1. Obtain IPv6 addresses and AS (if reqd.)
2. Start assigning DS IP to core network devices
3. Configure IGP routing protocols Ospf etc.
4. Establish a DS connectivity with the Provider
5. Configure IPv6 BGP with the Provider
6. Configure Access Layer switches for DS
7. Assigning DS IP to client machines and servers
8. Test IPv4 and IPv6 connectivity

Figure 1:
CMUQ IPv6 Testbed network design

2.1 IPv6 Configurations at Different Layers of CMU-Q Testing Lab Network

Select IPv6 configuration information is given below for each network layer. The configuration information supplements figure 1 to provide details of the IPv6 testbed.

1. The access layer is plain layer 2 with VLANs and standard port configurations. There are hosts connected to access switches running Windows client machines and Windows DHCP and DNS servers.

```
interface GigabitEthernet1/0/22
 switchport access vlan 124
 switchport mode access

interface GigabitEthernet1/0/2
 description Connection to SW1
 switchport trunk encapsulation dot1q
 switchport trunk allowed vlan 30,112
 switchport mode trunk
```

2. The distribution layer has the Layer-3 SVI configured. It has both IPv4 and IPv6 default gateway defined under the HSRP group. All layer-3 configurations for the VLANs, including security configuration (First Hop Security etc.), are set up here.

```
interface Vlan30
 ip address 10.1.30.2 255.255.255.0
 no ip redirects
 standby version 2
 standby 1 ip 10.1.30.1
 standby 1 priority 105
 standby 1 preempt
 standby 2 ipv6 2001:DB8:ABC:30::1/64
 standby 2 priority 105
 standby 2 preempt
 ipv6 address 2001:DB8:ABC:30::2/64
 ipv6 enable
 no ipv6 redirects
```

OSPFv3 works differently and it requires OSPF to be enabled under the interface.

```
interface Vlan124
 ip address 10.1.24.2 255.255.255.0
ipv6 enable
ipv6 address 2001:db8:abc:124::2/64
ipv6 router ospf 10 area 1

router ospf 1
 area 10 authentication message-digest
 network 99.9.9.2 0.0.0.0 area 10
 network 0.0.0.0 255.255.255.255 area 1
```

A new process is created for OSPF in the global configuration.

```
ipv6 router ospf 10
router-id 12.0.0.1
```

3. The core layer mainly has routing functions and fast switching of packets. All the links are usually point-to-point. It is recommended that these links are configured with /127 prefix for IPv6 addresses. OSPF and OSPFv3 are running in core to handle IPv4 and IPv6 traffic.

```
interface Vlan145
 ip address 10.1.45.5 255.255.255.0
 ipv6 address 2001:DB8:ABC:145::5/64
(recommended to use /127 in production)
 ipv6 enable
 ipv6 ospf 10 area 0
```

Global IPv4 routing process:

```
router ospf 1
network 10.1.45.0 0.0.0.255 area 0
network 15.0.0.0 0.0.0.255 area 0
```

Global IPv6 routing process:

```
ipv6 router ospf 10
 router-id 15.0.0.1
```

4. The edge layer has mainly exterior routing protocol such as BGP running with the provider or with another site. Both sites must establish communication with each other to ensure that they accept the IPv6 prefixes advertised by the other site.

```
router bgp 100
 bgp router-id 16.0.0.1
 bgp log-neighbor-changes
 no bgp default ipv4-unicast
 neighbor 10.12.0.9 remote-as 200
 neighbor 2001:DB8:ABC:100::9 remote-
as 200
 !
 address-family ipv4
  network 10.1.0.0 mask 255.255.0.0
  neighbor 10.12.0.9 activate
 exit-address-family
 !
 address-family ipv6
  network 2001:DB8:ABC::/48
  neighbor 2001:DB8:ABC:100::9 activate
 exit-address-family
ipv6 route 2001:DB8:ABC::/48 Null0
```

