GENI Availibility

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ABSTRACT

The Global Environment for Network Innovations (GENI) is a testbed for network research. GENI is funded by the Computer and Network Systems division of the directorate for Computer & Information Science & Engineering division of the National Science Foundation. This testbed exists to provide a unique virtual laboratory for at-scale networking experimentation, to enable repeatable experiments on large, complex, networked systems, to open the way for transformative research at the frontiers of network science and engineering, and to inspire and accelerate the potential for groundbreaking innovations [6]. The availability of a testbed capable of these claims is invaluable to the networking academic community and networking innovators in general. Experiments were performed to assess the availability of GENI resources. Intra-site Rspecs used on InstaGENI sites succeeded in adding reserved resources to a GENI slice 81.1% of the time while succeeding in bringing the reserved resources to a ready state 76.5% of the time. Multi-site Rspecs whether InstaGENI or otherwise failed to reserve resources 69.2% of the time while succeeding in bringing the reserved resources to a ready state 7.7% of the time. Intra-site Rspecs used on Exo GENI sites succeeded in adding reserved resources to a GENI slice and succeeded in bringing the reserved resources to a ready state 33.3% of the time.

INTRODUCTION

GENI (Global Environment for Network Innovations) provides a virtual laboratory for networking and distributed systems research and education. The architects of this testbed believe that it is well suited for exploring networks at scale, which should in turn promote innovations in network science, security, services and applications. GENI features include allowing access to compute resources from currently a limited number of locations around the United States. There are currently more pending sites than there are active sites. Other GENI features include the ability to connect compute resources using Layer 2 networks in diverse topologies that vary in accordance with the designed experiments, the customization of software and/or operating systems on requested compute resources, the control of how network switches in designed experiments handle traffic flows, as well as the ability to run unique Layer 3 and above protocols [6].

The existence of GENI, a virtual laboratory for exploring future internet technologies, creates major opportunities to understand, innovate and transform global networks and their interactions with society. The flexibility and dynamic deployment of experiments onto common infrastructure is a new approach, fostering change in how network system research and analysis is conducted.

With the inclusion of all the pending sites and as well as additional sites GENI may be able to fulfill its goals. The yet unrealized goals of GENI include support of at-scale experimentation on shared, heterogeneous, highly instrumented infrastructure, including experimentation aimed at demonstrating user acceptance and societal value. Enabling deep programmability throughout the network, promoting innovations in network science, security, technologies, services and applications. Providing collaborative and exploratory environments for academia, industry, and the public to catalyze groundbreaking discoveries and innovation. The project is still in a toddler stage.

Performing a large-scale experiment infrastructure requires requested large amounts of resources, ideally across multiple sites. Available resources that exceed the typical setup found in any one laboratory are able to be requested via GENI. Resources available via GENI include compute resources such as virtual machines and “bare-machines”, and network resources such as links, switches and WiMax base stations. Alternatives to IP connectivity across resources can be deployed using GENI. Switches as well as end hosts can be programmed in an experimental network using GENI. Allowing experimentation with novel network layer protocols and with novel routing algorithms.

METHODOLOGY

A set of experiments was performed to access the availability of GENI resources. Experiments were conducted between 0800 and 2359 Central Standard Time over a consecutive 4 day period, Monday May 2 thru Thursday May 5, 1016. Figure 1 displays the amount of experiments conducted each day as well as the time frame in which these experiments were conducted.

Day	2016	start time of first experiment	start time of last experiment	number of experiments
Monday	2-May	18:31:25	22:36:47	10
Tuesday	3-May	8:39:33	19:17:09	25
Wednesday	4-May	8:34:44	23:12:47	11
Thursday	5-May	9:30:10	14:45:23	2

Figure 1: Number of experiments conducted per day with associated start times of first and last experiments.

Prior to each consecutive set of experiments the GENI site was accessed which redirects to a local site login and password. For the University of Nebraska, Lincoln one is either directed to https://fed.nebraska.edu/ or https://login.unl.edu. On Monday a new slice was created and named availibility (an incidental misspelling of availability).

