



Integrated Environment Management for Information Operations Testbeds

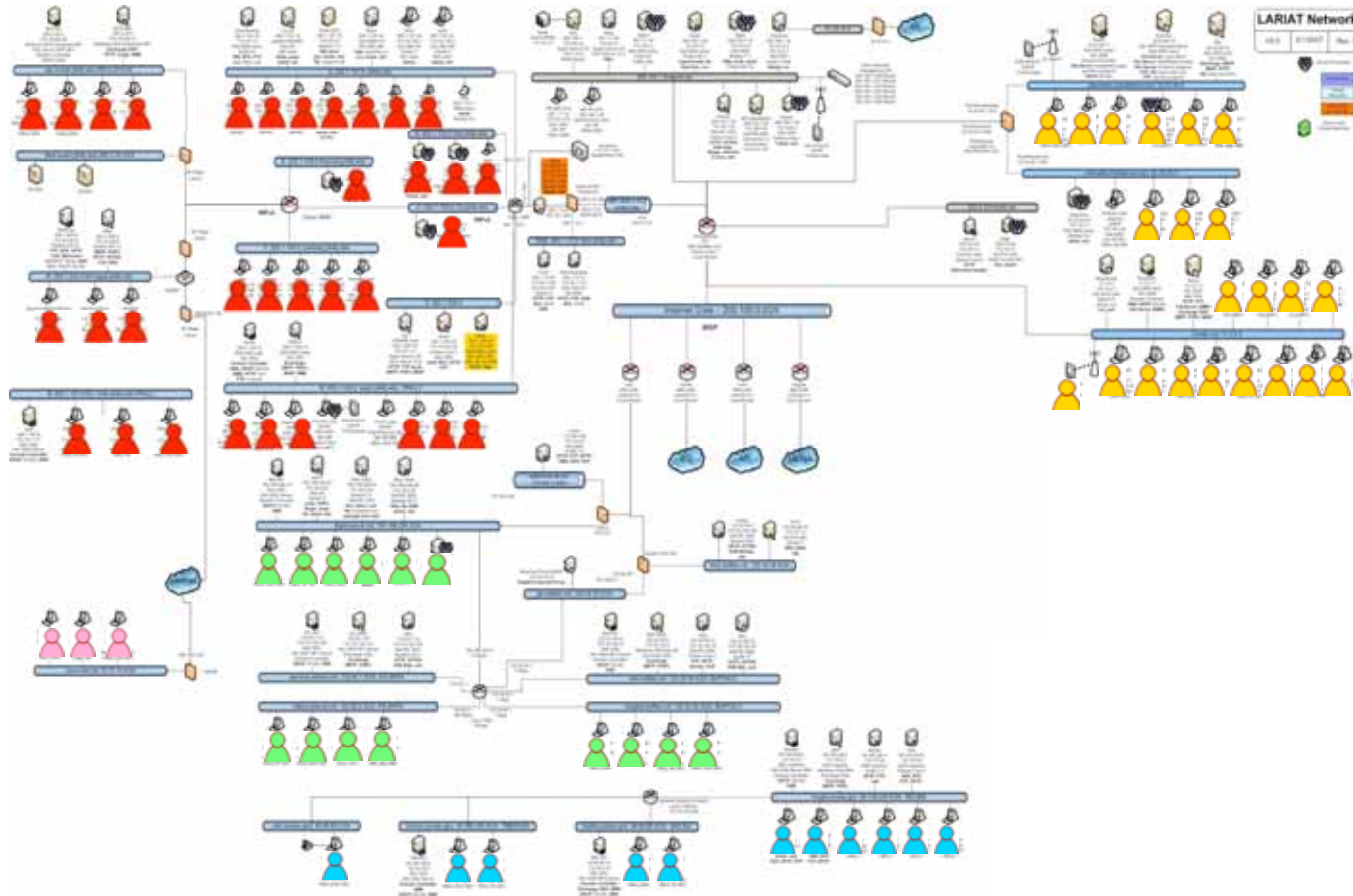
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LARIAT Provides High-Fidelity Network Emulation and User Simulation



