

# On Interconnecting GpENI with MAX: A Report

(A deliverable for GENI)

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## 1. Introduction

GpENI needs the capability of creating dynamic virtual circuits from any of the participating GpENI universities to the MAX network. In this document we investigate the changes needed in the GpENI infrastructure to establish a dynamic circuit connection to MAX. The current infrastructure of GpENI has already been described in the previous 2 deliverables [6] [7]. We discuss 3 options to connect to MAX: (1) by modifying certain configurations in GPN switch and using our existing Internet2 connection, (2) using ProtoGENI backbone, (3) by using a new GpENI switch. To understand the different options we provide background information on the terminologies such as DCN/ION, ProtoGENI, DRAGON, OSCARS, VLAN, QinQ in Section 2. Note that the changes described in the document will enable us to connect to Internet2 DCN which means that we can even connect to sites other than MAX.

## 2. Background

### 2.1 DCN/ION

Dynamic Circuit Network (DCN)/Interoperable On-demand Network (ION) [14] is a networking service in Internet2 that provides the researchers the ability to create short circuits of large bandwidth across the network. These circuits are created for the bandwidth intensive applications that are run over the Internet2 backbone network. This service uses both the software components of OSCARS [11] and DRAGON [4] to create dynamic circuits across various domain and across various network technologies. The circuits are created and deleted using the Web User Interface provided by the OSCARS software components. The Inter Domain Controller (IDC) [12] specification was created by the DICE Control Plane Working Group [13] which is basically the entity managing the circuit creation and deletion along with user authentication and authorization mechanisms in an Autonomous System (AS) or local domain.

### 2.2 ProtoGENI

ProtoGENI [15] is a control framework belonging to the NSF/GPO-funded GENI project. ProtoGENI uses the Emulab software and PlanetLab to create a slice of computing as well as networking resource across ProtoGENI testbed.

### 2.3 DRAGON

Dynamic Resource Allocation via GMPLS Optical Networks (DRAGON) [4] was a NSF fund-

ed project to dynamically provision network resources across various domains and across heterogeneous networking technologies. GMPLS [16] is the key protocol used to create circuits spanning across both optical and Ethernet domain and hence DRAGON creates a Layer 1 virtual circuit. A set of software components have been developed to leverage this capability across a testbed over the Washington D.C area. The major components of DRAGON software are VLSR (Virtual Label Switched Router), NARB (Network Aware Resource Broker), ASTB (Application Specific Topology Builder), RCE (Resource Computation Engine). As DRAGON provides the capability to create circuits that span across various domains the NARB acts as the entity that represents a local domain or Autonomous System (AS). In each domain each switch needs to be configured separately for creating a circuit and hence VLSR acts as the entity controlling switches. The RCE and ASTB are used for computing the resources required for creating circuits. Hence a particular DRAGON domain will have a NARB and one or more VLSR depending upon the number of switches in the domain.

## **2.4 OSCARS**

On-Demand Secure Service and Advance Reservation System (OSCARS) [11] is a networking service deployed in the DoE ESnet to create dynamic, deterministic and secure circuits across the ESnet network. MPLS [18] and RSVP [17] are the key protocols used to create advance reservations of bandwidth using the software components developed as part of OSCARS project. The Label Switched Path (LSP)s are created using MPLS both in Layer 2 and Layer 3 using OSCARS software. The circuits are created and deleted using a web interface provided by the OSCARS and hence this method is adopted in the DCN/ION project as interface for managing virtual circuits. The major software components of the OSCARS are Reservation Manager (RM), Path Setup Subsystem (PSS) and Bandwidth Scheduler Subsystem (BSS), Authentication, Authorization and Audition Subsystem (AAA). The RM, PSS, BSS are used for reserving resources and creation and deletion of actual circuits in the network and AAA is used to provide authentication mechanisms using X.509 certificate.

## **2.5 VLAN**

Virtual LAN [8] is a networking topology used to provide secure and reliable transport between hosts that are not physically connected to each other. IEEE 802.1Q [3] is the most commonly used standard for VLANs and it has been implemented in most of the commercially available switches. VLAN tag is a 32-bit field added to the Ethernet frame, which has a 12-bit field called VLAN Id specifying the VLAN number of the packet transmitted over the network. The VLAN number is the entity which differentiates packets of different virtual circuits over a network. There are two approaches to assign VLAN membership, static vlans and dynamic vlans. The static vlans are created by assigning ports to VLAN and dynamic vlans are created using software such as CiscoWorks 2000 in Cisco managed switches and it can also be created using SNMP [9]. VLANs are mostly used by the corporate networks to separate traffic of various applications which share the same network infrastructure. The VLAN tags are added when the packet enters the corporate network and they are removed when they leave the network.