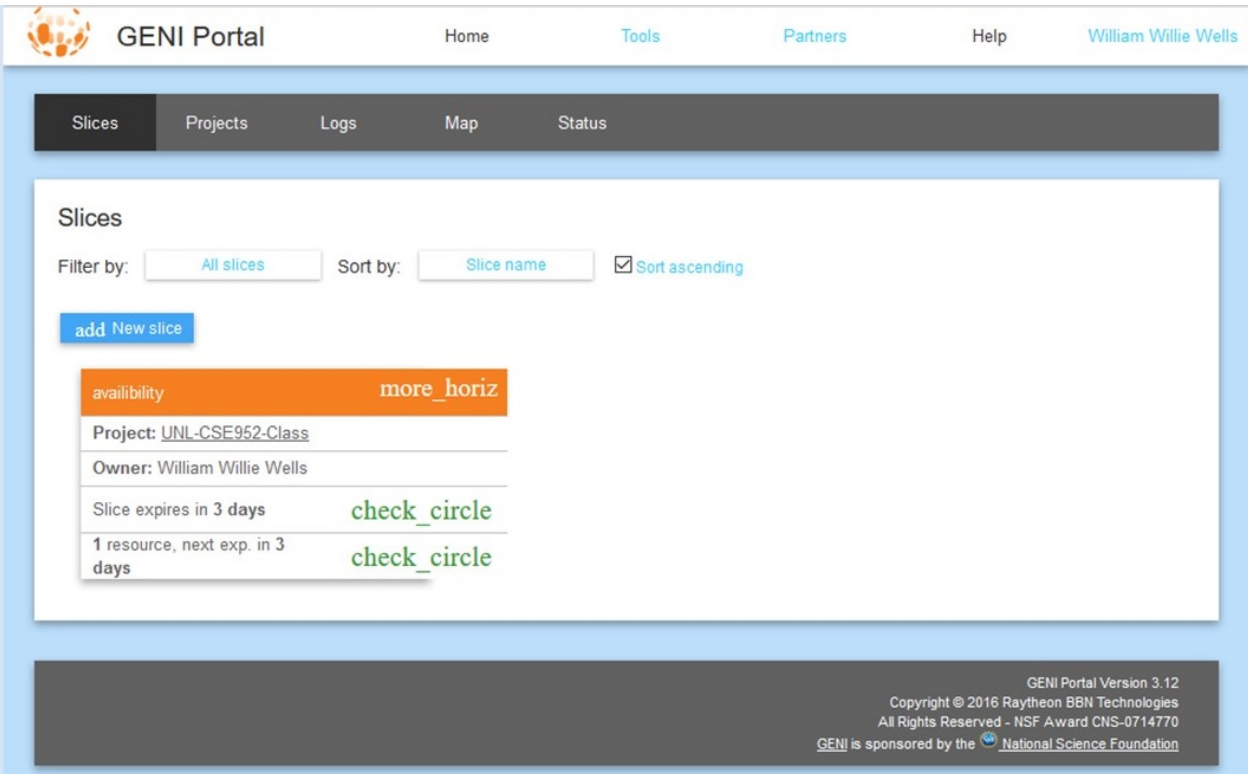

Figure 2: GENI slice page.

For each experiment the slice was selected which then brings up this page:

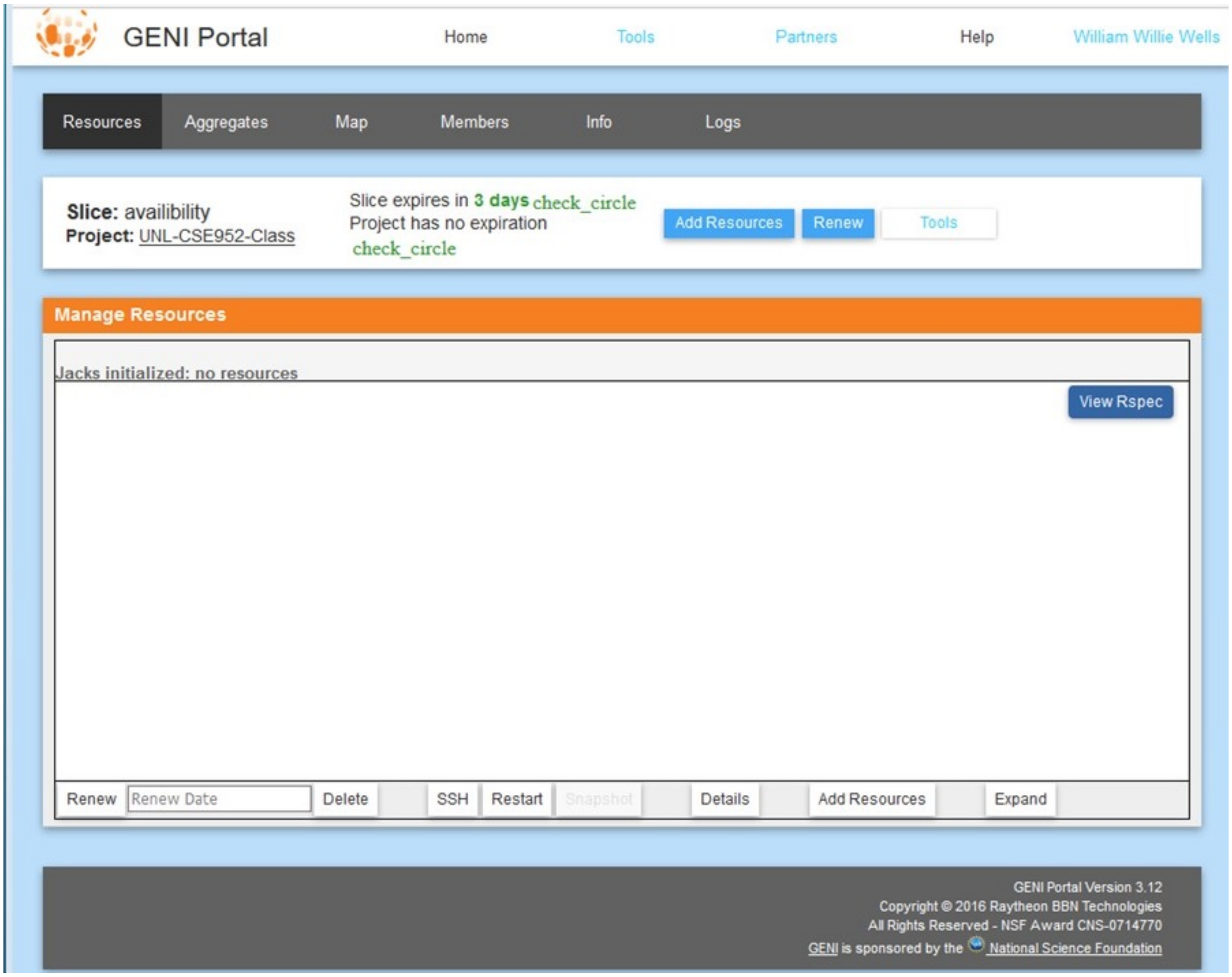

Figure 3: GENI empty resources page.

The Add Resources button was then selected and an Rspec was selected. A different combination of Rspecs was used each day.

Day	number of experiments	Rspecs Used		
Monday	10	OSPF 7-node 3-aggregate	OSPF 4-node	
Tuesday	25	OSPF 7-node 3-aggregate	OSPF 4-node	
Wednesday	11	bitcoin	4-node 2-aggregate	OSPF 4-node
Thursday	2	4-node 2-aggregate		

Figure 4: Rspecs used with respect to each day. The Rspec 4-node 2-aggregate was an Rspec created by the author of this paper. The other Rspecs are publicly available.

Figure 5: Rspec selection using the 4-node 2-aggregate Rspec with Case Western and University of Chicago InstaGENI sites.

The Reserve Resources button at the bottom of the page was then selected bringing up an Add Resources page with the option to view the detailed progress, which was selected. The detailed Progress Log was downloaded after the resource reservation was either completed or failed. The log contains start time, finish time, and error information as well as site(s) requested.