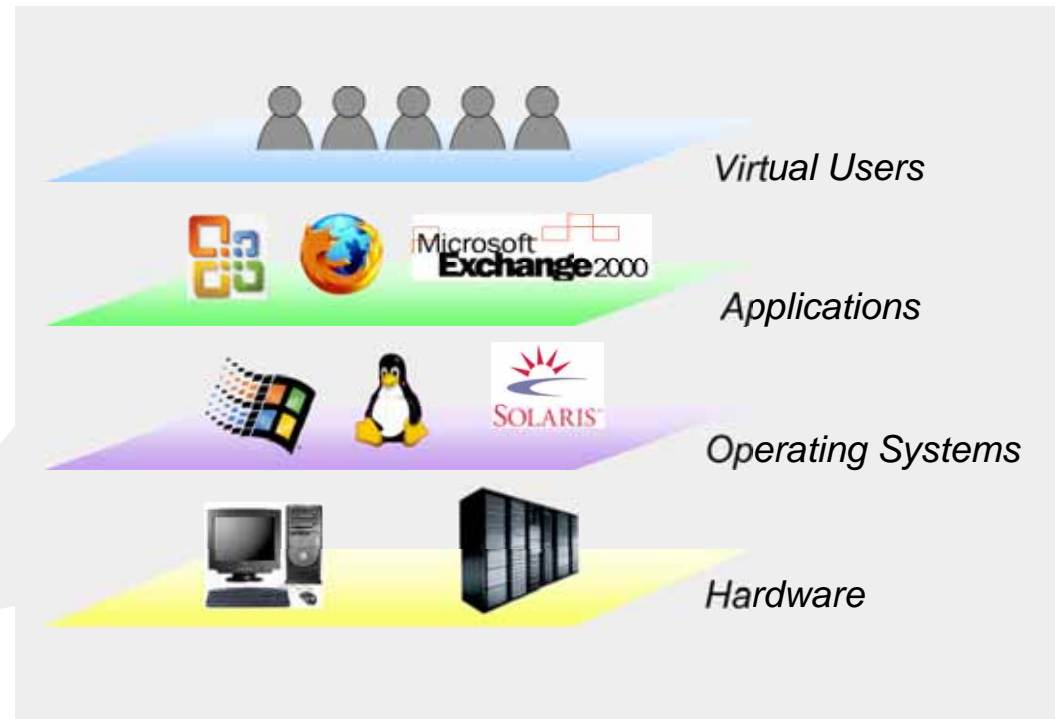
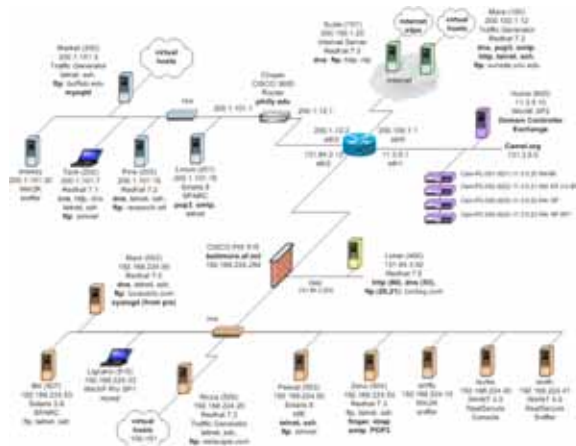
- LARIAT emulates all the users performing their daily duties
- Virtual users are overlaid onto existing physical networks
- Supports testbeds with 100s of nodes and 100,000s of users



Creating a Realistic Testbed is Challenging



- Testbed needs to be properly designed to meet the test objectives
- Configuration spans multiple levels: network, host, and user
- LARIAT works only if the underlying components work





A User Interface for Testbed Management



- **Two complementary approaches to effectively manage complex testbeds**
 - Intuitive user interface
 - Extensive automation
- **The Director simplifies the following key tasks of IO experiments**
 - Testbed specification
 - Testbed control (software deployment, troubleshooting and validation)
 - Testbed monitoring



Design Goals



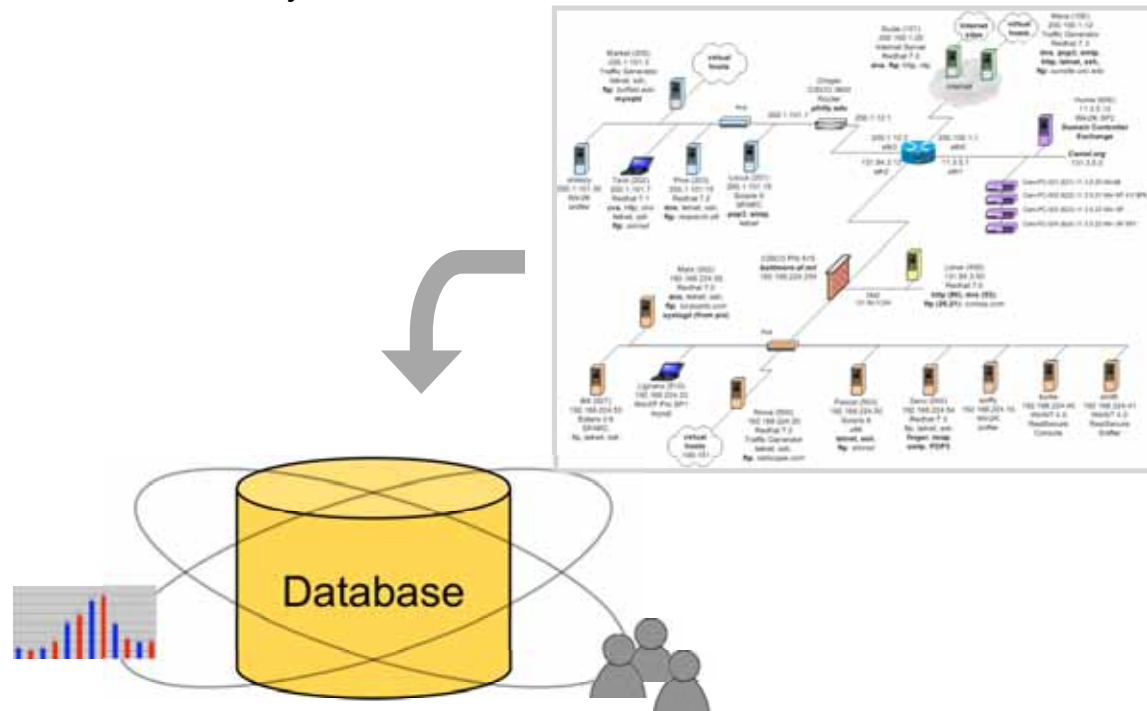
- **Appropriate System **A**bstractation**
- **Basic and Advanced **U**sage**
- ****S**calable Performance and Visualization**
- **Interpretable and Correct **F**eedback**



Test Definition Task



- **Configure LARIAT to emulate the desired test environment on the testbed network**
- **Challenges: complex configurations require a complex encoding**
 - Stored in a relational database with many interrelated objects and settings
 - Difficult to understand and adjust





Test Definition Solutions



- **Automatically populate the database (U)**
 - Assign traffic profiles and server contents to hosts
 - Generate users and projects they share
- **Manipulate network objects in hierarchical context (A, S)**
 - Allows designers to easily view, modify, and allocate testbed resources

The screenshot displays the 'Testbed Environment' application. On the left, a 'Database' pane shows a hierarchical tree of network objects. Blue brackets on the left side of the interface group these objects into three categories: 'Subnets' (top level), 'Hosts in A Subnet' (middle level), and 'Users of A Host' (bottom level). The main pane on the right shows the 'General' tab of a host configuration for 'PVD-PC-040'. Blue brackets on the right side of this pane group the fields into three categories: 'Host Configuration' (top), 'Name and Role' (middle), and 'Primary (Test) Interface' and 'Control Interface' (bottom).