Rank	Switch	IP Address	Device Model	Host Name
1	1	192.168.1.2	3750-e	R1-SW1-370
1	2	192.168.1.3	3750-e	R1-SW2-3750
1	3	192.168.1.4	3750-e	R1-SW3-3750
1	4	192.168.1.5	3750-e	R1-SW4-3750
1	5	192.168.1.6	3750-e	R1-SW5-3750
1	6	192.168.1.7	6509	R1-SW6-6509
1	7	192.168.1.8	6509	R1-SW7-6509
2	1	192.168.1.10	3750-e	R2-SW1-3750
2	2	192.168.1.11	3750-e	R2-SW2-3750
2	3	192.168.1.12	3750-e	R2-SW3-3750
2	4	192.168.1.13	3750-e	R2-SW4-3750
2	5	192.168.1.14	3750-e	R2-SW5-3750
2	6	192.168.1.15	6509	R2-SW6-6509
2	7	192.168.1.16	6509	R2-SW7-6509

Table 1: **Equipment Location and IP Addresses of Testbed Equipment**

All devices have the same user/password setup, and the same level of access.

Username: admin

Password: (will be provided)

enable password: (will be provided)

2.2 What Kind of Testing is Supported?

Since the CMU-Q testing lab consists of dedicated hardware and is completely isolated from other networks, your organization can learn about IPv6 and enjoy great flexibility in testing scenarios. The following access and testing scenarios are supported:

- VPN access to the lab network, with the ability to connect to any resident device
- Ability to log in to networking devices and study their running configurations
- Ability to run network probing and scanning of the lab network
- Administrative access to adjust networking parameters, but not change the structure of the network
- Administrative access to adjust networking structure (requires pre-planning with CMU-Q)
- Ability to connect your own device in the lab network for testing (subject to separate agreement and pre-planning with CMU-Q)
- Ability to connect a remote computer with common networking tools on any segment of the lab network
- Administrative access to a remote computer with common tools and ability to load your software on the computer for testing (subject to separate agreement and pre-planning with CMU-Q)

3. QATAR UNIVERSITY IPV6 TESTING LAB

Qatar University built IPv6 test environment on production network infrastructure since both IPv4 / IPv6 works independent to each other. QU was testing IPv6 commands on isolated / independent switches & devices before configuring the production devices for IPv6.

QU has three tiers network infrastructure including access, distribution and core infrastructure and IPv6 testing was performed at each layer independently before enabling end-to-end IPv6 connectivity. With this approach it was easy to troubleshoot the connectivity issue, if there any. QU also built knowledge base regarding IPv6 technology and training to support team.

Initially access, distribution and core infrastructure was setup for test IPv6 end users. After comprehensive IPv6 testing, underlying IPv6 infrastructure was converted to production with actual IPv6 end users. The major benefit is real application testing with IPv6 and avoid the repetition of test & production bed testing.

Qatar University is using OSPF for Intranet and BGP for Internet routing protocols and IPv4 & IPv6 run independently to each other i.e., without having any impact to users traffic. Here is the overall IPv4 / IPv6 setup as shown in the two diagrams below:

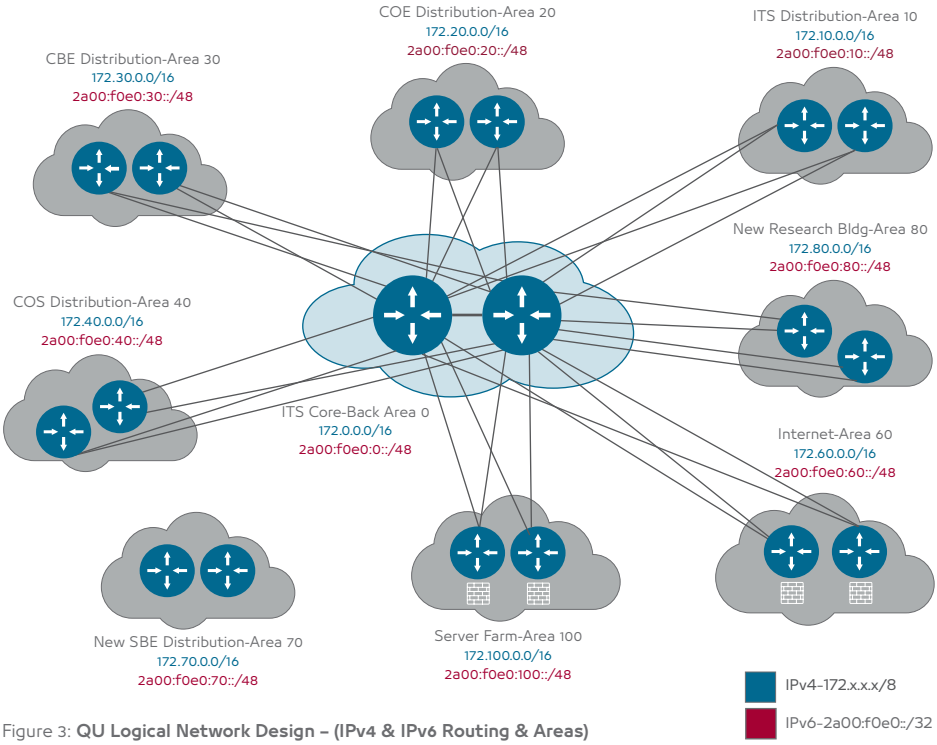


Figure 3: **QU Logical Network Design – (IPv4 & IPv6 Routing & Areas)**

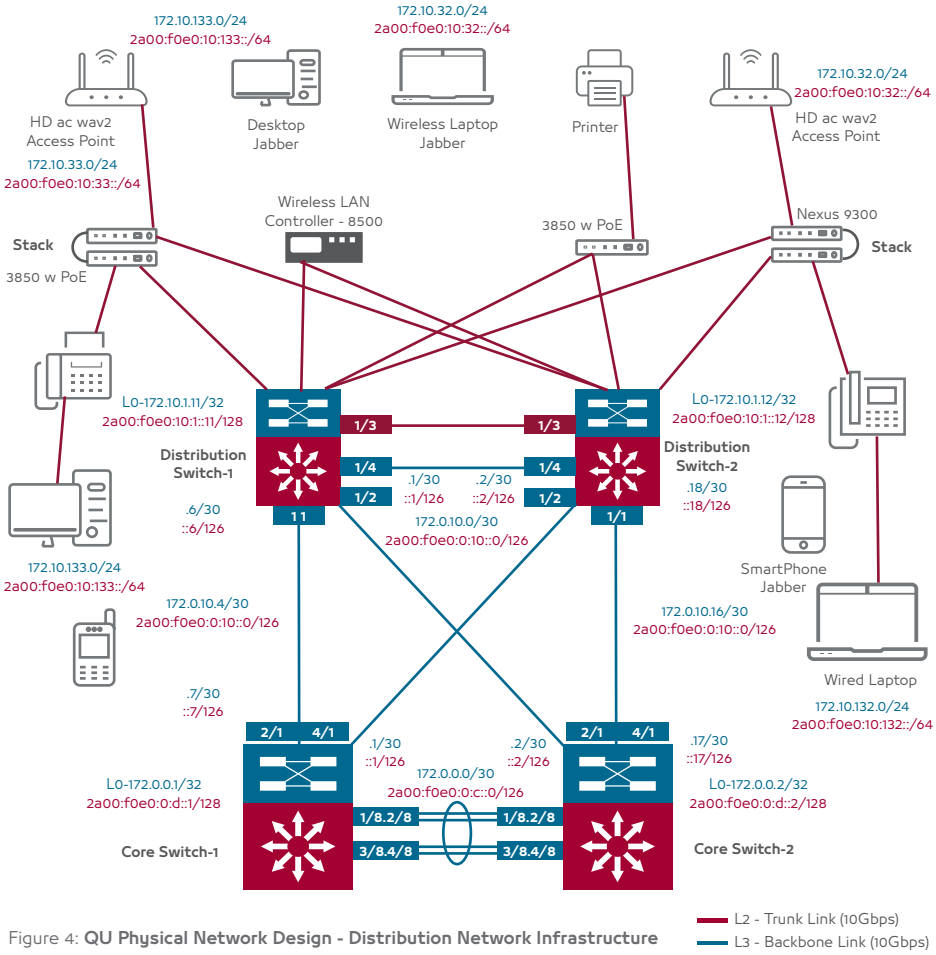


Figure 4: **QU Physical Network Design - Distribution Network Infrastructure**

The internet registry for our region, RIPE, has assigned QU with the Autonomous System (AS) number of 198499 and allocated the IPv4 and IPv6 subnets listed below. QU mimics the IPv6 addressing similar to the existing IPv4 schema. It is easy to configure and troubleshoot any network issue or concerns. QU has used a subset of these IPv6 ranges for initial IPv6 testing before using them in production.

3.1 QU IPv4 and IPv6 Address Mapping

	IPV4	IPV6
Private / Public Addresses Used in Campus	172.16.0.0/8 185.37.108.0/22 86.36.64.0/19	2a00:f0e0::/32
External Routing Protocol – BGP AS	198499	198499
Internal Routing Protocol	OSPF-V2	OSPF-V3
Server Farm Super net	172.10.0.0/16	2a00:e0f0:10::/48
Application Subnet	172.10.101.0/24	2a00:e0f0:10:101::/64
Server Node Address	172.10.101.21/24	2a00:e0f0:10:101::21/64

Table 2: **QU IPv4 & IPv6 Addressing**

3.2 IPv6 DHCP Server

1. Client IPv6 address assignments are handled by Router Advertisement

2. The DHCP server for IPv6 is used to provide information such as domain name and IPv6 addresses of DNS servers.