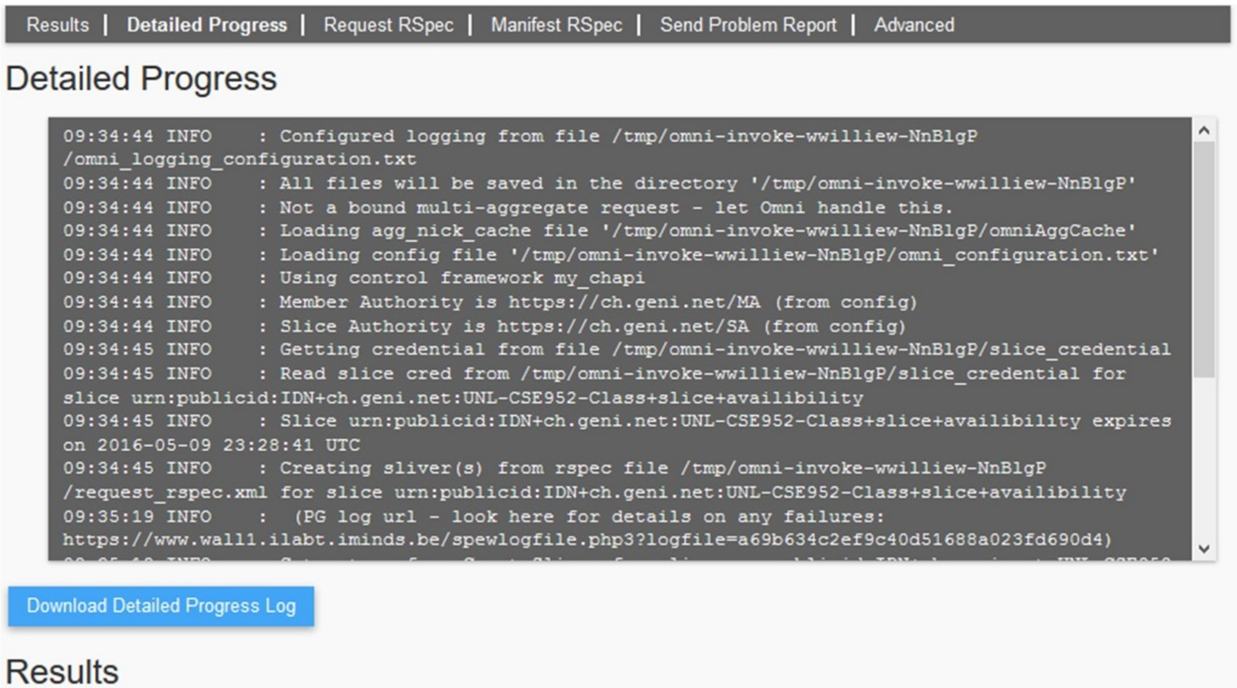

Figure 6: GENI detailed progress log.

The Slice was selected from the current page and then from that page the Details button was selected, when all sites displayed a ready status or when the first site failed the current time was annotated in an excel spreadsheet.