Subnets

Hosts in A Subnet

Users of A Host

Host Configuration

Name and Role

Primary (Test) Interface

Control Interface

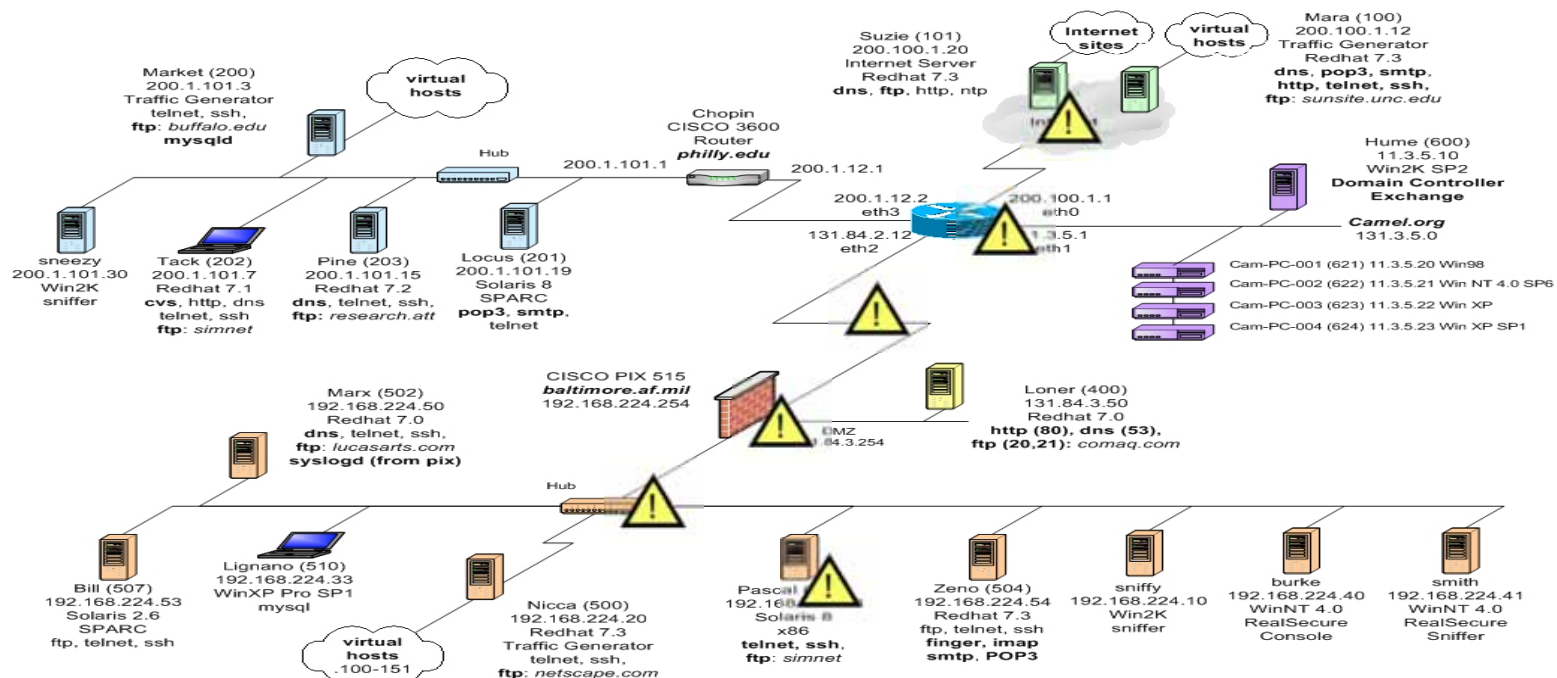
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Diagnostics and Validation Task



- Validate that the testbed is set up correctly
- Diagnose and troubleshoot problems
- Challenges
 - Large number of potential failure points (network, host, modules)
 - Difficult to pinpoint the cause due to network and software complexity