## **2.6 Q in Q**

Q in Q or Double tagging [3] is a method to add one more outer VLAN tag to already tagged packets. This is used by the Internet Service Providers to separate network traffic between different use groups so that one user group will be isolated from other group. However each member in a group can

have their packets tagged differently so that they can protect their packet from other members of the same group. IEEE 802.1ad is the standard specifying this method of double tagging the packets sent over the network. Similar to VLAN tagging the outer tags are added once the packets with inner tag enters the corporate network and the outer tag alone is removed when the packets leave the network.

### 3. Interconnection Options

The document *DCN/ION in GpENI Investigation Report* already discusses the options of enabling DCN/ION in GpENI network. However, with the help of ProtoGENI resources we have additional options to connect to MAX. In the following sections 3.1, 3.2 and 3.3 we discuss in detail the various options to connect to MAX.

#### 3.1 Option 1: GpENI Network Connectivity with DCN (using GPN switch)

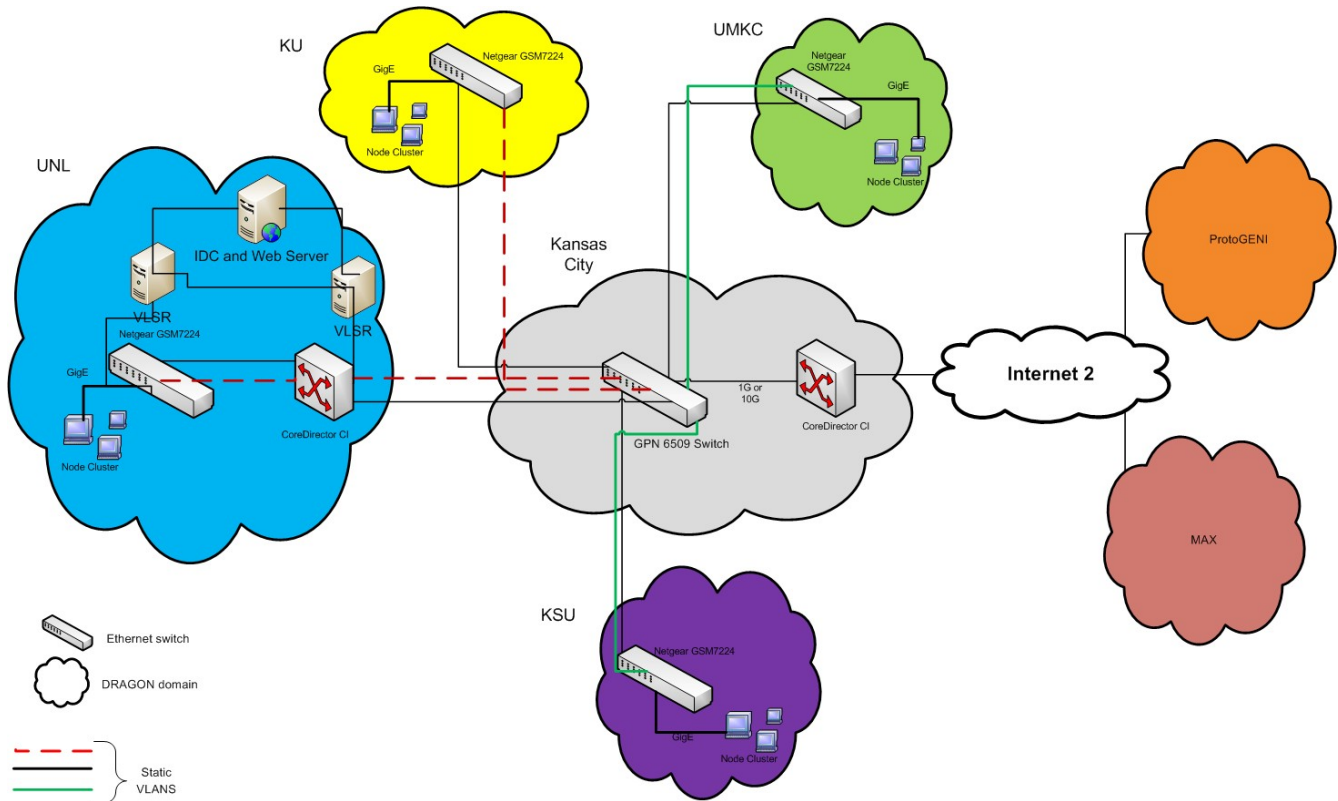


Figure 1: Connection to MAX using GPN switch and Internet2.