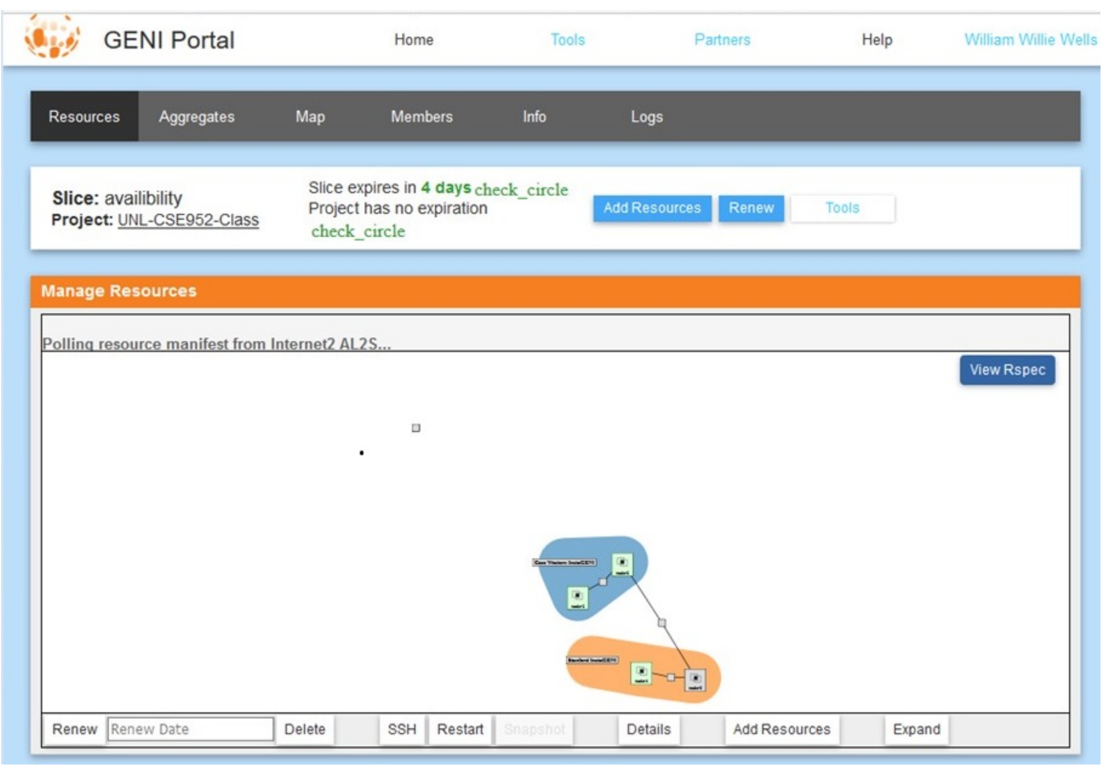

Figure 7: Resource readiness page.

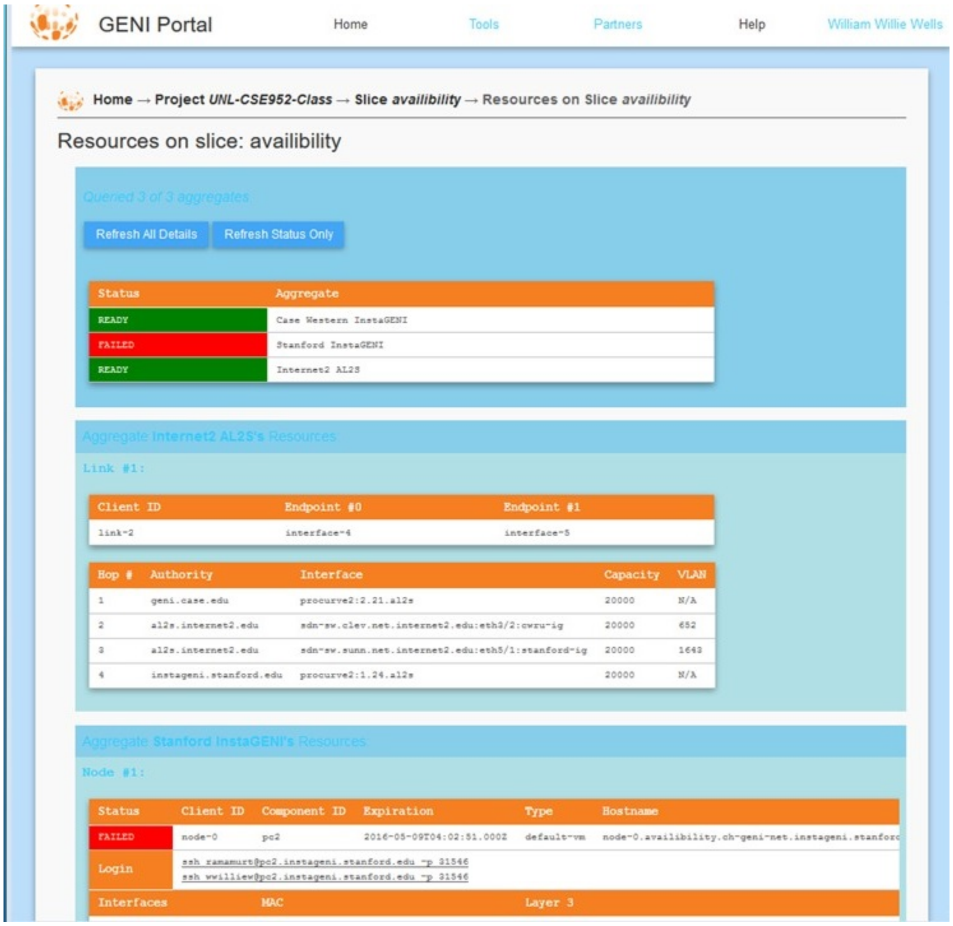

Figure 8: GENI detailed resource readiness page.