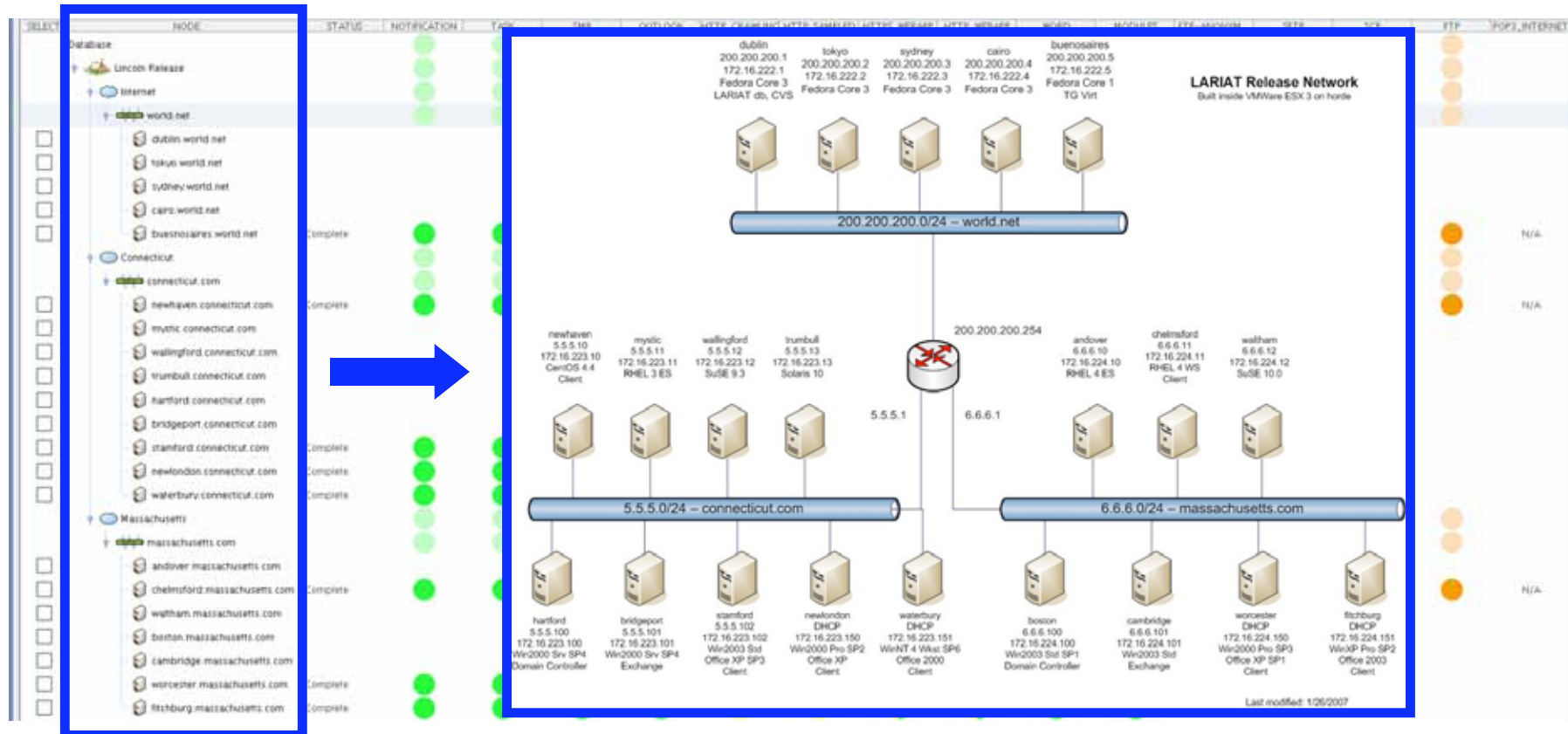


Diagnostic Solution: “Preflight”



(S)

Network Nodes





Diagnostic Solution: “Preflight”



Task Notification Status

(F)

SELECT	NODE	STATUS	NOTIFICATION	TASK	SME	OUTLOOK	HTTP_CHALLENGE	HTTP_SAMPLED	HTTPS_WEBAPP	HTTPS_WEBAPP	WORD	MODULES	FTP-ANON	SFTP	SCP	FTP	POP3_INTERNET
	Database																
	Lincoln Release																
	Internet																
	world.net																
	dublin.world.net																
	tokyo.world.net																
	sydney.world.net																
	cairo.world.net																
	buenosaires.world.net	Complete															N/A
	Connecticut																
	connecticut.com																
	newhaven.connecticut.com	Complete															N/A
	mytic.connecticut.com																
	wallingford.connecticut.com																
	trumbull.connecticut.com																
	hamford.connecticut.com																
	bridgeport.connecticut.com																
	stanford.connecticut.com	Complete															
	newlondon.connecticut.com	Complete															
	waterbury.connecticut.com	Complete															
	Massachusetts																
	massachusetts.com																
	andover.massachusetts.com																
	chelmford.massachusetts.com	Complete															N/A
	waltham.massachusetts.com																
	bedford.massachusetts.com																
	cambridge.massachusetts.com																
	worcester.massachusetts.com	Complete															
	fitzburg.massachusetts.com	Complete															



Diagnostic Solution: “Preflight”



Task Execution Status

(F)

