Lippis Report

Open Software-Defined Networking Test

for

Virtualized Networking

Open Networking
USER GROUP

Prospectus

The Prospectus

What: As a result of the huge growth in server virtualization and virtual machine (VM) deployment, the need to network or connect VMs has emerged. This type of networking is commonly referred to as Network Virtualization or virtualized networking. Its objective is to network VMs. The vendor community has responded to this need by providing Software-Defined Networking solutions based upon a network controller and virtual switching or vSwitch. There are only a few instances of vSwitches, such as the open source Open vSwitch or OVS, which is embedded in Xen, KVM and Virtual Box. Cisco offers the Nexus 1000V, IBM the Distributed Virtual Switch 5000V, VMware/Nicira offers an OVS plus a proprietary vSwitch while Microsoft provides the Hyper-V virtual switch**.**

These vSwitches provide data forwarding between VMs. To establish a virtual network, networking vendors are offering a control plane typically called "controllers." Unlike vSwitches, there are many different SDN controller offerings with some controllers focused upon OpenFlow (or Fabric-based) provisioning while others focus on overlay provisioning. The tests described in this Prospectus will test both, and will be categorized accordingly in the final presentation and report.

We seek to test solutions such as the following, listed in alphabetical order:

- ❑ Adara's Horizon series products,
- ❑ Big Switch Networks' Big Virtual Switch,
- ❑ Cisco Systems' eXtensible Network Controller or XNC,
- ❑ HP's Virtual Application Networks solution,
- ❑ IBM Systems' Networking Programmable Network Controller (PNC),
- ❑ Juniper's JunosV Contrail solution,
- ❑ Midokura's Midonet
- ❑ NEC ProgrammableFlow Controller,
- ❑ Nuage Networks' Virtualized Services Controller (VSC),
- ❑ One Convergence solution
- ❑ OpenDaylight SDN Controller,
- ❑ PLUMgrid's VNI solution,
- ❑ VMWare/Nicira's Network Virtualization Platform,
- ❑ Vello Systems' VellOS.

Only 10 Test Slots Available: Sign before EoD PT August 30, 2013.

2

As the virtualized networking market is relatively new, there are no independent industry tests to offer comparative evaluation data. The market is moving from education to pilots and now, to deployment. Network/IT architects and designers are entering the next market stage, which is to evaluate vendors and identify product differentiation before product acquisition and deployment. It's our hope that SDN network virtualization tests will provide empirical data that will enable Open Networking User Group (ONUG) members and the general market to speed up their deployments of SDN solutions, armed with trusted and repeatable independent test data.

Nick Lippis, CEO Lippis Enterprises and Open Networking User Group Co-Founder, in collaboration with Srini Seetharaman, SDN Technical Lead at Deutsche Telekom and previously a member of the OpenFlow team at Stanford University's Clean Slate Lab, have developed these SDN solution test methodologies. Nick and Srini have teamed with Ixia for the execution of the Open SDN Network Virtualization tests at the modern iSimCity laboratory in Santa Clara, CA. The goal of the evaluation is to provide the industry with comparative performance, reliability, scale and functional test data for SDN Network Virtualization environments.

Who: The test is open to all suppliers of network virtualization software and equipment. We encourage all suppliers to participate and enter the test.

Where: The test will take place in the modern Ixia test lab named iSimCity located in Santa Clara, CA. Ixia will supply all test equipment needed to conduct the tests along with engineering support for Ixia test equipment.

When: Testing time slots are available during the weeks of September 30 and October 7, 2013. Each supplier will be allocated time to run the test during its selected week. Vendor sign up will close at end of business day (PT) Friday, **August 30, 2013.**

How: Each supplier will bring its own engineers to accompany its software/hardware equipment to be tested. An Ixia test engineer will be available to assist each supplier through test methodologies. The supplier's engineers will sign-off on test data results at the completion of the test. The Lippis SDN Network Virtualization Test is based upon Ixia's IxNetwork and IxVM Suite of test scripts.

