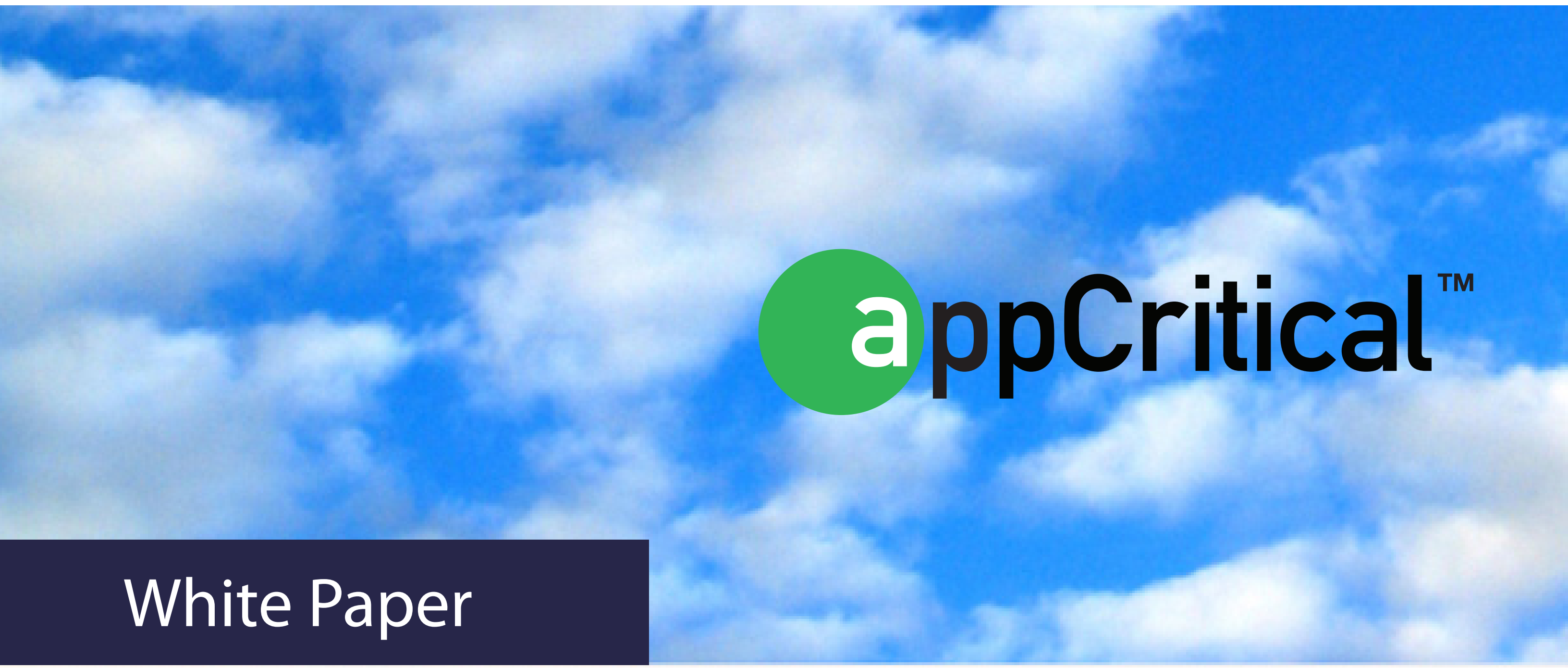
Managing Performance in Converged Networks: Not Your Father's NMS



White Paper

Apparent Networks™

ITEC Internet2 Technology Evaluation Center OHIO

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Apparent Networks is a leading innovator of network intelligence software. The **Apparent Networks** performance and diagnostic technologies, AppareNet and **AppCritical™**, operate non-intrusively on live networks, to and from any location worldwide. Without requiring specialized hardware or remote agents, AppareNet views the network from an application's perspective. In doing so, AppareNet/ **AppCritical** can rapidly identify the locations and causes of network bottlenecks, anywhere in the world so that companies can boost the performance of, and gain more value from, the network infrastructure they own or pay for. **Apparent Networks** improves its customers' businesses by helping organizations reduce operational costs, increase IP availability and protect revenues.

