WHITE PAPER

An Effective Solution for Testing IP Services

Executive Summary

IP service offerings are woven into the fabric of our business and social lives. We rely on these innovative services for business productivity, communication, entertainment, education and even national security. Almost all new applications delivered today by service providers are built on IP services.

Behind the scenes, IP services are characterized by enormous complexity, constant change, and custom building blocks. Each IP service has its own unique configuration which makes the testing of them an unprecedented challenge.

The challenge of testing IP services cuts across numerous industries; Network equipment manufacturers (NEMs), independent product/software vendors (ISVs), network operators/service providers (SPs), smart grid operators, and government agencies all struggle to test IP services.

Existing testing approaches are characterized by excessive costs, time-to-market delays and lack of quality of deployed services. According to NSP, the following industry trends are commonly found:

- The average time to test a new IP service or related product is more than 12 months.
- The average cost of testing exceeds $4 million, or 10% of product development costs.
- The average test coverage on a first release is less than 40%.

Mu's IP service testing solutions provide a fresh, adaptive approach designed specifically for the testing of IP services. With IP service testing using Mu's award-winning Test Suite, operators and vendor quality assurance (QA) teams can quickly, accurately and thoroughly test IP services across the development and deployment lifecycles.

This whitepaper discusses the challenges of testing IP services and shows why organizations are rapidly adopting IP service testing throughout their respective development and deployment processes for delivering higher quality products and services.

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Introduction to IP Services

IP Services are the Heart of Innovation

Many organizations' lifeblood revenues depend on IP services; Wired and mobile service providers are deploying LTE, IPTV and VoIP applications that represent a leap in user experience. Network infrastructure manufacturers are deploying new services and products for IPv6, carrier Ethernet services, and more. Smart grid and critical infrastructure providers are rolling out IPv6, SCADA and others. And Cloud services for applications and storage are fundamentally changing how businesses use applications.

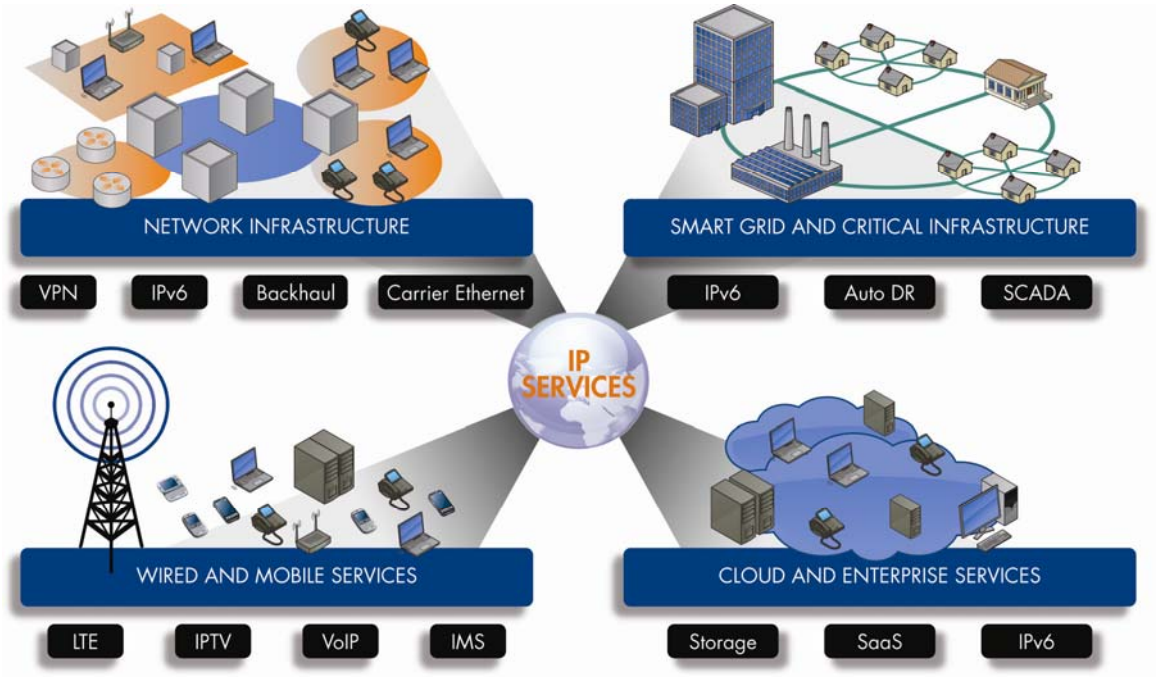

Figure 1: A broad variety of industries have turned to IP services to deliver innovative new applications and services to their customers.