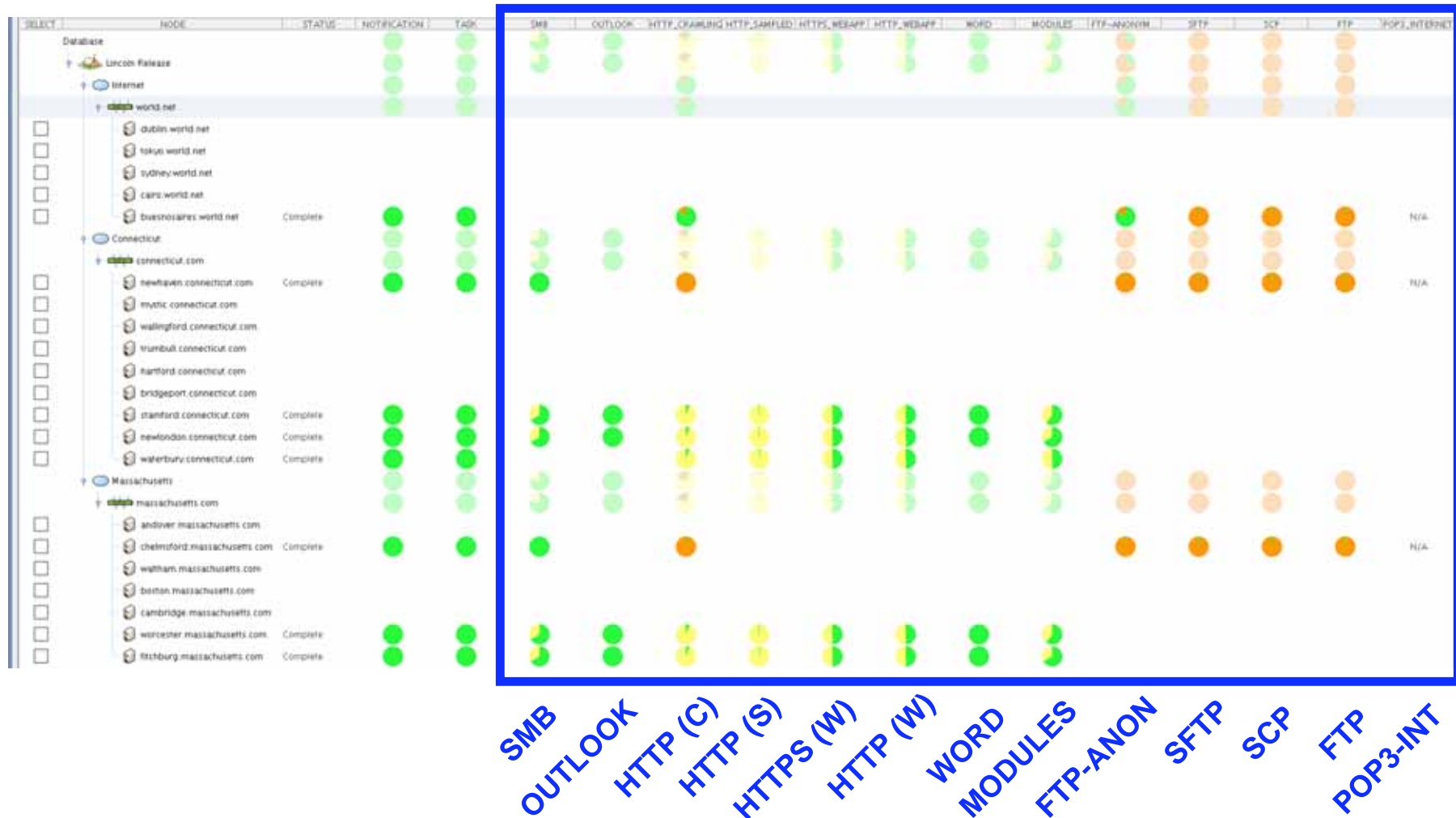
SELECT	NODE	STATUS	NOTIFICATION	TASK	SMTP	OUTLOOK	HTTP_CRAWLING	HTTP_SAMPLING	HTTPS_WEBAPP	HTTPS_WEBAPP	WORD	MODULES	FTP-ANONYM	SFTP	SCP	FTP	POP3_INTERNET
	Database																
	Lincoln Release																
	Internet																
	world.net																
	dublin.world.net																
	tokyo.world.net																
	sydney.world.net																
	cairo.world.net																
	buenosaires.world.net	Complete															N/A
	Connecticut																
	connecticut.com																
	newhaven.connecticut.com	Complete															N/A
	mytic.connecticut.com																
	wallingford.connecticut.com																
	trumbull.connecticut.com																
	hamford.connecticut.com																
	bridgeport.connecticut.com																
	stanford.connecticut.com	Complete															
	newlondon.connecticut.com	Complete															
	waterbury.connecticut.com	Complete															
	Massachusetts																
	massachusetts.com																
	andover.massachusetts.com																
	chelmford.massachusetts.com	Complete															N/A
	waltham.massachusetts.com																
	boston.massachusetts.com																
	cambridge.massachusetts.com																
	worcester.massachusetts.com	Complete															
	fitchburg.massachusetts.com	Complete															



Diagnostic Solution: “Preflight”



Task Execution Status by Traffic Module (F)





Diagnostic Solution: “Preflight”



Mouse over status pie charts for popup details

(F)





Diagnostic Solution: “Preflight”



Task status by host

(F)

SELECT	NODE	STATUS	NOTIFICATION	TASK	SMB	OUTLOOK	HTTP_CHALLENGE	HTTP_SAMPLED	HTTPS_WEBAPP	HTTPS_WEBAPP	WORD	MODULES	FTP-ANONYM	SFTP	SCP	FTP	POPS_INTERNET
	Database:																
	Lincoln Release																
	Internet																
	worldnet																
	dublin.worldnet																
	tokyo.worldnet																
	sydney.worldnet																
	carls.worldnet																
	business.worl																
	business.worl	Complete															N/A
	Connecticut																
	connecticut.com																
	newhaven.connecticut.com	Complete															N/A
	mytic.connecticut.com																
	wallingford.connecticut.com																
	trumbull.connecticut.com																
	hamford.connecticut.com																
	bridgeport.connecticut.com																
	stanford.connecticut.com	Complete															
	newlondon.connecticut.com	Complete															
	waterbury.connecticut.com	Complete															
	Massachusetts																
	massachusetts.com																
	andover.massachusetts.com																
	chelmford.massachusetts.com	Complete															N/A
	waltham.massachusetts.com																
	boston.massachusetts.com																
	cambridge.massachusetts.com																
	worcester.massachusetts.com	Complete															
	fitzburg.massachusetts.com	Complete															