Prasad Calyam, OARnet/ITEC-Ohio

OARnet, a division of Ohio Supercomputer Center is an Ohio-based Internet Service Provider that maintains OSCnet (formerly Third Frontier Network). OSCnet is one of the most advanced Regional Optical Networks (RONs) in USA. OARnet offers a full range of networking services to nearly 100 colleges and universities, as well as government agencies, corporate enterprises and non-profit institutions throughout Ohio. OARnet is home to the Internet2 Technology Evaluation Center of Ohio (ITEC-Ohio) and it is also the Network Operations Center (NOC) for the Internet2 Commons community and Megaconferences - the world's largest annual Internet Videoconferences.

Introduction

Network Management Systems (NMS) were last decade's answer to the ever-increasing demands of networks. They offered a best-effort solution that promised to make sense of the morass of data extracted from multitudes of devices. However, the assumptions behind their design and implementation rarely apply any more.

The old client-server approach provided a relatively controlled environment, where well-defined processes took place. The goal of IT was to increase the productivity of specific business processes and the budgets were relatively flexible. The issues facing network engineers revolved primarily around management and users had only limited contact with the network.

Today, application performance defines the success of networks, and almost every aspect of business depends on applications that depend on the networks. The networks grow and change more rapidly, with critical parts outsourced to ISPs and other providers. Information Technology has become as accountable as any other business unit to show ROI and even generate revenue.

Today, management of your networks just isn't enough. Application assurance is critical and this requires a new approach. Cumbersome, high maintenance Network Management Systems have begun to give way to rapidly deployable Network Performance Infrastructures (NPI) that support access for all stakeholders in the network community - from the experienced network engineer, to support staff and help desk and, most importantly, to the end user.

By definition, a well-implemented Network Performance Infrastructure provides a high level of immediate feedback from the network so that all forms of application performance can be assessed and guaranteed, and problems can be proactively identified and resolved, leveraging the advantage of effective participation by all stakeholders.

Worlds Apart

The transition from early data networks to modern day, high performance communications systems has changed the playing field dramatically. Very little is recognizable from the origins of networking.

In the old world:

- you owned or controlled most of the networks your key applications depended on;
- you could predict where critical traffic would flow and when;
- complex, slow deployment, agent-based systems were approved and implemented because the problems client/server created were new, acute and difficult to resolve;
- you dealt with a dog's breakfast of vendor-specific protocols that often forced you to maintain relatively homogeneous systems with clear functional boundaries;

- you had smart engineers designing and managing the networks directly;
- your users and customers had limited expectations of the networks - down time was expected and acceptable;
- business processes that depended on your network were limited and well-defined;
- IT was implemented to generate productivity increases and budgets were generous.

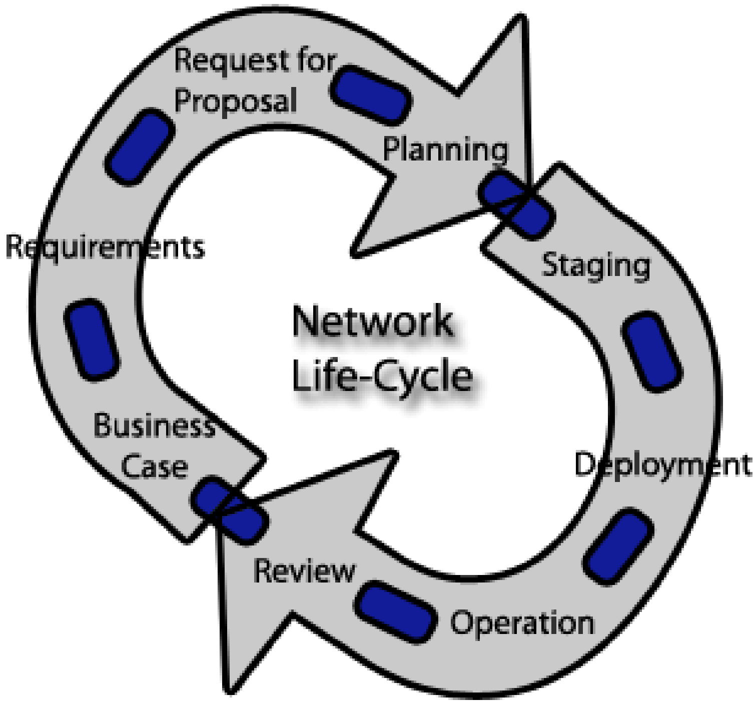
In today's world:

- your business depends on networks you do not own or control (ISP, ASP, customer, supplier);
- you can't predict where tomorrow's traffic will flow, what application will be deployed, or what will break next;
- there is less (or even no) time and money for deployment or maintenance of big, complex network management systems;
- it's "IP everything everywhere" forcing convergence and unified communications onto networks that contain legacy components;
- your users and customers have higher expectations and your business network is critical – even brief outages can be disastrous and costly;
- you rely increasingly on help desk and support staff with limited network expertise and few tools to do their job well;
- networks are mission critical - everything seems to depend on them;
- IT is expected to align with other business practices, including cost reduction and even revenue generation.