IP Services Introduce Risk

When AT&T and other Tier-1 operators invested billions of dollars[1], more than two-thirds of the expense was dedicated to enhancing the coverage, speed and capacity of its wireless and wired broadband networks. Specifically, much of the investment was dedicated to testing its LTE deployments and other enabling infrastructure investments.

The failure of a new IP service like LTE would have a significant impact on an operator, including revenue loss, a tarnished brand, increased customer churn and disruption to mission-critical services. Yet outright failures or IP service weaknesses are frustratingly

[1] AT&T News Release http://www.att.com/gen/press-room?pid=4800&cdvn=news&newsarticleid=26597

common in IP services – and costly. Studies point out the costs of poor quality products and IP services quickly exceeds $10,000 per incident[2].

IP Services are Complex

IP services are extremely complex and constantly changing. They are based on new or evolving standards and are comprised of multi-vendor systems that interoperate across an integrated environment. Failures are not isolated events; they have a cascading effect on a multitude of highly interdependent devices and networks.

The figure below illustrates an example of the complexity of an IP service for a TV channel. When a user selects a TV channel, numerous highly interdependent, interactions take place. Yet, the user perceives it to be a single operation. The reality is that it is far from simple. There are multiple entities involved, including video on demand clients, distribution servers, billing servers, video servers and routers. A complex set of communication exchanges occur among these systems.

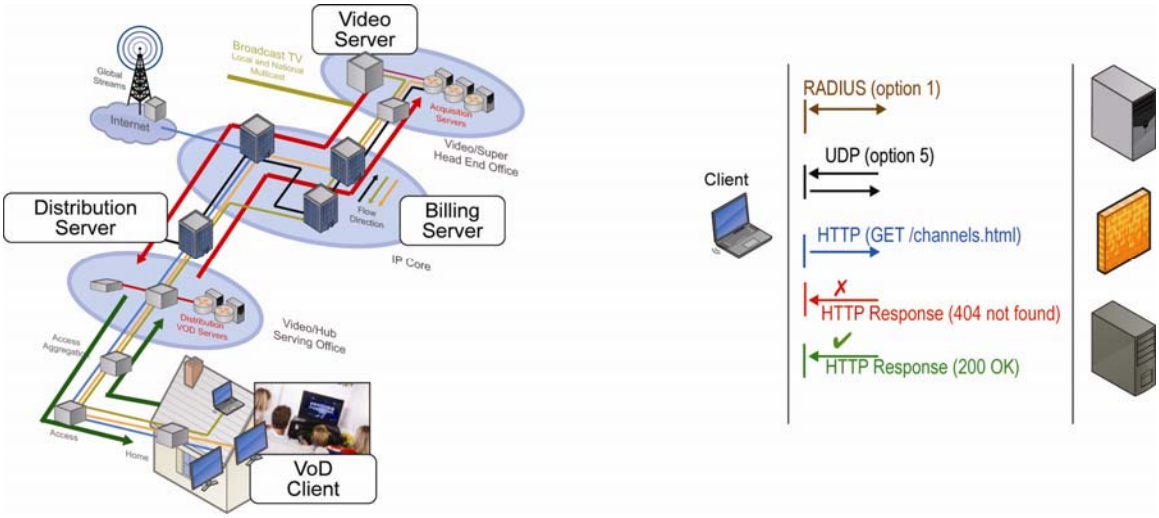

Figure 2: A seemingly simple request like selecting a TV channel is backed by a complex series of interactions, which makes thoroughly and accurately testing IP services an unprecedented challenge.

Test Organizations Face Growing Time, Cost and Quality Pressures

Owing to escalating complexity and risk, QA and test organizations at NEM, ISV, service providers and smart grid operators are under tremendous pressure to release services with the highest quality, as quickly as possible *and* at the lowest cost so their organizations will achieve their time-to-market and business goals.

