

## Options and cost implications for GENI network connectivity with Amazon EC2 cloud resources

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Resources allocated on the Amazon EC2 cloud have to be connected with other GENI resources to participate in an experiment. Disk resources (S3 or EBS) can only be accessed from EC2 servers called instances. EC2 currently provides resources in three different regions: 'US – N. Virginia', 'US – N. California' and 'EU – Ireland', while the lower costs are currently for resources located in 'US – N. Virginia'. Each region has a number of availability zones which ensures that machines are not within the same failure zone.

We report the different options available to date to access EC2 resources and their cost. Note that all options are IP-based and are layer-3 solutions at best.

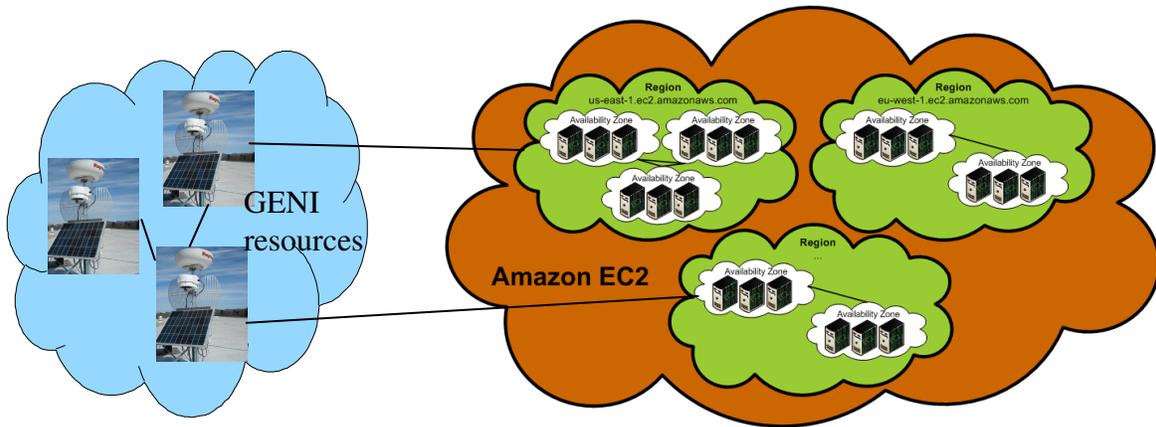


Figure 1. EC2 regions and availability zone<sup>1</sup>

### 1. Dynamically assigned IP addresses

EC2 instances (servers) are dynamically assigned IP addresses when they are created. A public IP address is available for remote connections and a private IP address is created for internal communications (inside EC2). All network traffic between EC2 instances (inside the same availability zone of the same region) is free. Traffic between resources

<sup>1</sup> Picture from <http://docs.amazonwebservices.com/AWSEC2/latest/DeveloperGuide/>

in different regions is considered Internet traffic. All network exchanges between GENI resources outside of EC2 and EC2 resources are charged as follows (same cost for all regions):

<b>Data Transfer In</b>	
All Data Transfer	\$0.10 per GB (free through June 30, 2010)

<b>Data Transfer Out</b>	
First 10 TB per Month	\$0.17 per GB
Next 40 TB per Month	\$0.13 per GB
Next 100TB per Month	\$0.11 per GB
Over 150 TB per Month	\$0.10 per GB

All data transferred between instances in different Availability Zones in the same region are charged \$0.01 per GB in/out.

## 2. Static IP addresses

Amazon offers static IPv4 addresses that can be assigned to instances at an additional cost. A customer is limited to 5 such addresses by default but more can be obtained on demand. An instance first starts with a generic public and private IP addresses and then can be remapped to a static IP address (called Elastic IP).

While this offers the opportunity to use static IP addresses in GENI experiment configuration files, a user could try to re-use these IP addresses after his lease has expired and interfere with other experiments.

Unused static IP addresses are charged \$0.01/hour. Assigning a static IP address to an instance cost \$0.10 (the first 100 assignments in a month are free).

## 3. VLAN connectivity in the EC2 instances

In order for EC2 instances to be part of a VLAN, the simplest solution is to run a VLAN software like OpenVPN<sup>2</sup> in the EC2 instances. It is the responsibility of the user to setup that VLAN so that it can communicate with the rest of its GENI resources. There is no additional cost for such setup besides the network traffic charges described in Section 1.

## 4. VLAN through Amazon Virtual Private Cloud (VPC)

Amazon Virtual Private Cloud service allows setting up a bridge to expand a VLAN with EC2 resources. Note that this can only be a layer 3 VLAN. Figure 2 shows the architecture proposed by Amazon VPC. Amazon VPC provides end-to-end network isolation by utilizing an IP address range that is specified by the user, and routing all network traffic between VPC and the user network through an encrypted IPsec VPN.