There is little wonder that the Network Management Systems of the last 20 years do not address today's needs. What should you be looking for instead?

Network Life Cycle

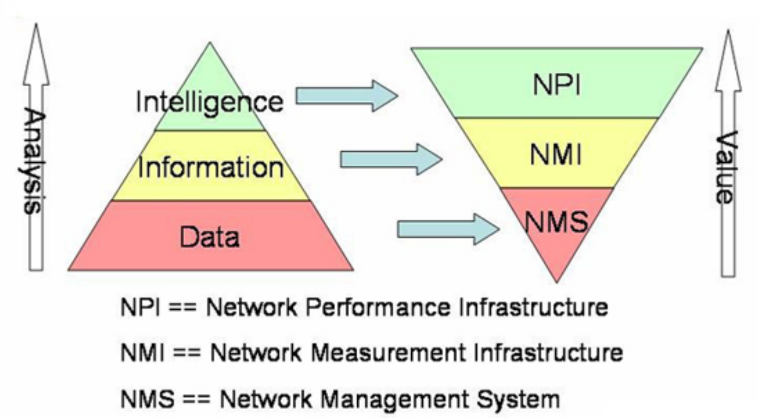
Today's networks are highly dynamic- they evolve within a never-ending cycle of planning, deployment, maintenance, and upgrading. The traditional NMS has serviced only a very small part of the Network Life Cycle (NLC) and typically at a very high cost.



Network Life Cycle (NLC) - describes the stages of network design, staging, deployment and operation.

Operation is still the obvious part of the process but the bounds of today's network operation have expanded dramatically to include applications, data centers, outsourced resources, and helpdesk/support for both internal and external users. NMS have primarily focused on data gathering and device management. This is useful but limited to networks that you own and have control over.

Incremental improvements in various management technologies have armed network engineers with increasingly sophisticated measures of network performance, including addressing aspects of various forms of application performance. They provide a view of performance defined in terms of a particular application or use of the network.



For example, consider the wildly differing requirements of data storage and Voice-over-IP. Technologies that assess networks specifically for these applications employ radically different methodologies and require distinct management processes. Each example of an application-specific measurement tool (see examples below) represents an instance of Network Measurement Infrastructure (NMI).

NMIs provide a coherent, contextual basis from which to make timely and specific measures particular to a use, application, or environment.

However, the performance of the network is not fully defined by any one of those particular views. These new technologies are highly attractive to anguished network personnel and yet they do not offer a sufficiently complete solution to warrant investment in time and money.

A fully coherent NPI offers an integrated view of the network based on all aspects of the end-to-end network path. This view includes perspectives from various NMI-type measures and assessments, and it also includes an integrated analysis of the overall performance. Further, an NPI provides that view relative to the applications that use the network, as well as the members of the network community (users, helpdesk, application support, engineers).

Approaching the Mountain from All Sides

Although NMIs are increasingly available and well-developed, they tend to be narrowly focused and relatively inflexible. The focus on application performance is driving the emergence of new metrics (such as MOS for VoIP and VQM for Video) and measurement technologies associated with them. The need for a coherent, overall solution to network performance is driving the integration of NMIs into a broadly accessible and flexible platform – the Network Performance Infrastructure.

The basic principles that should be embodied by an NPI include:

- Seeing the application's view, end-to-end, includes all the components that impact performance;
- Deploying the requisite infrastructure rapidly, and on demand, ensures that scarce resources are applied when and where needed;
- Being able to see into networks you don't own means you can out-source with confidence;
- 24/7 monitoring ensures that "network awareness" gives you immediate feedback;
- Real-time responsiveness based on current conditions reduces the dependency on historical data and makes the infrastructure more adaptable;
- Emphasizing "effective" over "absolute" means that you resolve the most common and most expensive problems most quickly;
- Distinguishing clearly between IP-level and influences higher up the stack means that application-specific issues can easily be separated from problems with the network;
- Your network's needs should be reflected in your performance infrastructure instead of retro-fitting your network to fit the demands of an inflexible management system;
- Capitalizing on every aspect of your existing infrastructure, including the effective participation of your end users, means nothing goes to waste;
- Providing appropriate access to all levels of management and the user base means that everyone can usefully participate in the process.