[2] NSP Partners http://www.tmcnet.com/webinar/mu-dynamics/mu_dynamics.htm

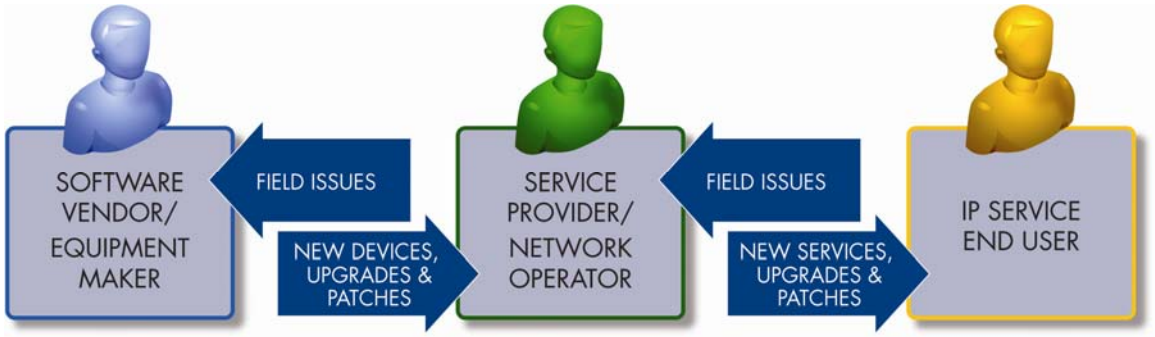

Figure 3: Vendors are under tremendous pressure to release new high quality services to customers on time and on budget.

Internal and external customers regularly ask test teams to improve their effectiveness while using the same or even fewer resources. This is true for all types of testing disciplines including functional, interoperability, resilience and security testing. The sheer number of input combinations, versions, custom extensions and unique configuration modes within IP services presents an increasingly difficult challenge. As such, test organizations are struggling to find a way to meet their organizations' objectives while the scope of what needs to be tested is exponentially increasing.

Current Approaches for Testing IP services are Ineffective

Current testing approaches, which rely on manual testing and network load testing tools, have severe limitations when used to test IP services, as evidenced by industry data from NSP:

- The average time to test a new IP service or related product is more than 12 months.
- The average cost of testing exceeds $4 million, or 10% of product development costs.
- The average test coverage on a first release is less than 40%.
- The time spent fixing such field issues is 2 weeks per incident.

Manual testing is highly labor-intensive; Testers write code and develop test scripts for their specific needs. The sheer number of combinations of inputs, configurations and versions that need to be tested makes this approach scale poorly over time.

Network load testing tools are commonly found in the tester's toolkit, but they are first and foremost designed to be infrastructure-level load generators or "packet blasters." They offer a set of static pre-built tests based on standards-compliant traffic, which means they don't easily test proprietary extensions or non-standard protocols. Their primary function is to ensure that a device sustains production-level network throughputs, generally for one protocol at a time.

Since IP services depend on a sequence of multiple protocols working together, single-protocol load testing offers minimal test coverage. Also, since the traffic in the network is

often based on custom extensions, custom network configurations and variations from the defined standard, this approach does not accurately represent real-world situations.

Shortcomings of Current Approaches

The above current approaches have significant shortfalls when testing IP services, including:

- **Inaccurate testing.** Legacy testing approaches cannot accurately emulate the IP service communication. Since IP services are unique, custom and constantly evolving, static scripts cannot recreate the real communication scenarios involving multi-protocol exchanges, proprietary messages and messages with custom extensions.

- **Time consuming.** Delays in receiving test scripts from the legacy test vendors, varying from weeks to months (or longer), translate into missed or postponed testing windows. Also, the manual approach is extremely time-consuming, especially in the face of rapidly evolving test requirements.

- **Poor test coverage.** Current approaches achieve extremely low test coverage since IP services are constantly evolving and the number of input combinations and versions that need testing are growing exponentially.

- **Disjointed testing.** Test teams today often work with disparate tools, using different approaches in various test phases like unit testing, functional testing, system/integration testing and field issue resolution. Unfortunately, there is little or no reuse of cross-functional test assets either within an organization or between the customer and the supplier organizations. This fractured approach creates an incomplete picture of an IP service's health.

Collectively, these limitations hamper the test team's ability to achieve quick, accurate, thorough and cost-effective results. And while it's widely said that meeting time, cost and quality objectives for any project or initiative is impossible, it doesn't have to be that way.

A New Approach for Testing IP Services

IP services introduce a new set of characteristics which make traditional testing approaches wholly unviable. To cater to the unique, custom and constantly changing attributes of IP services across the vendor-provider ecosystem, three fundamental aspects of testing IP services need to be addressed. These are:

- **Accurately reflect the logic of the service.** With IP services, the logic of the service must be accurately modeled. The tests need to be easily adapted to the communication behavior of the IP service and its unique implementation characteristics. This is particularly true when custom and proprietary extensions are employed (during development or deployment) and where static or canned test tools fail to deliver the necessary coverage.