This option discusses using the existing GPN switch for creating DCN network within GpENI. It further discuss the two ways:(a) static vlan and (b) Q-in-Q [3], to achieve this goal.

In the first method, static vlans are configured in the GPN switch so that DCN circuits can be created between universities with predefined VLAN tags. Hence this involves creating a table of VLAN tags for all possible source and destination of DCN circuits between GpENI universities and configuring them appropriately at the GPN switch. Hence to connect to MAX in this method we need to configure one more VLAN tag for each university or configure a VLAN tag so that all universities

use DCN to MAX only with this VLAN tag. This is basically a choice between individual circuits from each university to MAX or to have a single broadcast domain to MAX. These VLAN tags need to be configured to the interface of GPN in which the CoreDirector of Kansas City PoP is connected to the GPN switch. In this method we need to have an IDC controlling the creation of circuits with the predefined tags from each university. Hence the IDC could be placed in UNL and we need a VLSR for controlling all the Netgear switches of all the GpENI universities and a VLSR for controlling the CoreDirector. We can configure one of the PCs to act as a web server and configure the OSCARS software (see section 2.4) in it so that each university can create and delete circuits using the web interface of OSCARS software.

In the second method, Q-in-Q is configured in the GPN switch so that it acts as a pass through for packets of any VLAN tag generated by any of the GpENI universities. Hence to connect to MAX in this method we need to just include the interface of the GPN switch which is connected to the CoreDirector of the Kansas City PoP in the Q-in-Q cloud. In this manner we can create circuits of any VLAN tag from any of the GpENI university to the MAX. In this also the IDC placement and VLSR placement are similar to the method above but the only difference is that users can create circuits with arbitrary VLAN tag to MAX.

In both of the above methods we can also have separate VLSR in each GpENI university creating individual DRAGON domain in each GpENI university. Instead if we have a VLSR for controlling all the Netgear Switches then we have only one DRAGON domain representing all the GpENI universities. Figure 1 shows the IDC, VLSR and web server placement as discussed in this section.