When you start to put these principles to work, a meaningful picture starts to emerge. Let's consider a couple of examples of NMIs that are evolving toward NPI status.

Use Cases and Exemplary Technologies

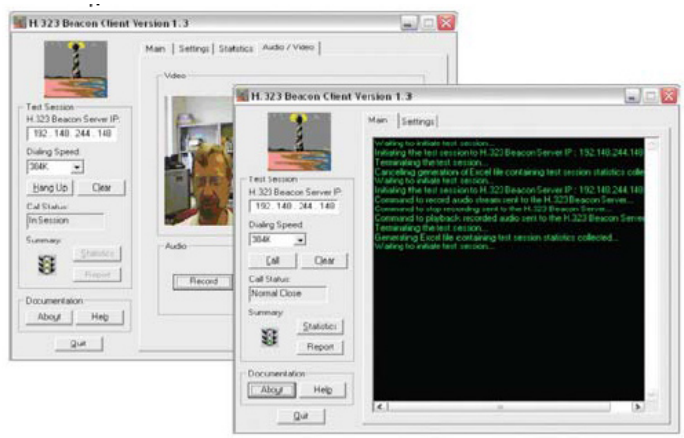
A use case for an NMI is found within the Internet2 community where ambitious video-based projects are regularly deployed and supported. The Internet2 Commons project aims to facilitate technologies for voice, video and data collaboration amongst researchers and students at universities connected to Internet2. The annual Megaconferences [1] are one of the world's largest Internet Videoconferences. They involve several world-wide sites coming together simultaneously to push the limits of the latest network and end-point technologies. To successfully support such large-scale collaborations, individual end-users cannot be expected to deal with network issues directly, so tools are being developed that enable the end-user (and network support) to see end-to-end, helping them identify and resolve their own video-related problems.

NMI Example: H.323 Beacon

OARnet developed the first version of the H.323 Beacon in late 2002 to meet the needs of the Internet2 Commons and Mega–conference community. H.323 Beacon is one of the new-generation network measurement tools which knows about the application itself and can troubleshoot end-to-end application performance problems specific to its character. The H.323 Beacon emulates H.323 videoconferencing applications and possesses the diagnostic capability to detect firewalls or NATs along the paths that hinder call establishment and audio/video media quality. H.323 Beacon has undergone continual development and its feature set has been enhanced considerably.

H.323 Beacon uses a distributed client/server architecture - the client actually refers to an end-node and the server can be visualized as a core-node. Testing between end-nodes can be achieved by using a number of core-nodes along a test path. This architecture facilitates the H.323 Beacon to perform end-to-end measurements related to H.323 videoconferencing sessions. The measurements supported by the H.323 Beacon include delay, jitter, loss and MOS for a variety of audio and video codecs. The voice MOS estimation adheres to the popular E-Model specification. The video MOS estimation uses the OARnet-developed GAP-Model. The GAP-Model uses light-weight active measurements to estimate network status. From those measurements, end-user Quality of Experience (QoE) rankings can be automatically predicted for varying activity levels in video content.

With the audio / video loop–back feature, the "local" audio/video quality as experienced at the remote end can be seen locally. Local video can be recorded at the Beacon server in AVI, MPEG, or QuickTime formats. Local audio can be recorded at the Beacon server in WAV format. The recorded audio/video files are transparently played back at the client to the end-users. At the end of the test session, a detailed test session report is generated that could potentially be handed over to more experienced support staff to resolve any identified performance problems.