The current slice resources if any existed were deleted by selecting Home→Slices, more_horiz→Delete resources. The process was repeated for the next experiment with a variation in either Rspec or in the site(s) requested.

All InstaGENI sites that were able to execute OSPF 4-node were requested in turn on either Monday or Tuesday of the study. On Wednesday one of the sites that failed the OSPF 4-node request the previous day was requested and that request succeeded. At various times during the experiment periods on Monday and Tuesday a request for OSPF 7-node 3-aggregate was initiated. ExoGENI sites were requested using the bitcoin Rspec on Wednesday. A second multi-site Rspec, 4-node 2-aggregate, was created and used on Wednesday. This second multi-site Rspec was created to test the multi-site resource reservation capability of GENI. Each site contains 2 nodes. A link exists that connects one of the two nodes in each site to the other site.

RESULTS

The time required to reserve resources will be reference as t_r, $30 < t_r < 75$ seconds for all successful resource reservations of InstaGENI sites tested. The t_r for successful ExoGENI site resource reservations was $t_r < 15$ s or $t_r = 155$ s. Failed ExoGENI site resource reservations corresponded to $t_r \in$ (6 minutes, 7 minutes) with an outlier of 17 seconds for a second attempt to reserve resources at NICTA and a second outlier of $t_r = 1147$ s when attempting to use ExoSM, a stitching site, as a primary site. A single failed resource reservation of InstaGENI sites had a $t_r = 8$ s while all other failures to reserve resources at InstaGENI sites corresponded to $t_r > 10$ m. Successful resource reservation of multi-site InstaGENI sites corresponded to a value of $t_r \in$ (46 s, 54 s). This information is displayed in Figure 9. Total successful resource reservation was 34/50 = 68.0%. Single site successful resource reservation was 30/37 = 81.1%.

Multi-site successful resource reservation was 4/13 = 30.8%. InstaGENI single site successful resource reservation was 27/28 = 96.4%. ExoGENI single site successful resource reservation was 3/9 = 33.3%.