- **Quickly drive multiple complex datasets.** The test solution must drive a rich and varied set of data inputs capable of exhaustively testing the service. An ideal IP service testing solution automatically generates thousands of unique test

cases that fully exercise the specific IP service under test. As a result, significantly increased levels of test coverage can be achieved while maintaining product or service delivery timelines.

- **Cover multiple types of testing.** An IP service needs to be tested for functionality, security, interoperability and resilience. Organizations can gain a unified approach to testing by viewing all the testing activities from a holistic perspective, rather than as a set of discrete activities. Employing a single platform – with sharable and reusable test assets – throughout the lifecycle means testing efforts are significantly accelerated and optimized across a broad set of organizational requirements.

To achieve high quality IP services, organizations should adopt a testing approach based on these three fundamental aspects. It is essential to recognize that IP services are more than a collection of individual low-level protocols, and the complete testing of these services requires aligning the testing to the higher level of the service.

Mu Dynamics Enables Adaptive Testing of IP Services

An adaptive testing approach with Mu's testing solution recognizes the unique and dynamic aspects of IP services deployments and provides high-precision testing in a significantly shorter amount of time while reducing costs. The Mu Test Suite covers the three core areas of IP testing, making it the only way to effectively test IP services.

The Mu test solution comprises of:

- **Test generation capabilities accurately reflecting the logic of the service.** Multiple test generation capabilities enable the dynamic and rapid creation of large numbers of test scenarios that accurately reflect the service logic. These test cases are generated from a rich set of inputs, including content from customers, Mu and the broader testing community.

- **Test execution to quickly drive complex service datasets.** The test execution engines can dynamically execute a large number of tests with a rich set of data inputs. They execute and analyze results automatically. During the test, the Mu solution uses its comprehensive set of monitors to observe the ongoing health of the services and network devices. The solution is highly automated and supports lights-out, 24x7 testing. At the conclusion of the test, the Mu solution creates a remediation toolkit for expediting issue resolution.

- **Platform purpose-built for multiple test types.** Once test assets are created, they are used to test multiple aspects of the service (often within multiple teams or among the provider-vendor, ISV and operator) such as functionality, security, interoperability and resilience. With Mu, there are no limits to reusing these test assets. The ability to reuse assets across organizations and across a variety of test phases dramatically reduces the total cost of testing within organizations.

Figure 4: Mu delivers complete testing of IP services. The Mu solution offers a rich set of data inputs, addresses multiple use cases, and leverages common test assets between the operator and vendor ecosystem.

The inputs into the Mu Test Suite include:

- **Customer-generated input**: For the first time, customers can quickly create tests based on their own IP service implementation. This input takes the form of captured real-world IP service traffic from a lab environment or a production network. The only way to quickly create accurate test cases that reflect the exact set of exchanges and network configuration is to start from the actual IP service traffic itself. In many cases, test teams already have large libraries of packet captures from their labs and from the production or live network. Testers can leverage these dormant assets to generate thousands of highly accurate and relevant service-level tests. Testers can also generate test content using the Mu scripting language.

- **Mu-provided input:** Mu provides test content that generates and executes tests. The Mu test suites provided include thousands of test cases for the most common networking protocols, which can be used for testing the resilience, security, interoperability and functional aspects of the service. The Mu development team is continuously releasing test cases for new protocols and message types enabling test teams to leverage them across the development and deployment lifecycle.

- **Community-generated input:** Mu is the first company to build a user community for the sharing of packet captures for IP service testing at http://pcapr.net. Through online community sources, customers have access to a rich and growing set of traffic patterns ready for test creation and execution. Customers have access to packet captures of over 250 protocols on Mu pcapr alone. Other community-driven sites such as http://wireshark.org are also rich sources for generating tests.

Save Time, Money *and* Improve Quality; Realize a 10x+ Improvement in Test Effectiveness with Mu

Mu's IP service testing delivers significant benefits, including:

- **Increased Quality**
  - **Testing Accuracy.** Using the actual communication traffic of the IP service as the basis for test creation activities is the only way to ***accurately*** model the communication behavior of the IP service and cater to its unique implementation. This is particularly critical when custom and proprietary extensions are employed.
  - **Increased Test Coverage.** By automatically generating thousands of test cases that fully exercise the IP service under test using realistic data, test organizations can achieve significantly increased levels of ***test coverage***.
- **Reduced Time and Testing Costs**
  - **Reduced Time to Test.** The automated approach enables the ***rapid*** creation of tests for the scenarios the tester cares about the most.
  - **Unified Testing Approach**. By viewing all the testing activities from a holistic perspective, organizations gain a unified approach to testing. Testing efforts can be greatly accelerated and optimized throughout the lifecycle by employing a single, multi-faceted platform that supports significant reuse of test assets. The same test scenario can be leveraged for functional, interoperability, security and resilience testing as well as across organizations. For example, an operator could send a set of scenarios to the vendor and the vendor could accurately and thoroughly test against these critical scenarios. This approach is the first to unify multiple testing disciplines over a single platform for IP service testing.