H.323 Beacon Screenshot

NMI Transformation to NPI: H.323 Beacon to ActiveMon

Early deployments of the H.323 Beacon at Internet2 and other communities were focused on a client-to-server service architecture. H.323 Beacon servers were deployed at strategic network points such as data centers where MCUs were located. End-users used their H.323 Beacon clients to troubleshoot paths between their sites and the MCUs. Soon, there came a necessity for deploying server-to-server architectures, where network paths needed to be continuously monitored and routine performance reports had to be generated. In addition, end-users were interested in integrating other commonly used open-source NMI tools such as Traceroute, OWAMP, Iperf, Pathrate and Pathload to complement the network monitoring information provided by the H.323 Beacon. Further, end-users wanted an integrated analysis of the network-wide status and how the network paths were performing over multi-resolution time scales. For example, they wanted to know how today's network performance of the monitored paths compared to last week's or last month's or even last six months' performance. The intention was to use this information for a variety of network troubleshooting and network planning purposes.

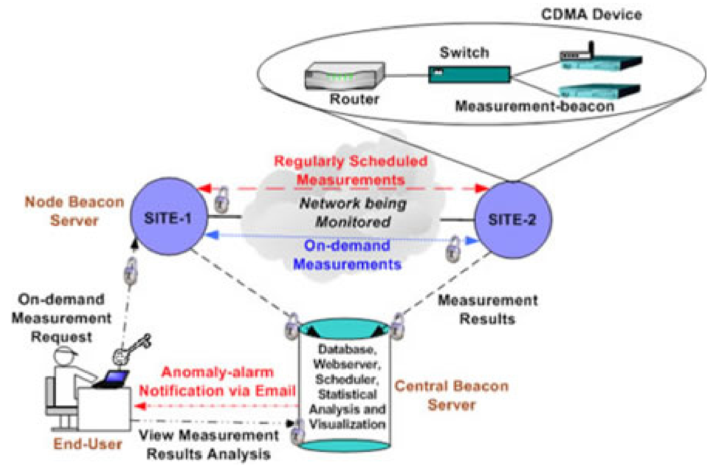


Figure A1: ActiveMon System Framework

Towards meeting such end-user demands, H.323 Beacon and other open-source tools were integrated into the OARnet-developed "ActiveMon" open-source software. ActiveMon is an extensible framework for generation and analysis of active measurements for routine network health monitoring.

The framework (shown in Figure A1) provides secure monitoring of network health metrics such as route changes, delay, jitter, loss, bandwidth and MOS. Using a scalable scheduler called "OnTimeMeasure", regularly scheduled as well as on-demand measurements are initiated in a regulated and non-conflicting fashion between multiple measurement servers distributed at strategic points in a network. ActiveMon also supports efficient measurement data storage. Using relevant statistical and visualization analyses, coupled with alarm generation capabilities, ActiveMon can help determine end-to-end network performance bottlenecks on a routine basis.

With ActiveMon's ability to integrate a wide range of measures/analyses to provide high-levels of network performance transparency, it can be categorized as an NPI. As an NPI can thus help troubleshoot a much larger variety of application problems compared to NMIs such as the H.323 Beacon, which was designed solely for solving H.323 applications

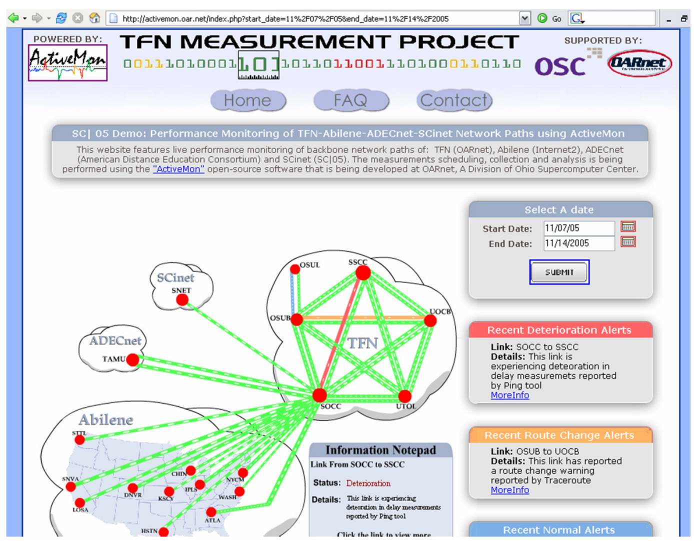


Figure A2: Third Frontier Network Weather-Map generated by ActiveMon related problems. Today, ActiveMon has been successfully deployed over OARnet's OSCnet (formerly Third Frontier Network) as shown in Figure A2. With the emergence of Measurement Level Agreements (MLAs) between measurement federations such as TFN, Abilene and ADECnet, end-users and network engineers are able to securely and non-intrusively extend ActiveMon's capabilities to troubleshoot between their networks and other networks they don't own.