The figure below illustrates a typical network virtualization deployment that is overlaid upon a physical network. This structure will be the basis of the SDN Network Virtualization Test Methodology.
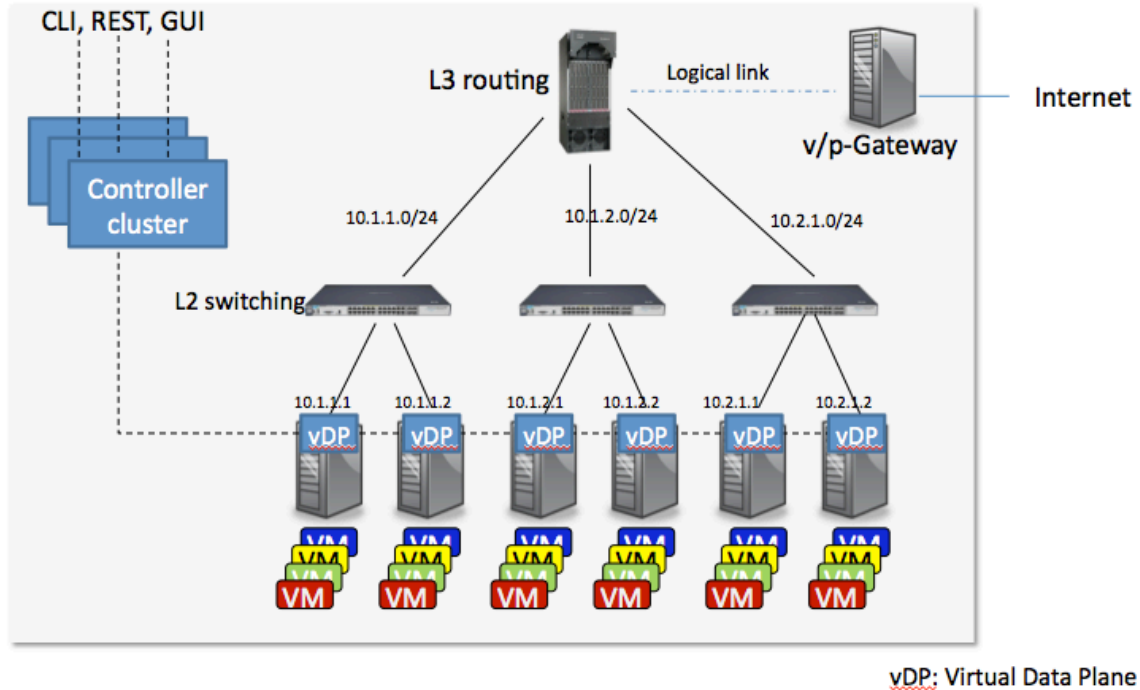
SDN Network Virtualization Test Methodology

The SDN Network Virtualization Test Methodology consists of three performance tests and one functionality test. The performance tests seek to measure scale, reliability and CPU utilization. Three separate tests are defined for data, control and management plane functions. The functionality evaluation is a check-off list that verifies a basic set of network virtualization functionalities. The following details the four tests.

Test 1) Data Plane Performance Test: During this test, we seek to measure data plane throughput, CPU utilization, forwarding latency and the number of flows per second supported. The test configuration consists of three hosts, servers A, B and D, plus a gateway C. A physical network that supports 40GbE Top-of-Rack switching, non-blocking

Only 10 Test Slots Available: Sign before EoD PT August 30, 2013.

4
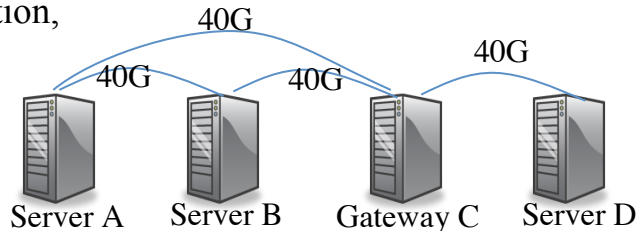
connectivity between servers, layer 3 forwarding and a virtual/physical gateway provide the underlay for the server connectivity.

In this test, Ixia's IxVM, which is a virtual test port, is used as the VM running within hypervisors generating traffic on the ingress and capturing results on egress. IxVM will generate traffic starting at 50% to 100% of maximum throughput to measure data plane throughput, CPU utilization, forwarding latency and the number of flows per second supported. The following four scenarios will be tested:

1. Send IPv4 and IPV6 unicast traffic between VMs on server A at rates from 50% to 100% of maximum throughput. This will be repeated for TCP and UDP traffic.

2. Send unicast traffic between servers A, B and D at rates from 50% to 100% of maximum throughput. This will be repeated for TCP and UDP traffic.