	BEFORE MU	AFTER MU
Average test time of new IP product or service	> 12 months	< 1 month
Approximate cost of testing (opex and capex) one major release	$4M (assuming team of 20+ and costs of tools, labs)	< $250K
Test coverage on first release	< 40%	> 80%
Number of critical issues within the first year	> 25	< 10
Time spent in solving field issues	> 2 man-weeks per issue	< 2 days per issue

Methodology Walkthrough for Functional Testing

The following functional testing example illustrates the benefits of Mu's adaptive testing solutions. A vendor is building a SIP proxy that processes voice packets for mobile phones. As part of its development and test processes, it must perform functional testing

for call setup and teardown. Functional testing, which determines whether the product features work as specified, is only one kind of testing required before the product can be shipped to the customer, which in our example is a major service provider.

The challenge is that the SIP proxy has numerous configuration modes, passwords and other options that must be tested. A manual approach is too time-consuming, and legacy test tools do not support the product's cutting-edge, custom functionality.

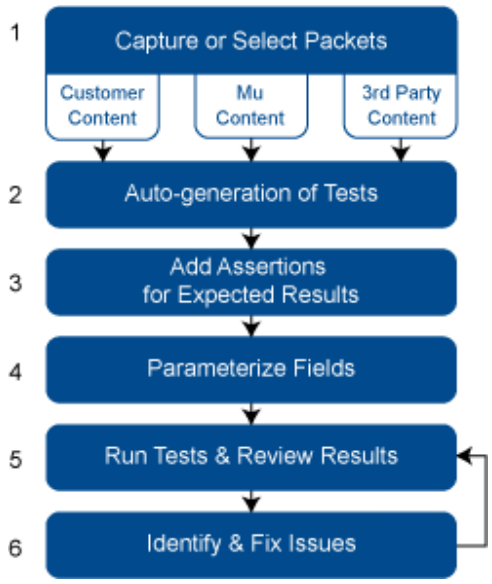

Figure 5: Mu has a simple, scalable methodology for functional testing.

Capture Actual IP Service Traffic for Test Creation

The key premise of adaptive testing is to use the IP service's *actual traffic* as the basis for testing. Simply put, the tests resulting from the IP service traffic packet captures offer the only true replication of the real system. The Mu Test Suite is used to capture traffic between devices in the lab and quickly recreate these scenarios. After the capture, the Mu solution assumes the role of one or more systems in the exchange and recreates the scenario as one or many tests. ***The Mu Test Suite is the first solution to enable rapid recreation of tests from packet captures in this fashion.***

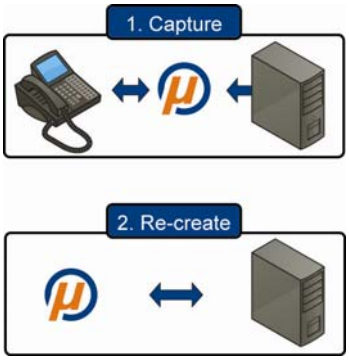

Figure 6: The Mu Test Suite is the first solution to enable rapid recreation of tests from packet captures.

Figure 6 is a simplified representation of the process of capturing traffic and recreating scenarios shown in Figure 7.

Automated Test Generation and Execution

The Mu Test Suite automatically generates testing scenarios based on the packet capture. It then transforms this static packet capture into a set of semantically meaningful, dynamically generated, stateful test cases that accurately reproduce the original communication exchange. It deciphers the packets and determines which transport protocols are involved (e.g., HTTP, TCP, IPv4, IPv6 or SSL) as well as the fields that comprise the payload.