Another NMI → NPI Example: AppareNet becomes AppCritical

AppCritical meets the essential requirements of industry Best Practices by integrating the benefits of a comprehensive NMI technology into an NPI infrastructure that meets the need of the converged performance market. The core NMI capability in the AppareNet technology identifies Layer 3 as the foundation of all application performance. It performs measures/analyses that identify and isolate key features of the network path in real-time. By extending these features to address the issues of rapid on-demand deployment, remote data gathering, continuous monitoring, user-specific and application-specific views, and universal accessibility, the complete **AppCritical** solution takes the NMI approach to the next step.

The AppareNet measurement technology follows a point-and-shoot methodology, requiring very little pre-configuration to execute a comprehensive analysis of almost any network path. A network engineer only needs to select the deployed point of view from which to measure (the Sequencer) and enter the IP address of any arbitrary end-point – such as a server, IP phone, workstation, or mobile IP device. Then, simply by pressing "Start", the Network Intelligence System (NIS) discovers the end-to-end path, identifies all visible Layer 3 elements, and begins comprehensive testing without a prior knowledge.

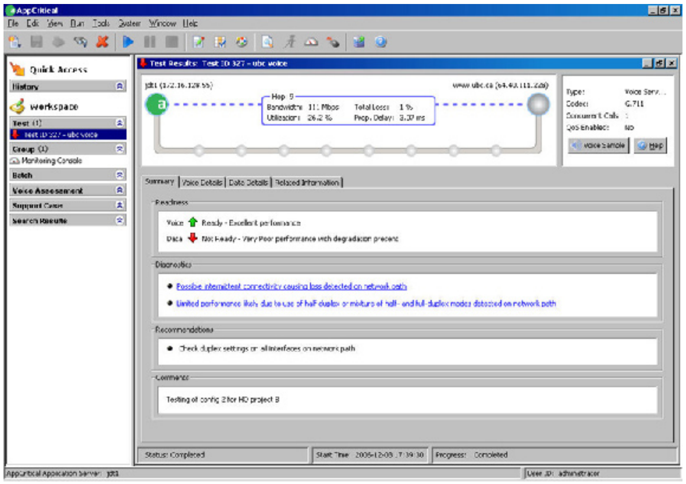


Figure B1: AppCritical End-to-End Network Path Analysis

The real-time result is an end-to-end assessment of the network's characteristics in detail, summarized simply and effectively as either optimal (green light) or degraded (red light). In addition, the expert diagnostics system can identify a wide variety of common problem behaviors and will tell the user what the cause is and where to look. The sampling technique allows this technology to be deployed without remote software or with a remote probe. In addition, it can see detail within networks that contribute to the end-to-end performance, including through and into third party networks.

AppCritical combines this measurement and diagnostics capability with several other key functionalities:

- The network sampling component (the measurement point of origin) can be deployed and re-deployed on-demand anywhere, even behind firewalls;
- For rapid, one-time deployments to resolve remote issues, a throw-away version of the sampling component can be delivered by e-mail or the Web for manual deployment;
- Simplified interfaces with "smart" views support end users to transparently test their own connections without consultation with network managers;
- The intelligence gathered by end-users travels with their trouble calls so that network engineers can see what the user saw;
- It can monitor critical paths on an on-going basis;
- It offers Service Quality Definitions that are customizable to meet the network requirements of specific elements or applications;
- It automatically focuses its monitoring on trouble spots, escalating to full detailed diagnostics without human intervention;
- It proactively notifies management systems and/or network staff of impending problems with detailed diagnoses – not simply alarms;
- It produces aggregated reports and statistics for multiple paths;
- It offers test plan schemas that define end-point types for packaged and customized testing procedures.

This approach ensures that the NPI can be rapidly deployed into any network as needed, supports all members of the network community to contribute to the rapid resolution of application performance degradation, and can operate automatically with minimal human intervention. The solution can be flexibly applied to the needs of Enterprise networks, ISPs and ASPs, Support organizations, and Network-Dependent Vendors. Further, the framework is designed to support automation and the future demands of autonomic and self-healing networks.