### 3.2 Option 2: GpENI Network Connectivity with ProtoGENI (using GPN switch)

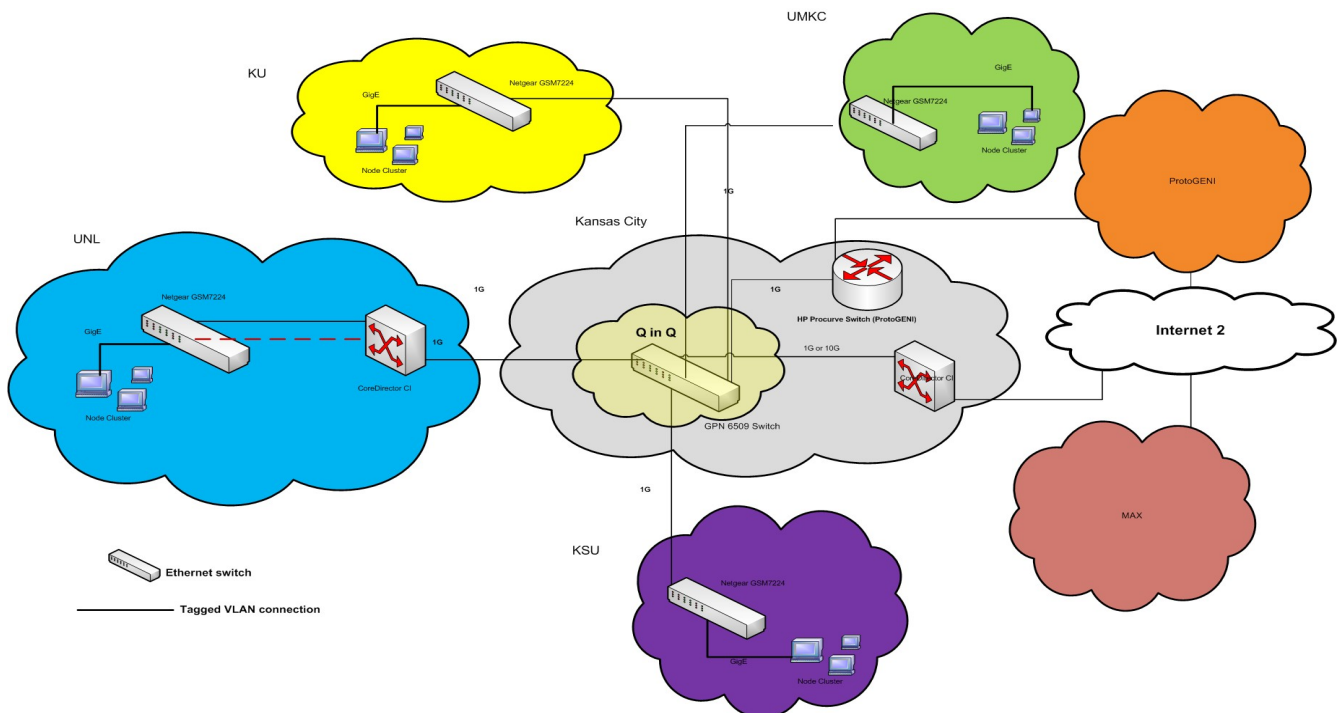


Figure 2: Connection to MAX using GPN switch,ProtoGENI and Internet2.

ProtoGENI has a 10G backbone in the Internet2 network and it has already deployed its nodes(which includes HP 5400 switches, NetFPGA cards, and 2 PCs) at 3 Internet2 sites (Kansas City, Salt Lake City and Washington D.C.).

Currently, in the HP Procurve [19] switch deployed at Kansas City, there is no free 10GigE port available. Hence, in this option we create a 1GigE connection between the GPN switch at Kansas City and the HP procurve switch in the ProtoGENI node and using this connection to connect to MAX.

Currently in the GpENI network all the universities deliver untagged packets to the GPN switch. Since the ProtoGENI requires the packets to be tagged with specific VLAN, the Q-in-Q cloud need to be setup in the GPN switch and each university is required to transmit packets to the GPN switch with predefined outer VLAN tag agreed with ProtoGENI. Q-in-Q would be used on the GPN switch to alleviate the need for VLAN number coordination within GPN. The component manager of the ProtoGENI need to be setup so that we could request dynamic circuits from GpENI to any node of ProtoGENI. The figure 2 shows the connection between the GPN switch and the ProtoGENI node in the Kansas City PoP. In this case we will be using the client software of ProtoGENI instead of DCN to create dynamic virtual circuits. However the circuits can only be created from and to the ProtoGENI nodes and hence the traffic inside GpENI will remain as a broadcast domain.