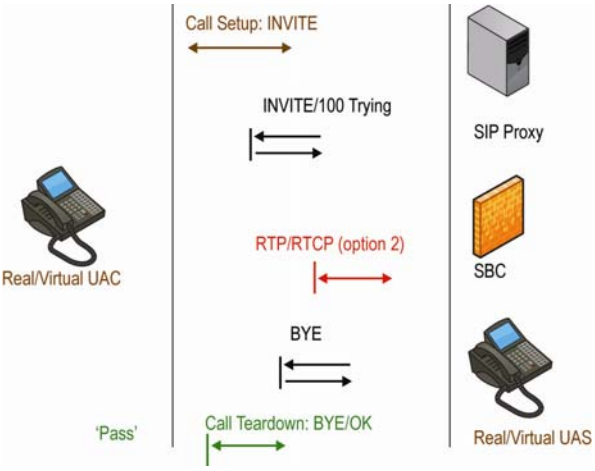

Figure 7: The actual SIP exchange is far more complex.

The tester defines the expected outcomes for each test scenario based on the specific testing requirements. Now the tester can replay the exchange against the SIP proxy and functionally test the call setup and teardown procedures -- using the same Mu XML testing template that was created from the original packet capture.

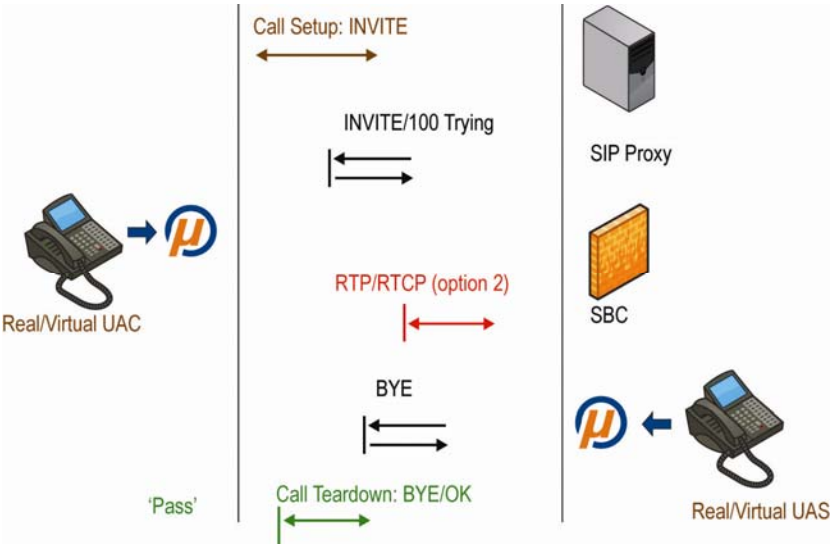

Figure 8: Mu also can be used for automated test generation and execution.

Expedited Resolution

In our fictional example of testing the SIP proxy, the operator discovers a set of issues with certain options. These issues need to be resolved before the product can ship. The Mu solution provides executive and technical reports to help interpret weaknesses or failures and presents a comprehensive view of the quality level based on the test results.

When it finds faults, the Mu solution provides the user with remediation assets, such as packet captures, scenario templates, transaction files and Linux executables, which facilitate rapid reproduction of the problem. As a result, when the tester finds issues, the Mu-generated remediation toolkit can then be relayed to the developer for resolution. This is a tremendous productivity gain for the engineering teams.

Other Use Cases Enabled by Reuse of the Same Test Assets

The Mu Test Suite is applicable across multiple test disciplines, including functional testing, resilience testing, interoperability testing, security testing, as well as with field issue resolution. The Mu solution can automatically fuzz-test the same scenarios, thus testing the resilience of the system. The Mu solution rapidly emulates multiple other systems and versions to ensure that the new product or service is backward compatible with other implementations.

Mu can also be used to recreate field issues, which expedites remediation. If an issue arises after the system has shipped, a packet capture from the field can be used to recreate the field issue and the regression test suite is enhanced with the new customer/field issue driven test.

Conclusion

IP services are mainstream and critical to the success of many industries. However, their very nature – unique, custom and dynamic – creates new challenges for testing. Legacy test tools and processes have not evolved to meet this challenge. As a result, IP service deployments are often late, over budget, and of low quality.

Operators and vendor QA teams need quick, accurate and thorough testing and expedited field issue resolution of IP services. Mu's testing solution has been specifically built to meet this challenge. Mu's solution is the only available today that tests IP services thoroughly, reflecting the logic of the service. Mu's solution is also the only one to use customer's service traffic as a basis for test case generation to ensure accuracy. In addition, Mu is the only solution to offer a leveraged single platform across multiple aspects of testing. The end result is a 10-fold effectiveness gain by Mu customers who in turn deploy products/services that are significantly faster, cheaper, and of higher quality.

Learn more or get a demonstration of Mu capabilities online at www.mudynamics.com/demo.