3. Older operating systems with older IPv6 stacks, but without IPv6 DHCP support (Windows XP), will query the DNS server they received from IPv4 DHCP.

```
Ethernet adapter Local Area Connection:

   Connection-specific DNS Suffix  . : qu.edu.qa
   IPv6 Address. . . . . . . . . . . . . .: 2a00:f0e0:10:132:59f1:2d64:d240:81f9
   Link-local IPv6 Address . . . . . .: fe80::e12f:2fe4:a2d6:c957%13
   IPv4 Address. . . . . . . . . . . . . . : 172.10.132.115
   Subnet Mask . . . . . . . . . . . . . . .: 255.255.255.0
   Default Gateway . . . . . . . . . . . . .: fe80::5:73ff:fea0:84%13
                                              172.10.132.1
```

3.3 IPv6 DNS Server (Internal / External)

1. QU started adding AAAA entries for QU servers with IPv6 addresses. We can initially just serve DNS on IPv4 only. Note: DNS servers are listening on IPv4 can return IPv6 addresses when clients query for AAAA.

2. During IPv6 roll out, QU configured IPv6 addresses on the DNS servers' interfaces and started listening for DNS queries on IPv6.

3. For inbound IPv6 traffic, QU also added IPv6 DNS addresses with Qatar NIC registry.

```
d:\Users\shuja>nslookup
Default Server:
mppsdquadusrdc1.qu.edu.qa
Address:  172.10.35.35
> set query=aaaa
> www.kame.net
Server: mppsdquadusrdc1.qu.edu.qa
Address:  172.10.35.35
Non-authoritative answer:
Name:    orange.kame.net
Address:
2001:200:dff:fff1:216:3eff:feb1:44d7
Aliases:  www.kame.net
```