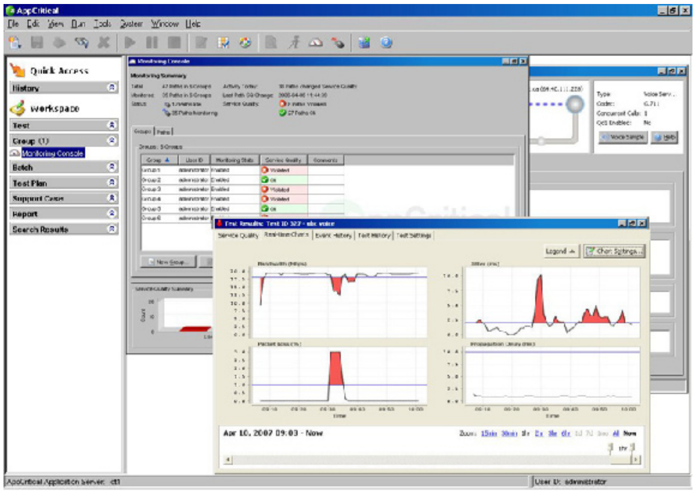


Figure B2: AppCritical Real-Time Monitoring of Many Network Paths

AppCritical Use Case: Managed Services

A C S

ACS provides a wide range of IT and business processing outsourcing services. With over 58,000 employees worldwide and multiple platforms and network topologies being managed, the project has had a tremendous impact at ACS.

The project impacts all ACS datacenters, Wide Area Network (WAN) services, Local Area Network (LAN) segments, Voice over IP (VoIP) infrastructure, mainframe, and midrange networks that ACS manages.

ACS has deployed **AppCritical** by **Apparent Networks** to conduct real-time proactive monitoring, perform network assessments and troubleshooting, and provide actionable diagnostics for a range of client networks including data networks, converged network infrastructures for VoIP, and video applications. With **AppCritical**, ACS can quickly pinpoint the source of various client network issues and determine diagnostics, as well as provide detailed measurements such as maximum available bandwidth, latency, and utilization. ACS can also provide continuous monitoring and measurement of other parameters that impact voice and data such as packet loss, jitter, bandwidth constraint, MTU mismatches, duplex issues, media errors, and driver problems. **AppCritical** can analyze performance elements such as QoS configurations and codec versions, and generate measurement of MOS scores (Mean Opinion Score, a measure of quality) for Voice-over-IP applications. Most significantly, ACS can now provide both end-to-end path diagnostics and inter-hop analysis of converged network paths without affecting existing network traffic and without requiring agents or probes to be installed at remote site locations.

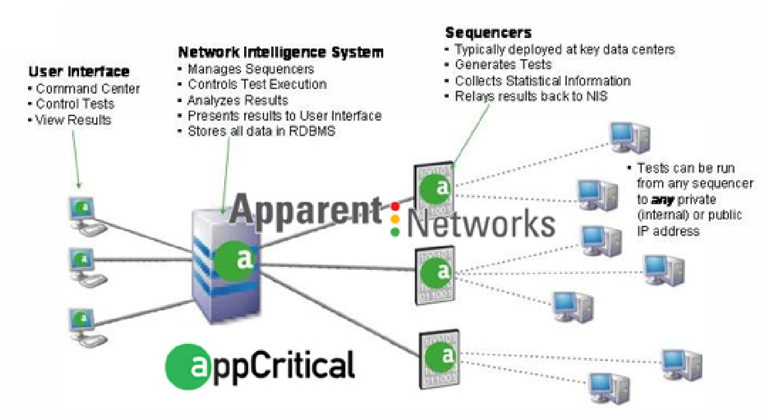
ACS uses **AppCritical** to continuously monitor and manage all of its customers' network paths to help ensure that their networks are highly stable and readily available. Analysis is done in real-time on live networks, and any faults or Service Quality thresholds that are violated are first confirmed, then diagnosed, and automatically reported to quickly resolve fault issues before they are noticed by users.

The ACS real-time proactive monitoring, network assessment, and troubleshooting capabilities bring benefits through:

- **Remote troubleshooting** – View the entire end-to-end path that an application travels, within minutes, without installing probes or requiring someone to be located at remote sites. ACS can perform both local and remote troubleshooting.
- **Speedy, real-time assessment** – Perform measurement and diagnostics of issues such as latency, packet loss, bandwidth, utilization, jitter, media errors, duplex issues, MTU mismatches and packet reordering for data, VoIP and video, leading to quicker resolution. ACS can perform assessments and audits for backbone networks, VoIP roll-outs and ever-changing networks prior to integration or deployment.
- **Accurate identification of cause and location** – Pinpoint critical network problems such as half/full duplex conflicts, poorly performing routers/switches/NICs, MTU errors, and media errors. ACS can supply a deeper command of the network, with proactive response times and conclusive answers to long outstanding issues.