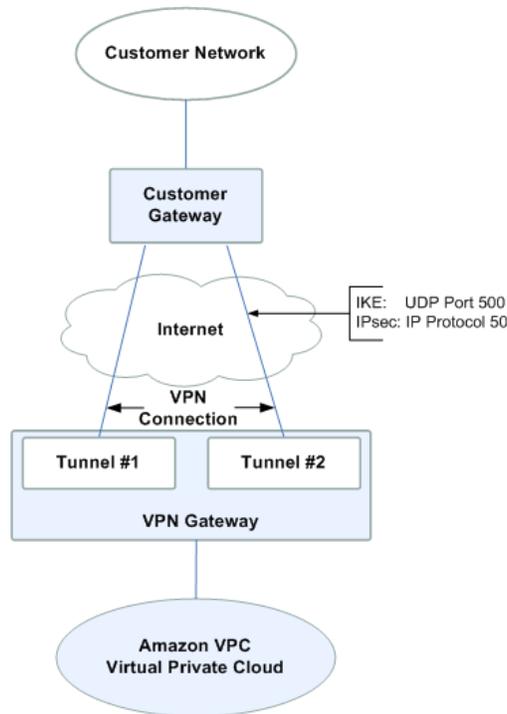
The customer gateway can be either software or hardware. The current documentation (<http://docs.amazonwebservices.com/AmazonVPC/latest/NetworkAdminGuide/index.ht>

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<sup>2</sup> <http://openvpn.net>

ml?Introduction.html) only lists Cisco Integrated Services routers running Cisco IOS 12.4 (or later) software and Juniper J-Series routers running JunOS 9.5 (or later) software as compatible devices.

There is a base price of \$0.05 per VPN Connection-hour plus the cost of the network traffic described in section 1. Note that all resources in the VPC can only access resources outside VPC (even if they are in EC2) through the tunnel and your own Internet connection.



**Figure 2. Amazon VPC architecture overview<sup>3</sup>**

More information about setting up Amazon VPC can be found at <http://docs.amazonwebservices.com/AmazonVPC/latest/NetworkAdminGuide/index.html?GenericConfig.html>.

The VPC account is bound to the Amazon EC2 (AWS) account. The current limitations of Amazon VPC are:

- One (1) VPC per AWS account
- Twenty (20) subnets per VPC
- One (1) VPN gateway per AWS account
- One (1) VPN connection per VPN gateway
- One (1) customer gateway per AWS account

<sup>3</sup> Picture from <http://docs.amazonwebservices.com/AmazonVPC/latest/NetworkAdminGuide/>

Providing the VPC functionality can only work for a single user (one VPC per AWS account only). This would not allow a broker to manage its resources globally and have multiple concurrent users using a pool of EC2 resources.

Another option illustrated in Figure 3 would consist in having the broker run the customer gateway and act as a bridge with the end-user resources. This option would still have the limitation that all users going through the same broker would be sharing the same VPN on the EC2 side. Having as many AWS accounts as GENI users does not seem practical and would make accounting and billing much more complex.

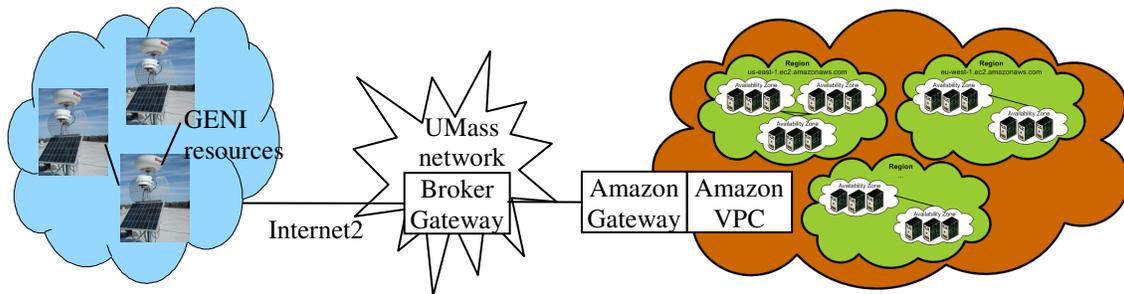


Figure 3. VPN connectivity through a broker

## 5. Recommended solution for year 1

The EC2 offering is expanding quickly and we expect additional VLAN support for EC2 resources through Amazon VPC or another service (note that Amazon VPC just went from restricted beta to public beta in December 2009).

Given the current lack of offering for layer-2 connectivity with EC2 resources and the current limitations of the Amazon VPC offering, the recommended solution is just to use the public IP addresses provided by Amazon to address EC2 resources. If VLAN capabilities are required, the user can easily setup a software IPsec VPN in the EC2 instances it is running. We propose to offer Amazon images with a pre-installed OpenVPN package for that purpose.