3. The above will be repeated for multicast and broadcast traffic.

4. Send virtualized network flows from servers A, B and D to terminate at gateway C to the point of gateway termination failure. Vendors may encapsulate in any protocol of their choice, be it VXLAN, NVGRE, STT, etc. To participate in the gateway test, vendors must bring their own gateway node for gateway throughput and tunnel termination tests.

During each test run the following metrics will be captured:

1. Average throughput (Gbps): East-west, north-south
2. CPU utilization (%)
3. End-to-end latency (ms)
4. Maximum sessions allowed (flows/sec)

In addition to testing the data plane with unicast, multicast and many-to-many traffic flows at varying packet sizes and flows, the Lippis Cloud Performance test iMix is used to generate stateful and stateless traffic and measure data plane latency and throughput from ingress to egress. To understand data plane performance under load, six iterations of the Lippis Cloud Performance test at traffic loads of 50%, 60%, 70%, 80%, 90% and

100% are performed, measuring latency and throughput on the vSwitch and CPU load.

The Lippis Cloud Performance test iMix consists of east-to-west database, iSCSI and Microsoft Exchange traffic, plus north-to-south HTTP and YouTube traffic. Each traffic type is explained below:

East-West database traffic is set up as a request/response. A single 64 Byte request is sent out, and three different-sized responses are returned (64, 1518 and 9216 bytes). A total of eight ports are used for east-west traffic. Four ports are set as east, and four ports are set as west. These eight ports are not used in any other part of the test. The transmit rate is a total 70% of line rate in each direction. The response traffic is further broken down with weights of 1/2/1 for 64/1518/9216 byte frames, for the three response sizes. That is, the weight specifies what proportion from the rate set per direction will be applied to the corresponding Tx ports from the traffic profile.

East-West iSCSI traffic is set up as a request/response with four east and west ports used in each direction. Each direction is sending at 70% of line rate. The request is 64 bytes, and the response is 9216 bytes.

East-West Microsoft Exchange traffic is set up on two east and two west ports. The request and response are both of size 1518 and set at 70% of line rate.

The following summarize the east-west flows:

> **Database**: 4 East (requestors) to 4 West (responders)
> **iSCSI**: 4 East (requestors) to 4 West (responders)
> **MS Exchange**: 2 East (req) to 2 West (responders)
> **Database/iSCSI/MS Exchange weights**: 1/2/1, i.e. 25%/50%/25% of rate set per direction and applicable on selected ports. East rate: 70% = West rate: 70%.

North-South HTTP traffic is set up on four north and four south ports. The request is size 83 bytes, and the response is size 305 bytes. The line rate on these ports is 46.667% line rate in each direction.

North-South YouTube traffic is using the same four north and south ports as the HTTP traffic. The request is of size 500 bytes at line rate of

Only 10 Test Slots Available: Sign before EoD PT August 30, 2013.

6

23.333%. There are three responses, totaling 23.333% in a 5/2/1 percentage breakdown of size 1518, 512 and 64 bytes.

Results will be graphed as illustrated in the graphic:
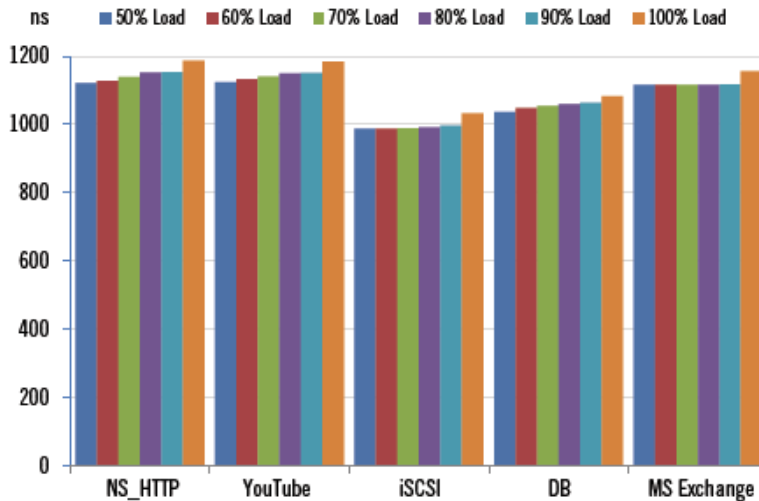
Test 2) Control Plane Performance Test: The question of SDN controller scale is at the heart of this test; that is, how many hypervisors and logical ports, VMs, flows and vSwitches do SDN Controllers support until failure—that is, until the controller cannot process topology changes, controller failure, software upgrades, etc. Non-confirmed industry data suggest that as many as 5,000 hypervisors and 100,000 logical ports or 25,000 vSwitches can be under the control of a single controller, assuming four logical ports per vSwitch. Multiple flows or aggregate and per second flows will also be tested by sending a large number of new flows to the controller while dropped flows are monitored.