3.4 IPv6 Configurations at Different Layers of QU Network

Here are the IPv6 configurations at different layers of QU network infrastructure

1. Access layer switches: No additional changes for IPv6

2. Distribution layer switches:

```
interface Vlan70
  no ip redirects
  ip address 172.70.70.5/24
  hsrp version 2
  hsrp 70
     authentication md5 key-chain HSRP-
     MD5
     preempt
     priority 105
     ip 172.70.70.1
  ip dhcp relay address 172.10.35.31
  ip dhcp relay address 172.10.102.33
  ip dhcp relay address 172.10.36.31

ipv6 address 2a00:f0e0:70:70::5/64
  ipv6 nd managed-config-flag
  ipv6 nd other-config-flag
  ipv6 nd prefix default no-advertise
  no ipv6 redirects
  ipv6 router ospfv3 10 area 0.0.0.70
  hsrp 70 ipv6
     preempt
     priority 105
     ip 2a00:f0e0:70:70::1
ipv6 dhcp relay address 2a00:f0e0:10:35::31
ipv6 dhcp relay address 2a00:f0e0:10:36::31
```

3. Core layer switches:

```
interface Ethernet1/1
  no ip redirects
  ip address 172.0.70.6/30
  ipv6 address 2a00:f0e0:c:70::6/126
  ip ospf network point-to-point
  ip router ospf 10 area 0.0.0.0
  no ospfv3 passive-interface
  ipv6 router ospfv3 10 area 0.0.0.0
  no shutdown

router ospf 10
  router-id 172.70.0.1
  area 0.0.0.70 range 172.70.0.0/16
  log-adjacency-changes detail
  auto-cost reference-bandwidth 100000

router ospfv3 10
  router-id 172.70.0.1
  address-family ipv6 unicast
  passive-interface default
```

4. Perimeter internet WAN router:

```
interface Loopback0
ipv4 address 86.33.33.34/32
  ipv6 address 2a00:f0e0:33::10/128
interface GigabitEthernet0/0/1/0
  ipv4 address 82.18.16.25/29
  ipv6 address 2001:1a10:100:c:8781::2/127
  ipv6 enable
  negotiation auto

router bgp 198499
neighbor 82.18.16.24
  remote-as 8781
  address-family ipv4 unicast
     weight 1000
     soft-reconfiguration inbound always
neighbor 2001:1a10:100:c:8781::2
  remote-as 8781
address-family ipv6 unicast
  soft-reconfiguration inbound always
```

3.5 What Kind of Testing is Supported?

Since the IPv6 testing infrastructure is part of the QU production network, the following testing capabilities are available:

- IPv6 testing in the QU setup will be performed under the supervision of QU, due to the combined production and test network setup. Your organization can join a WebEx personal room session for supervised access (an alternate room will be provided if this is not available)
- Your institution can perform test IPv6 configuration, connectivity testing, including ping, traceroute, routing table, show commands, and limited debugging commands
- During these interactive sessions, QU can also guide and assist institutions in setting up IPv6 test or production rollout. QU can provide hands-on practical IPv6 experience, however, QU will not configure any of your devices
- Organizations can mimic or compare their setups with the QU setup, as and when required

When you contact us, we will schedule a follow-up meeting to discuss your lab access request and next steps. We will present an in-depth technical overview of the labs, in addition to, the particular learning and testing scenarios desired. We will formulate a plan, make any agreements in case your equipment needs to be interfaced in the lab, determine the duration of the testing and provide access.

4. ACCESS PROCEDURES AND RULES

If your organization wishes to use the IPv6 testing labs at CMU-Q or QU, please use the following information to request access and learn about access procedures.

4.1 Access Request

Please use the following joint email contact address to reach the Communications Regulatory Authority, Carnegie Mellon University in Qatar, and Qatar University. This email address is the preferred method of contact with respect to IPv6 testing labs or other IPv6 adoption questions. Email sent to this address will be forwarded to individuals at CRA and the universities simultaneously.