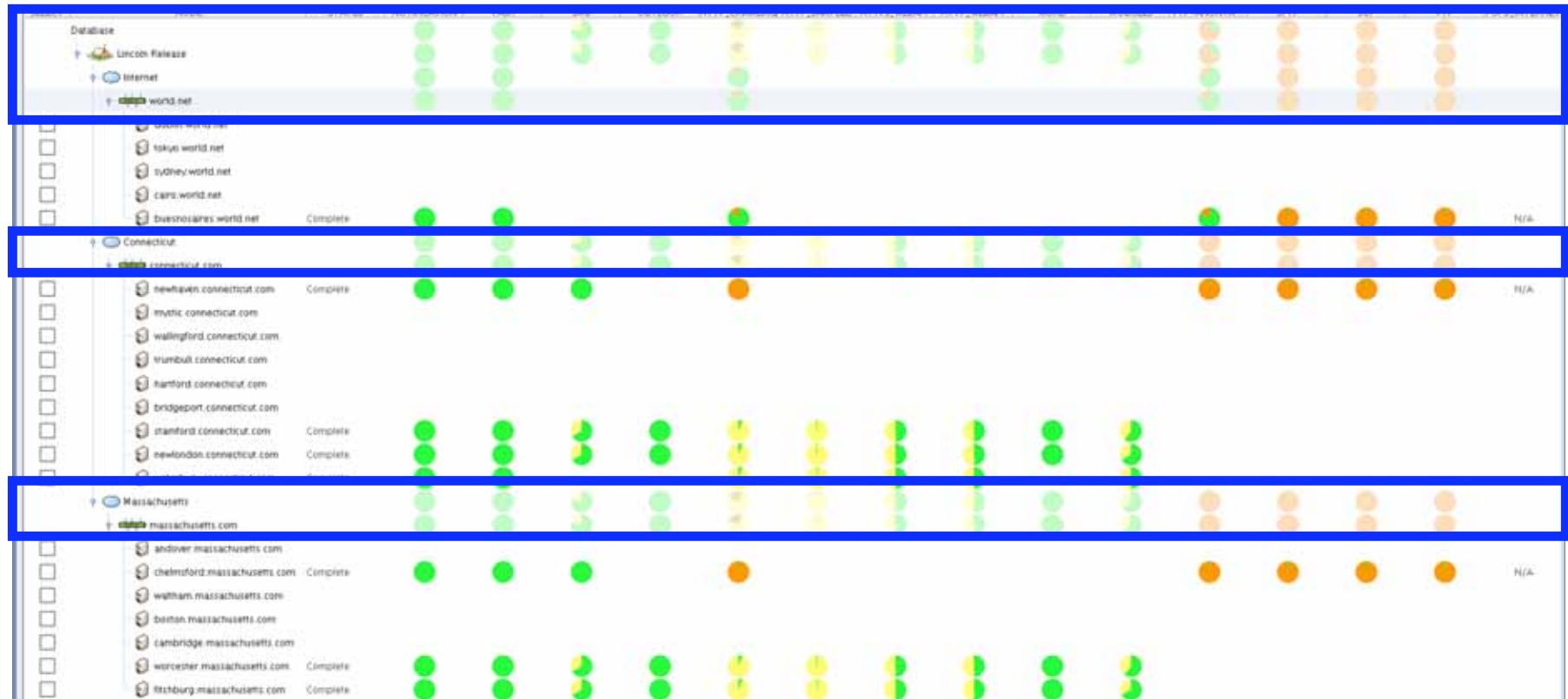


Diagnostic Solution: “Preflight”



Task status aggregated by subnet, network, and site

(S, F)





Diagnostic Solution: “Preflight”



Drill down to pinpoint errors (Particularly useful for large networks)

(S, F)

SELECT	NODE	STATUS	NOTIFICATION	TASK	SMB	OUTLOOK	HTTP_CRAWLING
	Database						
	Lincoln Release						
	Internet						
	Connecticut						
	connecticut.com						
<input type="checkbox"/>	newhaven.connecticut.com	Complete					
<input type="checkbox"/>	mystic.connecticut.com						
<input type="checkbox"/>	wallingford.connecticut.com						
<input type="checkbox"/>	trumbull.connecticut.com						
<input type="checkbox"/>	hartford.connecticut.com						
<input type="checkbox"/>	bridgeport.connecticut.com						
<input type="checkbox"/>	stamford.connecticut.com	Complete					
<input type="checkbox"/>	newlondon.connecticut.com	Complete					
<input type="checkbox"/>	waterbury.connecticut.com	Complete					
	Massachusetts						



Diagnostic Solution: “Preflight”



User accounts were not loaded on the file transfer servers?

(F)

Services were not started?

The screenshot displays a network management interface with a table of nodes and their status. The nodes listed include 'Lincoln Release', 'Internet', and several 'world.net' nodes. The 'STATUS' column shows green circles for most nodes, indicating they are online. The 'TASK' column shows green circles for most nodes, indicating tasks are completed. The 'SFTP' column shows orange circles for most nodes, indicating SFTP services are not running. The 'SCP' and 'FTP' columns also show orange circles for most nodes, indicating these services are not running. A detailed log of SFTP login failures is shown in the bottom left, with a blue box highlighting the log entries. The log entries show multiple failed login attempts for various usernames and passwords on trumbull.connecticut.com and waltham.massachusetts.com. A dotted arrow points from the log entries to the SFTP status column in the node table.