In addition to scale, we seek to measure tenant reliability; that is, we will provision a large number of tenants and measure the time in which such tenants are available for use. Further, during tenant provisioning, engineers will inject controller faults and observe if backup schemes are consistent. In addition, illegal traffic injection will be sent to the controller while processing a large number of virtual networks to test the controller's ability to continue processing packet flows.

Metrics of observation include response time in milliseconds and CPU utilization of controller as a percentage of overall CPU capacity.

The SDN Controller test configuration consists of a number of VMs, vSwitches and a controller cluster. The basic configuration is depicted here:

To gain scale the controller test will support 5,000 hypervisors and 100,000 logical ports. Ixia's IxVM will be the VM running within the hypervisors. There are two approaches to accommodate this level of scale: 1) deploy two 42 RU server racks with 60 VMs per server or 2) deploy the inception model (named after the movie *Inception*).

The inception model is the spawning of a hypervisor within a VM, i.e., create a template such as VM "A" with VMWare ESX, Citrix Xenserver or KVM installed within it. One VM is installed within each VM "A". One to 10,000 instances of template VM "A" are run to emulate the one to 10,000 hypervisors.

Test 3) Management Plane Performance Test: Utilizing the test bed configuration outlined in Test 2 above, the controller management plane will be stressed to find its breaking point. Custom scripts have been developed for Test 3. Since there is not standardized management, i.e., northbound API for all SDN solutions, we will provide easy ways to map queries to each solution's specific API, or we may simply use Quantum. Here, a large number of REST API queries will be sent to the controller for virtual network creation, logical port changes, status querying. Also a large number of CLI configuration changes will be sent to the controller, all with the intent to understand its management plane scale. During these tests, response time will be measured in milliseconds as well as CPU utilization of the management plane as a percentage of total CPU capacity will be recorded.

Test 4) Functionality Tests: There are two parts to the functionality test, including: 1) a simple "support" or "does not support" feature questionnaire to be populated by the vendor and 2) a limited number of functionality verification tests. For the "support does not support" test, participating vendors will be provided a list of features and asked to check off a box to indicate if its product currently supports the feature or not at this time. Examples of feature functionality test are:

Only 10 Test Slots Available: Sign before EoD PT August 30, 2013.

8

❑ Cross-server migration
❑ External and internal reachability
❑ L4-L7 service pluggability

Feature verification will be conducted while the controller is in a Test 2 configuration and be limited to the following test:

• Provisioning intra-DC virtual network
Tenant A and Tenant B can be created, and logical ports of VM assigned to each Virtual network
Pairwise reachability within each tenant
• Traffic isolation across tenants
Tenant A can't see Tenant B's traffic (including broadcasts)
• Rate limiting traffic
Two tenants' (A and B) traffic management complies with max/min b/w provisioned via policy
• Elasticity of Virtual Network
East-west migration of VMs is supported, without losing connectivity and network disruption of no more than 10 seconds.
• Layer-2/3 VXLAN/overlay gateway functionality validation

FAQ

What does it cost to participate?

There is no fee to participate in the test.

Can I test more than one SDN Virtual Network Configuration?

Yes, a vendor may test up to two Virtual Networks, such as different vSwitches and/or controllers.

Can I submit more than one product for testing?

Yes, a vendor can summit as many products as lab time allows.

Can a vendor obtain the Lippis Report test configuration files before testing at iSimCity to test its equipment in its own lab?

Yes, but a license may be required from Lippis Enterprises. A vendor may acquire a custom report license, which includes the Lippis Report Test configuration files before testing at iSimCity. Configuration files are available now. This license enables vendors to test their equipment with the exact Lippis Report test scripts that will be used during testing, assuring that a vendor knows its results before its products are tested in public. Please contact Nick Lippis at nick@lippis.com for the test report license agreement.

Can a vendor pre-test its equipment before its scheduled test at iSimCity?