Joint email:
IPv6academia@cra.gov.qa

Communications Regulatory Authority
Technical Affairs Department
Phones: +974 4499 4150, +974 4499 4087

Carnegie Mellon University in Qatar
Information Technology
Phone: +974 4454 2835

Qatar University
Information Technology Services Department
Network and Telecommunications
Phone: +974 4403 3482

4.2 Access Procedures

We will use the following procedure to grant your organization access to the IPv6 testing labs. CMU-Q and QU are collectively referred to here as the universities.

1. Contact CRA, CMU-Q or QU to express interest in accessing the testing labs. Please describe your overall objectives in using the IPv6 testing lab.

2. The universities will schedule an overview session to introduce the testing labs and dual stack networking at a high level, and to discuss the particular purpose of the access (learning, testing).

3. The universities and your organization will determine the best method of access, including who will have access, the timing and duration of access, support hours, the type of equipment to be tested, and responsibilities for equipment in case of damage. Testing is at your organization's risk and the universities cannot be held liable for any damage or loss.

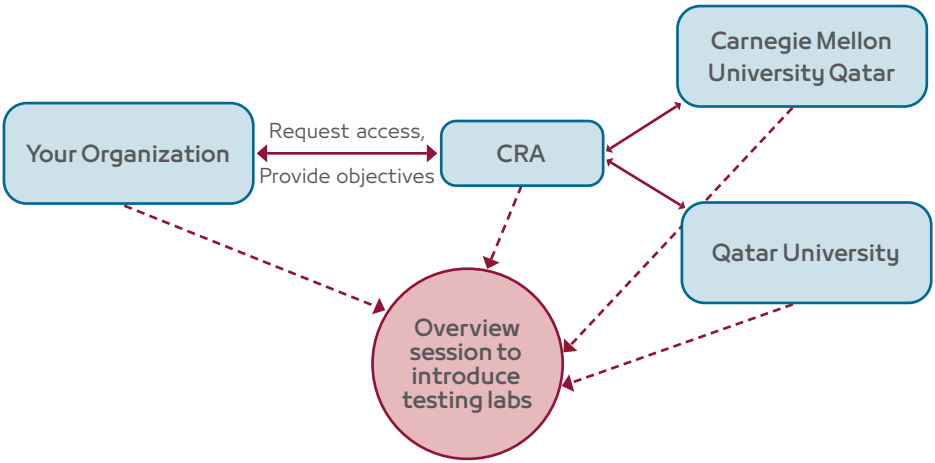


Figure 5: **Procedure for Conducting Testing Labs Overview Session**

4. We will determine the period of access and other support parameters.
5. The universities and your organization will enter into a Memorandum of Understanding noting the above.
6. Engagement, learning and testing can then begin and will last through the agreed-upon dates.
7. If appropriate, CRA will follow up with your organization to assist and track adoption of IPv6.

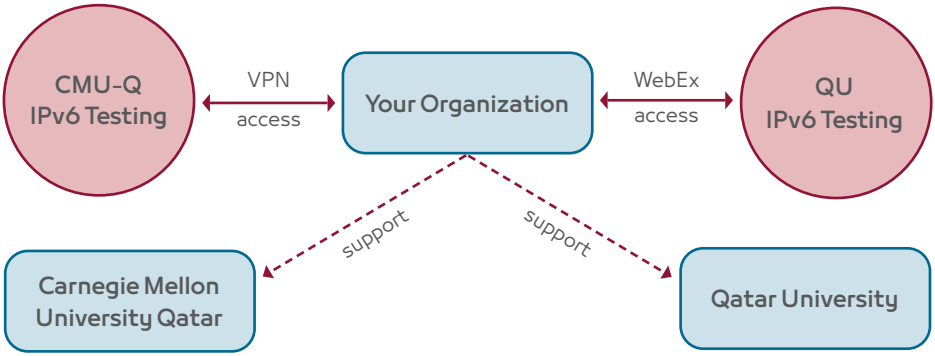


Figure 6: **Testing Lab Access and Support Mechanisms**

5. TESTING LAB ACCESS AND COVID-19

This document is being published in early 2021 during the COVID-19 pandemic. Physical access to university campuses and lab equipment is restricted under the current health and safety rules. Remote access is provided to facilitate experimentation; however, this limits what can be tested.