SELECT	NODE	STATUS	NOTIFICATION	TASK	SMB	OUTLOOK	HTTP_CRAWLING	HTTP_SAMPLING	HTTPS_WEBAPP	HTTPS_WEBAPP	WORD	MODULES	FTP-ANONYM	SFTP	SCP	FTP	IPSP	INTERNET
	Lincoln Release																	
	Internet																	
	world.net																	
	dublin.world.net																	
	tokyo.world.net																	
	sydney.world.net																	
	cairo.world.net																	
	buenosaires.world.net	Complete																

248 sftp [ERROR] trumbull.connecticut.com (5.5.5.13) - login Failed 65280. username: xipings, password: YMOsae
249 sftp [ERROR] trumbull.connecticut.com (5.5.5.13) - login Failed 65280. username: yeohom, password: JqYhYm
250 sftp [ERROR] trumbull.connecticut.com (5.5.5.13) - login Failed 65280. username: yhcarril, password: cDRIZPA
251 sftp [ERROR] trumbull.connecticut.com (5.5.5.13) - login Failed 65280. username: zhenhah, password: KTxPGD
252 sftp [ERROR] trumbull.connecticut.com (5.5.5.13) - login Failed 65280. username: zjbaumri, password: BnZVqba
253 sftp [ERROR] trumbull.connecticut.com (5.5.5.13) - login Failed 65280. username: zssteski, password: tmhtQAu
254 sftp [ERROR] trumbull.connecticut.com (5.5.5.13) - login Failed 65280. username: ztparis, password: REHoAQy
255 sftp [ERROR] waltham.massachusetts.com (6.6.6.12) - login Failed 65280. username: ajleredd, password: QFIqiE
256 sftp [ERROR] waltham.massachusetts.com (6.6.6.12) - login Failed 65280. username: akcummin, password: RbmLYwBm
257 sftp [ERROR] waltham.massachusetts.com (6.6.6.12) - login Failed 65280. username: alegrej, password: BkdBloM
258 sftp [ERROR] waltham.massachusetts.com (6.6.6.12) - login Failed 65280. username: angelym, password: ajMQmOHZ
259 sftp [ERROR] waltham.massachusetts.com (6.6.6.12) - login Failed 65280. username: aprilec, password: GPhTWypk
260 sftp [ERROR] waltham.massachusetts.com (6.6.6.12) - login Failed 65280. username: ars, password: rFEJhyq
261 sftp [ERROR] waltham.massachusetts.com (6.6.6.12) - login Failed 65280. username: arunacc, password: UUnDlamR

SFTP SCP FTP



Test Monitoring Task



- **Continuously monitor testbed hosts to ensure normal operation**
- **Allow operators to detect and mitigate potential problems**
- **Challenges**
 - Large number of hosts and frequent events or measurements
 - Real-time processing of information
 - Variable time window of interest

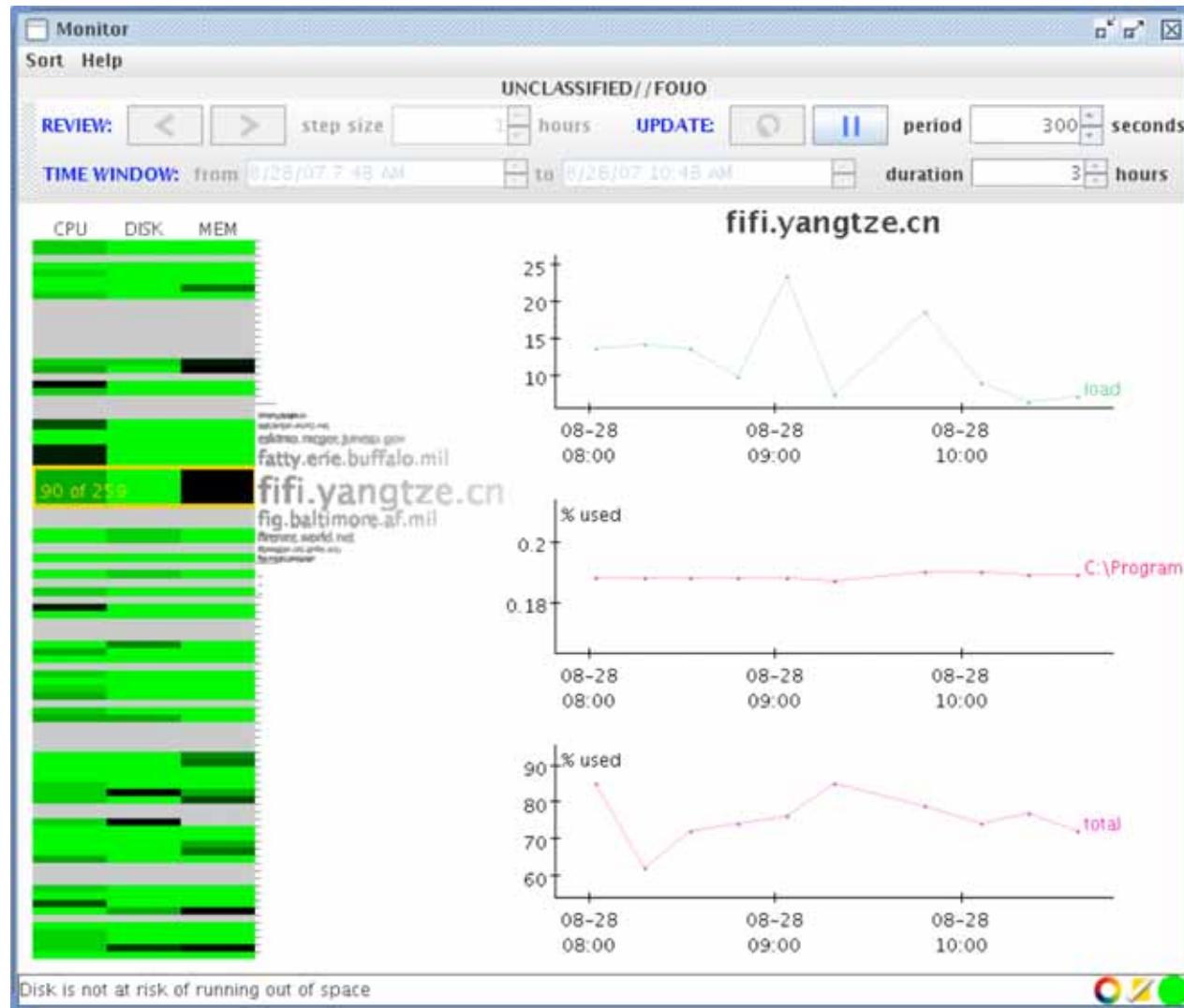


Test Monitoring Solution: Host Health



(S, F)