Yes, however a fee will be required. A professional services fee of $10,000, plus lab time and other equipment costs, will apply to pre-test requests, independent upon the location of those tests—that is, be it remotely monitored or in the iSimCity lab. The professional services fee must be paid before pre-testing is conducted. Please contact Nick Lippis at nick@lippis.com for more information.

Can a vendor re-test its equipment at iSimCity after its scheduled test?

Yes, however a fee will be required. A professional services fee of $10,000, plus lab time and other equipment costs, will apply to re-test requests, independent upon the location of those test—that is, be it remotely monitored or in the iSimCity lab. The professional services fee must be paid before re-testing is conducted. Please contact Nick Lippis at nick@lippis.com for more information.

To assure the final test report is not delayed while a vendor re-tests its equipment, re-testing will only be available for two weeks after the last test week is conducted. That is, re-testing of equipment is not available after October 15, 2013, unless mutually agreed upon by the vendor and Lippis Enterprises.

Can I drop out before test week?

Yes, but a fee will be payable to Lippis Enterprises. Once a company executive signs this agreement, the company is committed to the test. A dropout fee of $25,000 will be issued if the company does not show up for

Only 10 Test Slots Available: Sign before EoD PT August 30, 2013.

its scheduled time slot or cancels its participation at any time between signing the agreement and its scheduled test slot.

Can an equipment supplier pull its test data from being included in the ONUG presentations and final report after its product has been tested?

No.

Who owns the performance data results?

Lippis Enterprises is the exclusive owner of all test data results, including spreadsheets, reports, video and audio podcast, plus still photos taken during test week. Products tested will be included in the current test report and potentially subsequent test reports, presentations etc., at the discretion of Lippis Enterprises Inc.

What will be done with the test results?

The SDN Virtual Network Test results will be presented at Fall 2013 ONUG™ Conference to be held at JP Morgan Chase in Manhattan on October 29 and October 30, 2013. Dr. Srini Seetharaman, Mr. Nick Lippis plus Mr. Michael Githens of Ixia will present the test results at ONUG.

In addition, Lippis Enterprises will write an industry report that details test methodologies, product categorization, if needed, and test results. Dr. Seetharaman, Ixia and Lippis Enterprises will review and approve the final report before it is made public. The industry test report will be published in late mid-December or early January. Past industry test reports may be view by [clicking here](#) for a copy of the Spring 2013 report.

Can equipment suppliers provide a short two-paragraph product description to be included in the final report?

Yes. We encourage suppliers to identify their product's unique value beyond performance, in writing of approximately two paragraphs. This fact-based write-up will be edited and included in the industry report.

How will test results be communicated to the industry?

The test results will be communicated to the industry at ONUG (October 2013) plus via online event, either by video podcast, webinar, etc., promoted via the Lippis Report, social networking plus traditional business and trade press. The final report will be available on the opennetworkingusergroup.com and lippisreport.com sites. The test report will be promoted via social networking sites, distributed to ONUG attendees post conference, the Lippis Report subscribers of 35,000 IT business leaders as well as available to traditional business and trade reporters.

Previous Lippis/Ixia test reports were covered in the *Wall Street Journal*, the *New York Times*, *Light Reading* and numerous other industry and news outlets.

Can an executive of my company be interviewed for a Lippis video podcast?

Yes, there will be a sign-up schedule for video podcast interviews. These interviews may be conducted remotely or at Ixia's iSimCity. Lippis/Ixia will have a photographer and videographer along with staging to record short video interviews to be included in the final report and used for its promotion. The recording of video interviews are at the discretion of Lippis Enterprises and Ixia, and thus make no guarantee that video podcast will be recorded.

Can equipment suppliers promote the availability of the final report and test result announcement event?

Yes, Lippis Enterprises and Ixia will provide copy to promote the live test result event at ONUG.

Can equipment suppliers use the test results in our own marketing?

Yes, Lippis Enterprises will license the report and/or customize a report to participating equipment suppliers. The 2013 license agreement is available; please contact nick@lippis.com to request a copy. We encourage every participating supplier to review the license agreement to maximize its use and value of this industry event.

Only 10 Test Slots Available: Sign before EoD PT August 30, 2013.

Those that acquire a custom report license will be granted rights to the custom report, Lippis Report test configuration files, still photos (if any), video podcast (if any) and a plaque for display at industry events, such as ONUG, and trade shows that states "This Product Was Tested by The Lippis Report/Ixia/Seetharaman Open Networking Benchmark Tests." Further, participating firms that acquire a custom license may issue press releases after the full test report is completed. The Lippis Report will issue an email to all firms that have acquired a custom license as to when they may issue press releases. Quotes from Nick Lippis are available upon request and approval.