Since the health and safety rules are revised in response to the changing COVID-19 situation, we will determine the extent to which access is provided in our initial session. Your organization should be prepared to access the testing lab remotely; hence Appendix A and B has the full remote access procedures for CMU-Q and QU labs. Physical access can be provided only when the health and safety rules permit, and the universities have largely returned to the pre-pandemic mode of operation.

Appendix A: Remote Access Procedure for CMU-Q IPv6 Testing Lab

You can use a VPN to remotely access the CMU-Q IPv6 testing lab. Connect your browser to https://lab-vpn.qatar.cmu.edu/ and follow these instructions:

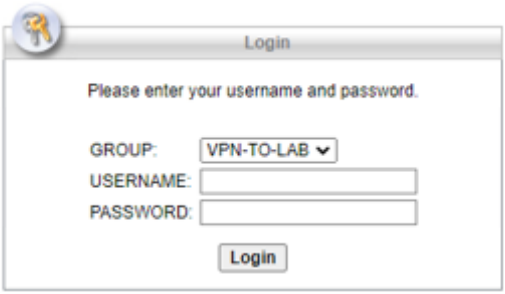


Figure 7: **VPN Login Window**

The below details include the access username and password to CMU-Q IPv6 Testing Lab. The username is given below, and the password will be provided once the access request is granted.

Username: cmu-lab
Password: (will be provided)