- **Real-time proactive monitoring and batch reporting** – Give an accurate assessment of the network upfront and decrease the Mean Time to Resolve (MTTR). ACS can run scheduled batch tests, provide quicker escalation of critical network alerts, and take a proactive monitoring approach without taxing the network system, enabling it to identify weaknesses within customers' networks and provide resolution before they become a major problem.

The bottom line: higher network availability, improved network performance, and exceptional service quality.



With over 12,000 managed devices, it's a daunting task. The reward is the ability to proactively monitor and manage network and application errors, before the users are even aware of a problem. **AppCritical** monitors four major network parameters (bandwidth, latency, jitter and packet Loss), in a real time state, providing statistics and test results to the ACS ECC, enabling first call resolution, and reducing MTTR (Mean Time To Resolve), providing the engineering group faster response to issues as they arise.

With **AppCritical**, network assessments during due-diligence provide data to the design and transitions teams. Engineering receives baseline information, providing information for network enhancements. Network issues are pinpointed with accuracy. VoIP deployments will be streamlined. Customer (QoE) Quality of Experience is dramatically increased.

All of this providing ACS customers with excellence in engineering.

Best Practices for an Effective NPI

The case for a modern Network Performance Infrastructure can now be made. The hallmarks of a complete solution are defined by Best Practices.

Here are the keys to look for:

1. Continuous monitoring of performance (not just availability) as an essential starting point

1.1. ideally a Layer 3 or 4 demarcation point separates network issues from application

1.2. application performance is assessed specific to each application type

1.3. "smart filtering" that limits or eliminates redundant or false positive notification

2. Rapid response to performance problems that slip through the cracks

2.1. a real-time measurement/assessment/ problem diagnosis capability

2.2. automated expert analysis

3. Rapid deployment and configuration

- 3.1. capable of on-demand responsiveness
- 3.2. can be deployed remotely within otherwise inaccessible networks
- 3.3. no need for a priori knowledge of the network
- 3.4. auto-discovery and self-configuration

4. Empowerment through access to the performance infrastructure throughout the Network Vertical

- 4.1. network engineers
- 4.2. helpdesk and support engineers
- 4.3. end-users and customers
- 4.4. strong share-ability of results between all the members
- 4.5. intelligent support for all members

5. "Smartened up", not dumbed-down, client-side views

- 5.1. application-specific analyses and diagnostics
- 5.2. action-oriented expert feedback

6. Extensibility in the form of adaptability and configurability

- 6.1. in application type and requirements
- 6.2. vertical member role and responsibilities
- 6.3. variable data source and performance analysis methodology
- 6.4. follows work process

7. Intelligence archiving that supports sharing of network data between organizations

- 7.1. Methodologies that provide visibility into networks that you don't own
- 7.2. Federated access and data sharing
- 7.3. Anonymization and secured data access

The Future of Autonomics

The elements of the complete Network Performance Infrastructure are not just for today's needs. They are congruent with the trends for near-future technologies. Autonomics, self-healing networks, and on-demand computing will require the same capabilities delivered in a dynamic package. Instead of serving the user and their associated support desk, the NPI will be the source of direction and performance analysis for automated and adaptive computing resources. To date, users have been the "performance monitors", while support staff have acted like the "diagnostics tool", and network engineers have fulfilled the role of "expert system". The lack of effectiveness in this approach has driven the trend to NMIs that have helped humans solve their problems and subsequently to NPIs that proactively prevent and remediate performance issues. Soon we can expect the user to be relieved of the tiresome task of monitoring their own environment. As NPIs provide the basis for self-healing and adaptive networks, applications will enable the optimization of their own performance automatically.

References

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http://www.apparentnetworks.com/technology/autognostics.asp

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Apparent Networks, Inc. develops and markets software that provides a unique approach to improving performance by measuring and diagnosing live converged networks as part of pre-deployment assessment, troubleshooting and continuous real-time monitoring.

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