Sample custom test reports can be downloaded here:

http://www.extremenetworks.com/products/active-active_fabric-lippis-report.aspx

http://www.aristanetworks.com/media/system/pdf/Lippis_AA_Report_ARISTA_Spring_2013.pdf

Note that all firms that in the past have acquired a custom test report license used them to create a press release to market their results, posted the report on their web sites and distributed it to their sales and channel partners to win business.

How do I assure my company's participation in this test?

All that is required is that an authorized executive of your company sign the prospectus agreement below **BEFORE August 30, 2013,** and email it to both Nick Lippis (nick@lippis.com) and Michael Githens (mgithens@ixiacom.com). Upon receiving a signed authorization, Nick Lippis will schedule your company's test slot at iSimCity. There are a limited number of test slots available, and we will assign them on a first-come, first-served basis. It is possible that all test slots will fill up. In that event, we will be unable to fulfill all requests for testing.

In signing below, the vendor acknowledges and agrees to the above terms of the "Open SDN Virtual Network Test" by Lippis Enterprises taking place at Ixia's iSimCity.

Further, in signing below, the vendor acknowledges and agrees to release the use of the company's name as a participant in the "Open SDN Virtual

Network Test" by Ixia and Lippis Enterprises.

Potential marketing activities include a press release outlining the test evaluation event, possible press interviews during and after test week plus video and/or audio broadcasting, tweeting, social network post and podcasting of the event. Participant also understands that individual company names will not be used, but in conjunction with all participants in the event.

Participant understands that neither Lippis Enterprises nor Ixia will release the results of the test or of individual vendor testing until after the final test week event is complete. If requested to be interviewed by media, the participating company has the right to decline an interview—whether in writing, audio or video.

Lippis Enterprises, Srini Seetharaman and Ixia look forward to working with you in accordance with our general provisions and contributing to growing the Open SDN Virtual Network market through delivering trusted independent test data to the industry.

Accepting for: **Equipment Supplier**

By: _____ _____
Authorized Signature   Please Print Name

Title: _____

Date: _____

Only 10 Test Slots Available: Sign before EoD PT August 30, 2013.

General Provisions

We will devote reasonable professional efforts to carrying out the work required. The results obtained, our recommendations, and written material will be our best judgment based upon the information available to us.

All test data and test report content contemplated by this Agreement are protected by United States and international copyright laws. Lippis Enterprises retains all ownership and other rights in test data, the final test report, Lippis Report audio and video podcasts, and any and all Lippis logos and/or trademarks used in connection with this test series.

Except as expressly provided for in this agreement, Lippis Enterprises makes no other warranties, express or implied, or arising by custom or usage of trade for any materials developed, delivered or provided hereunder, and specifically disclaims any implied warranties of merchantability or fitness for a particular purpose. Neither party hereto will be liable for lost profits, lost opportunities, or indirect, incidental, consequential, special, punitive or exemplary damages, even if such party has been advised of the possibility of such damages. In no event will Lippis Enterprises' liability under this agreement for any form of action exceed the fees paid to Lippis Enterprises under this agreement.

With respect to claims or actions against one or both parties by third parties insofar as such claim, demand or action is attributable to sponsor's advertisement, the acts or omissions of sponsor, or a breach by sponsor of a representation and/or warranty made in this Agreement, sponsor shall (i) indemnify Lippis Enterprises against any liability, cost, loss, or expense of any kind; and (ii) hold harmless Lippis Enterprises and save it from any liability, cost, loss, or expense of any kind. Lippis Enterprises shall have the right to select and control legal counsel for the defense of any such claim, demand or action and for any negotiations relating to any such claim, demand or action; however, sponsor must approve any settlement of any such claim, demand or action to the extent that such settlement imposes any restrictions on or requires sponsor to contribute financially to such settlement.

Each party is acting as an independent contractor and not as an agent, partner, employee, or joint venture with the other party for any purpose. Neither party will have the right, power, or authority to act or to create any

obligation, express or implied, on behalf of the other.

This letter shall constitute the agreement between us, and any change must be confirmed in writing. This agreement will be interpreted according to the laws of the Commonwealth of Massachusetts.

Only 10 Test Slots Available: Sign before EoD PT August 30, 2013.

16