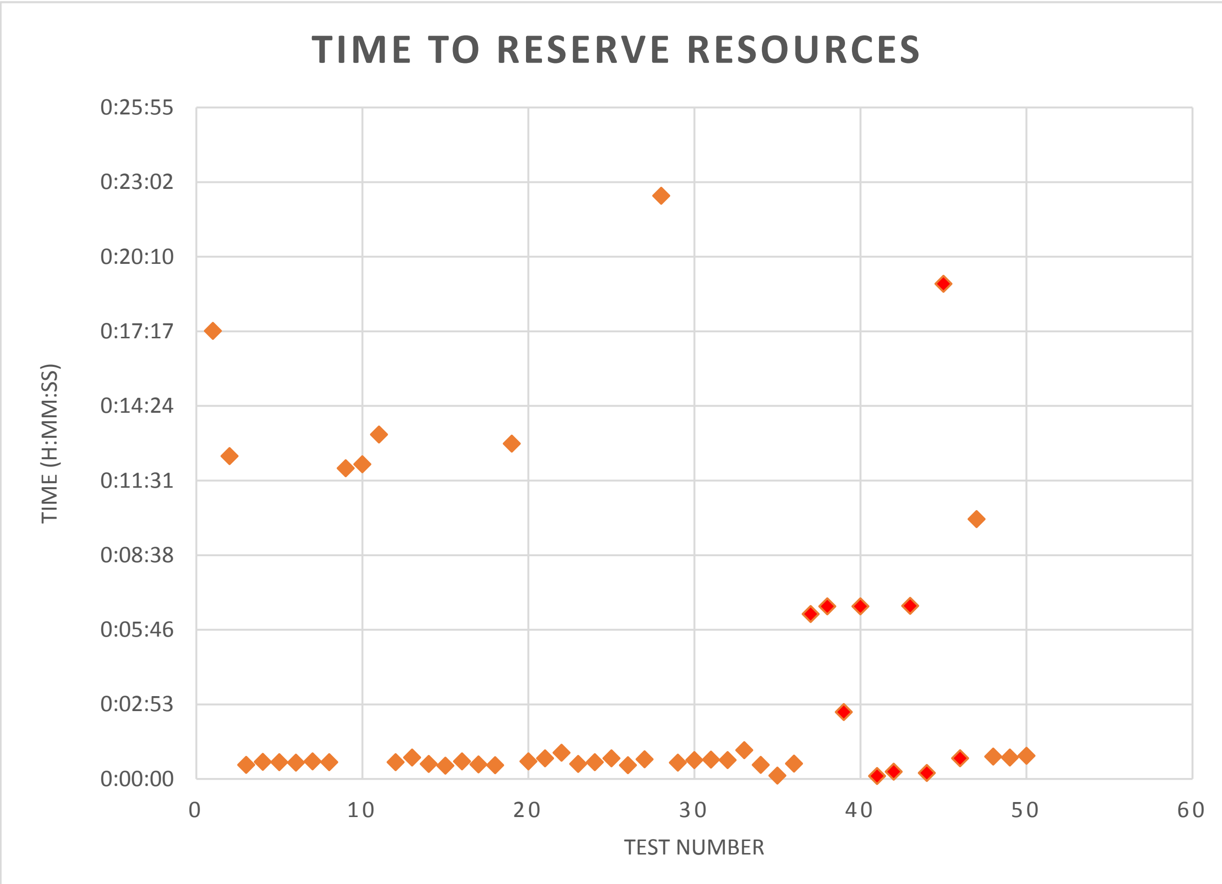

Figure 9: Time to reserve GENI resources from initial request until either a finished or a failed status message is received. The test numbers 38 through 46 involved ExoGENI sites all other test involve InstaGENI sites.

Time taken from initial request until resources are ready for use is a less accurate measure than the previous time measurement. This is due to the fact that the resources are ready time was taken after observing that all requested resources were ready or observing that the allocation of reserved resources had failed. These times are subject to human error whereas the initial request time and the resources are reserved time are machine generated. Any errors in recorded times versus actual ready/failed times are errors in the positive direction, increased time. Even though human error is a factor in these times the errors do not exceed 2 minutes of additional time.

This time measurement will be referenced as time until allocation, t_a. The range for t_a, is $t_a \in (2 \text{ m}, 50 \text{ m})$. The mean value is t_a = 23 minutes and 10 seconds while the median value is t_a = 22 minutes and 40 seconds. This information is displayed in Figure 10. Out of the 34 successful reservation requests 27 succeeded in allocating resources, 27/34 = 79.4% success rate. Single site successful resource allocation was 26/27 = 96.3%. Multi-site successful resource allocation was 1/4 = 25.0%. InstaGENI single site successful resource reservation was 23/27 = 85.2%. ExoGENI single site successful resource reservation was 3/3 = 100.0%.