### 3.3 Option 3: GpENI Network Connectivity with DCN (using GpENI switch)

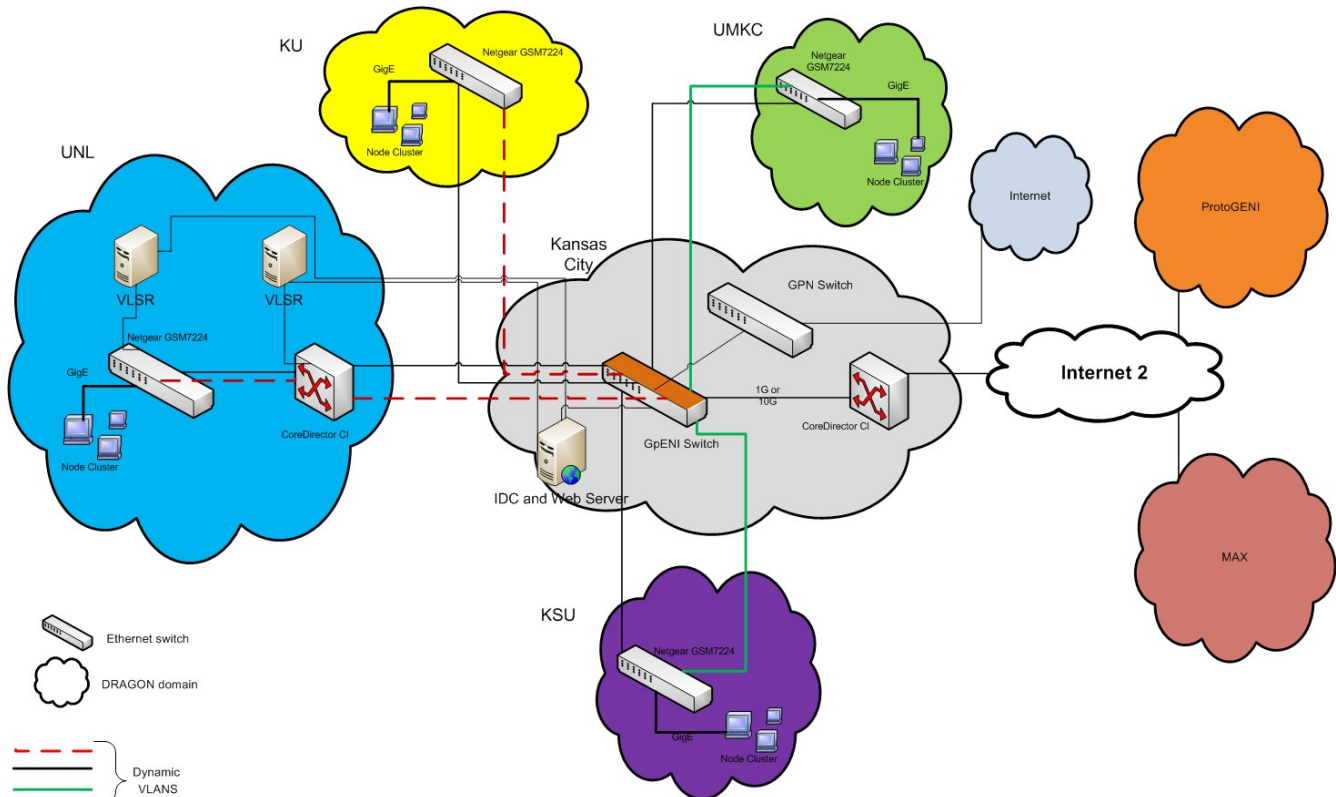


Figure 3: Connection to MAX using GpENI switch.

This option discusses acquiring a new Ethernet switch (GpENI switch), which is already supported by the DCN/ION software suite and replacing the existing GPN switch with the GpENI switch.

MAX network can be connected in this method by just connecting the CoreDirector of Kansas City PoP to the GpENI switch. We can have a dedicated IDC controlling the GpENI switch and 1 VLSR controlling all the Netgear switches and a VLSR controlling the CoreDirector in UNL campus. In this case only the dynamic circuit from or to the UNL need to be in the order of 50Mbps as CoreDirector is in the path. Otherwise the dynamic circuits between other universities could be of any bandwidth capacity supported by the interface of the GpENI switch. Having CoreDirector participate in dynamic circuit is just a choice and hence if we want to create dynamic circuits of any bandwidth to UNL we could remove the VLSR controlling the CoreDirector switch and make it as a pass through switch, simply passing the traffic to other end irrespective of the packets VLAN tag. In this method the IDC need to be located in the Kansas City PoP and the VLSRs could be in each university or we could have one VLSR controlling all the Netgear Switches located in the UNL. The GpENI switch can be connected to Internet2 with DCN or it can be connected to ProtoGENI backbone also if we have a connection between the GpENI switch and the HP procure switch of ProtoGENI node.

## 4. Discussions

	<b>Option 1</b>	<b>Option 2</b>	<b>Option 3</b>
<b>Connectivity</b>	Internet2	Internet2 with ProtoGENI	Internet2 or Internet2 with ProtoGENI
<b>Hardware</b>	Existing GPN switch	Existing GPN switch	New GpENI switch
<b>Cost</b>	Less	Less	High
<b>Capability</b>	Individual circuits from CoreDirector of Kansas City to any Internet2 site but broadcast domain within GpENI	Individual circuits from ProtoGENI node to any ProtoGENI node but broadcast domain within GpENI	Individual circuits from any GpENI universities to any Internet2 or ProtoGENI site
<b>Software</b>	DCN/ION software suite	Emulab + PlanetLab	DCN/ION or Emulab + PlanetLab

The above mentioned options were arrived at after discussions with several people from MOREnet, MAX, USC (ISI), KANREN and IS of UNL. We will initially attempt option 1 and option 2 and later on when funds are available we plan to switch to option 3 as it gives more flexibility in creating dynamic circuits.

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