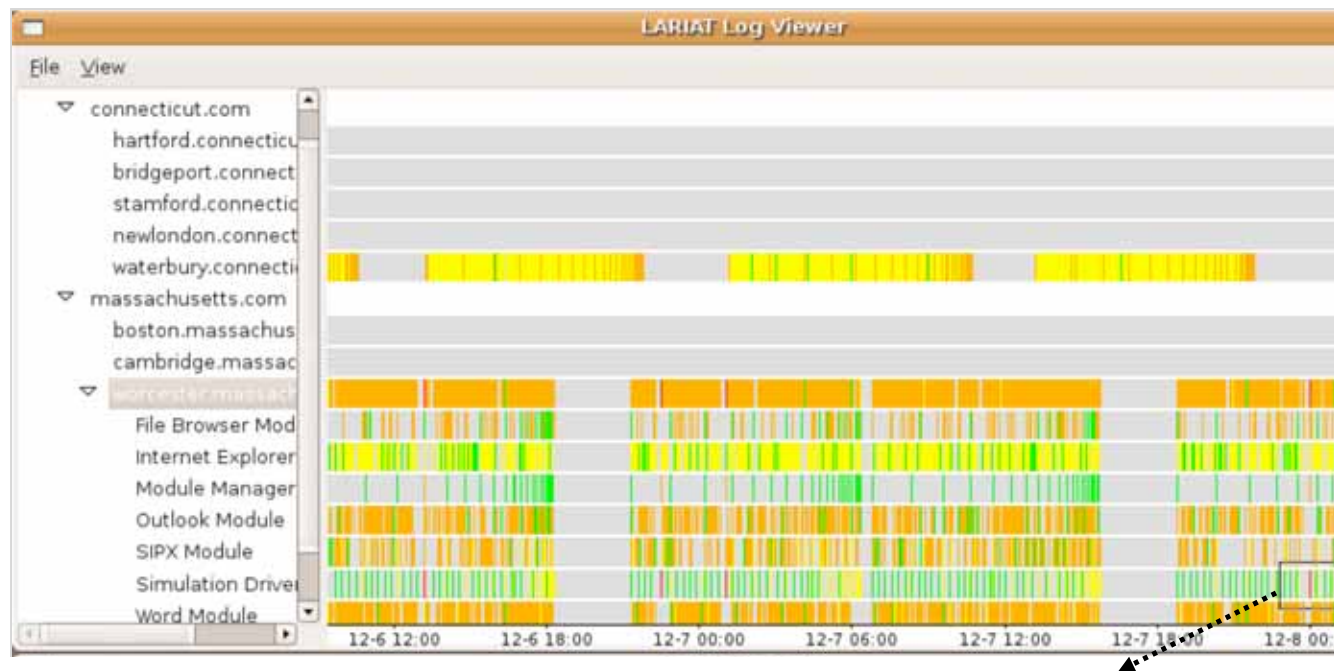
Testbed
status
at-a-glance



Usage
history of
selected
host



Test Monitoring Solution: Traffic Status



(S, F)




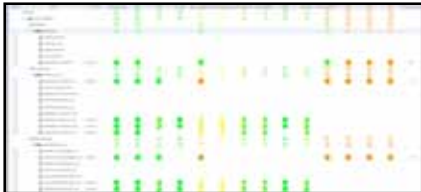
} Host
activity
timeline

} Timelines
by module



Assessment



Appropriate System Abstraction		<ul style="list-style-type: none">-Hierarchical model of the testbed environment-Unified host control mechanism masking underlying differences
Basic and Advanced Usage		<ul style="list-style-type: none">-User parameters are auto-populated but can be fine-tuned-Basic parameters are generally shown first
Scalable Performance and Visualization		<ul style="list-style-type: none">-Host health monitor can scale to arbitrary number of hosts without losing sight of trouble spots-Traffic health monitor can scale to arbitrary time window effectively
Interpretable and Correct Feedback		<ul style="list-style-type: none">-Clearly displayed task execution status, categorized by network, hosts, subtasks, with counts and detailed log messages available on demand



Summary



- **LARIAT is a realistic, scalable traffic generation and testbed management tool for evaluating IO technologies**
- **The LARIAT Director, with the help of task automation**
 - Enables more complex and realistic test configurations
 - Significantly contributes to LARIAT's success
- **Today, it takes a few weeks to install, configure, validate, and baseline a large, complex testbed**
- **LARIAT is widely used for many types of IO tests**



Backup





Related Work



- **Experiment and Testbed Management Software**
 - Plush
Framework for deploying distributed applications in PlanetLab
 - Experiment Workbench
Framework for experiment management in Emulab
 - SEER
User interface for the DETER testbed
- **Network Traffic Monitoring and Analysis Tools**
 - Network Eye
Visualization of the inbound and outbound traffic of a “home” network
 - TNV
Timeline visualization of network events by hosts and their corresponding connections and packet contents



Contributions



- **Developed an interface that enables experimenters to design and execute complex IO tests more easily using LARIAT**
 - Conceptual view of the testbed
 - Simplified operations
 - Centralized control and monitoring
- **Demonstrated the use of interface and visualization techniques in large-scale testbed management software**
 - Intuitive and scalable visual representations
 - Hierarchical tree for testbed environment*
 - Dynamic heatmap for host health*
 - Aggregation with visual cues for high-level assessment
 - Task status view*
 - Host health view*
 - Overview-to-details for troubleshooting