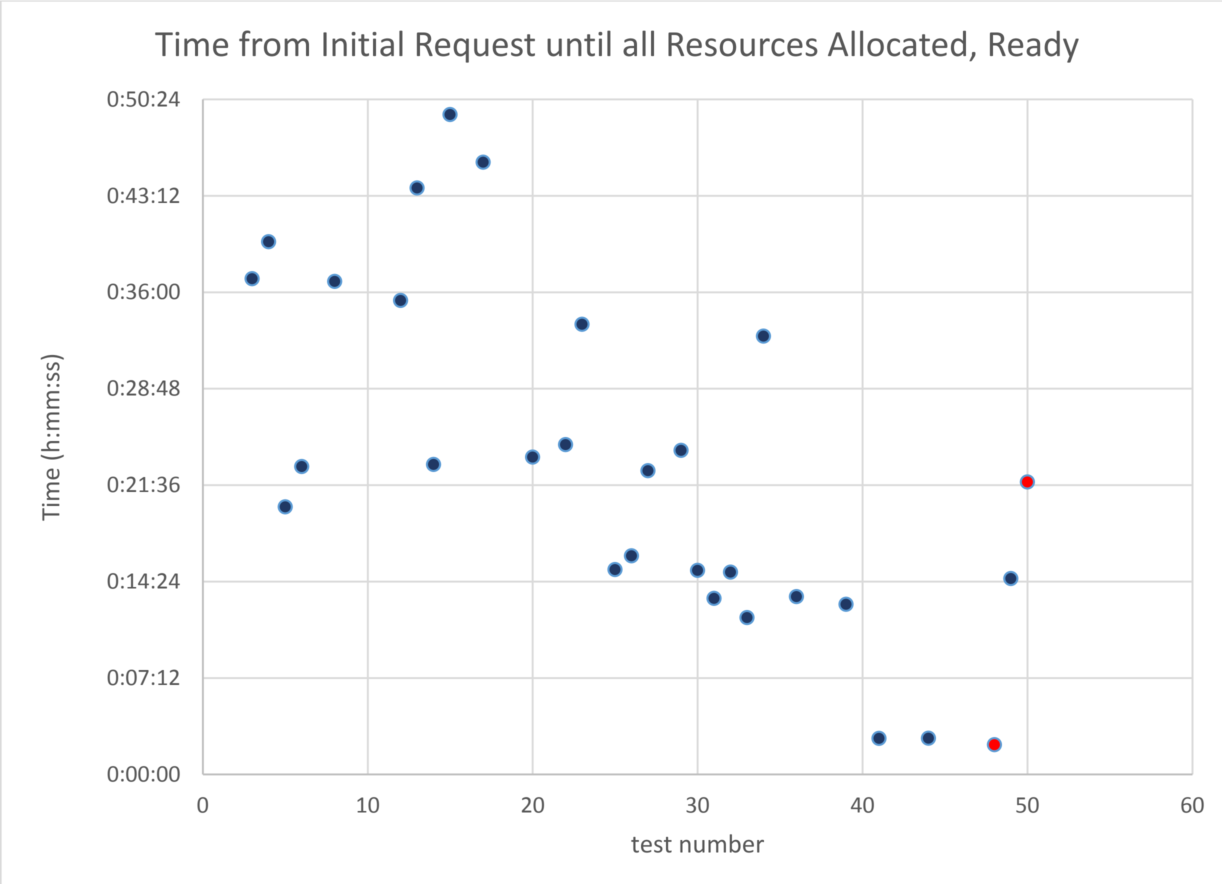

Figure 10: Time from initial request until all resources are ready for use or failure. The red dots (test 48 and 50) represent failures. All other failures are missing from this figure either because their failure time is the same as the previous figure or those times were not recorded.

Error messages for the failed multi-site tests include: requested VLAN unavailable GENI, code 14, protogeni. Single site error messages include: no available physical nodes of type pcvm found for the single InstaGENI resource reservation failure, and “BadStatusLine: '' (missing result) for the bitcoin Rspec and ExoGENI failures.

CONCLUSION

ExoGENI sites either failed the first stage or succeeded at both stages, overall time from initial request until all resources were ready for user interaction was lower, but time until the resources were reserved compared to InstaGENI sites was higher. InstaGENI site resource availability failed at either stage of the 2 stage process and in some instances the user had to wait over 30 minutes until those reserved resources were ready for use. If all the sites on the GENI site map become fully functional failures due to nodes being busy or unavailable may decrease, but with additional sites the opportunity for error prone Rspecs to enter the public space may increase with the accompanying additional users. If NSF desires to fulfill their mission and vision for GENI, multi-site stitching must become less error prone for the average user.

Future Work

This study was conducted only on weekdays during one week of May. Adding data from all days of the week and across multiple weeks would be a next step in this type of study. A year’s worth of data may also inform the experimenter of peak GENI use times by the existing GENI user community, such data may be inferred through node availability.

Four different Rspecs were used with different properties in this study. If additional public and private Rspecs were used to test overall GENI availability there would be more value to the results. If the same trends were observed while using a large pool of diverse Rspecs, failures may be attributed to something other than faulty, misconfigured Rspecs with higher confidence. Multi-site and single site Rspecs of various size and types of nodes should be used.

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