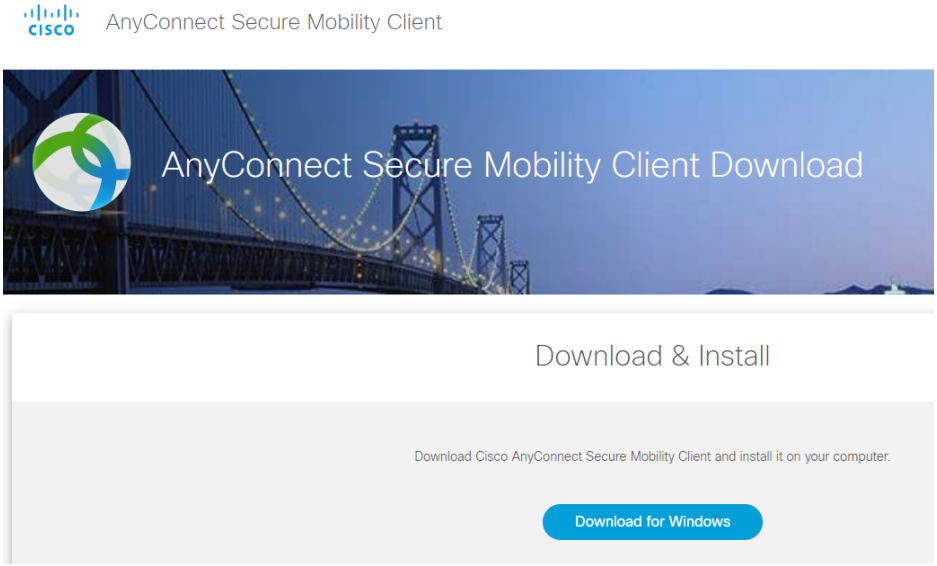


Figure 8: **Downloading the AnyConnect Secure Mobility Client**

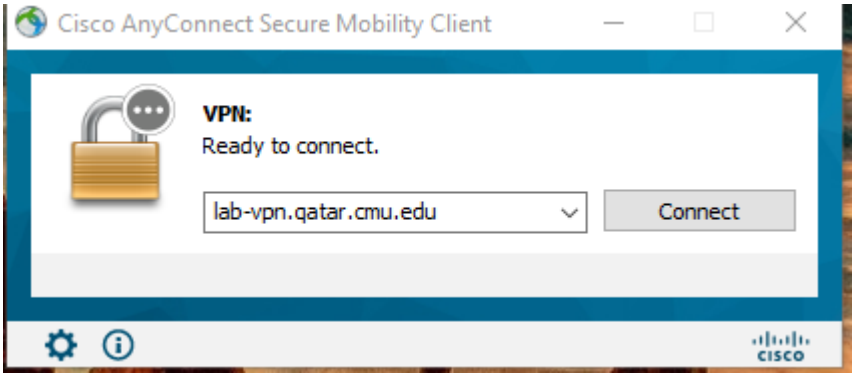


Figure 9: **Initiating the VPN Connection**

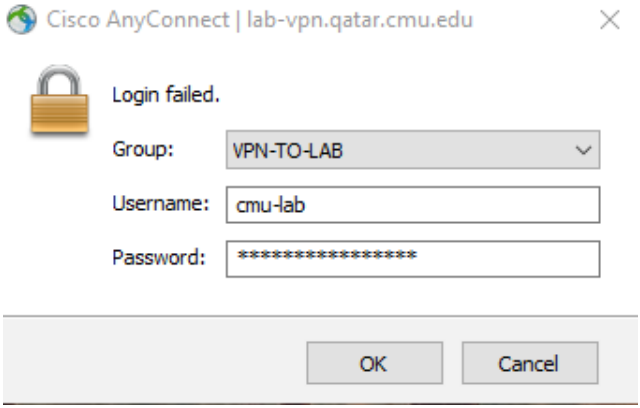


Figure 10: **Logging into VPN**

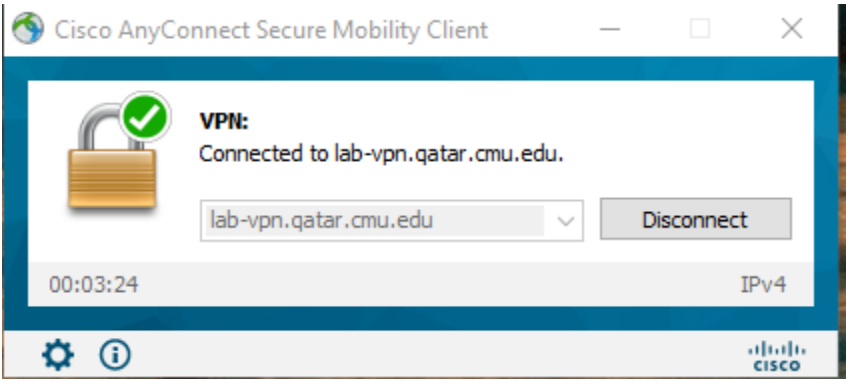


Figure 11: **VPN Connected Status**

Appendix B: Remote Access Procedure for QU IPv6 Testing Lab

For visitors who are interested in remote access to QU's lab, please contact QU to coordinate the suitable date and time for remote access. QU's contact details are provided in the access request section of the guideline.

This is the personal room link for remote access: https://qu-edu.webex.com/meet/shuja or https://qu-edu.webex.com/meet/melhedi. You will have to join the room with your institution's official email address.

After login, QU will demonstrate and guide you through the IPv6 setup of the QU campus and lab. Kindly note you will only have access to production setup, which will be helpful in your own lab and production setup to compare the configurations. You will be able to perform limited / nonimpact IPv6 changes to the test environment and no debugging commands are allowed. QU may also be able to assist you in setting up your lab or IPv6 rollout remotely, however, QU will not access or configure any devices.

Kindly note all remote access sessions will be recorded for auditing purposes.

www.cra.gov.qa