An Intelligently Managed Network Infrastructure for E-Business

A White Paper
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e-Business is the driving force today—businesses are trying to gauge their opportunities and learn how to succeed in a challenging marketplace. e-Business offers access to large markets, reduced costs for customer support and sales by using innovation rather than size to compete, and keeping up with competitors.

At the same time there are still significant risks to be considered. Service and security breakdowns are regularly reported at the most sophisticated e-Business sites.

The early e-Business phases are focused on building a strong Internet presence through rapid and sustained innovation, creating a strong branding identity, and raising barriers to competition. Survivors make the transition to maximizing their profits and effectiveness.

Choosing the appropriate technologies and service providers has never been more important. e-Business criticality places more stringent demands on IT groups and their service providers, and the chosen network infrastructure makes a difference.

The networking industry has been discussing “intelligent” networks for a long time, and tremendous strides have been made. However, there...
are levels of intelligence within a network infrastructure, and while some levels have already developed others are just beginning to be recognized. This paper discusses the next level of infrastructure intelligence—the capacity to intelligently manage the network infrastructure itself.

An Intelligent Network Infrastructure

There are significant opportunities for enterprise IT groups and their service providers to distinguish themselves as contributors to e-Business success.

Service providers and IT groups directly affect the value of the enterprise, its stock prices, and its public perception by their performance. The recent holiday season provided ample examples of companies that failed to meet customer’s expectations and suffered accordingly.

Infrastructure Constraints

Managing the network infrastructure is often an obstacle to e-Business success. Some of the major obstacles include:

- **Complexity**—The e-Business environment grows increasingly complex with n-tier server architectures, interconnected service providers, and multiple technologies. Most management staff cannot respond effectively when this complexity is coupled with accelerating change.
- **High administration costs**—Too many staff-intensive management tasks escalate costs and limit scaling to seize new opportunities.
- **Lengthy management processes**—The e-Business world is all about speed and the network infrastructure must adapt quickly to changing business requirements.
• **End-to-end QoS management**—The e-Business delivery chain is more complex and the quality of the entire delivery process must be managed. Most of the infrastructure is not under the direct administrative control of the e-Business, adding to the challenge.

• **Reactive management**—Network administrators must be able to identify and pinpoint potential infrastructure trouble spots before they have any impact on service quality.

• **e-Business perspectives**—The network infrastructure must deliver services with acceptable quality. Administrators and planners must be able to track and measure service flows across the infrastructure.

None of these obstacles are solvable by only adding more management staff. The traditional staff-intensive approach has never been adequate, and the new challenges make that approach certain to fail for e-Business. Another ingredient is needed—intelligent network infrastructures that solve problems with **embedded management functionality** rather than with more staff labor.

**A Continuum of Intelligence**

Defining intelligence is difficult since every vendor positions its products and management capabilities as “intelligent.” There are ranges of functions that can be considered as intelligent, which adds to the confusion. Intelligent functions can be characterized as:

♦ **Element management**—Functions that reduce staff labor for installation, deployment, and operations.

♦ **Monitoring and alerts**—Tracking service behavior and alerting the management system to problems.

♦ **Policy enforcement**—Automatic oversight of management operations and activation of responses to problems.

♦ **QoS management**—Functions for delivering the performance specified in service-level agreements. Functions include traffic classification, bandwidth management, and prioritized forwarding.

♦ **Traffic management**—Functions that increase traffic flow through shaping, load balancing, and admission control.

♦ **Infrastructure management**—Managing the network infrastructure as a system of cooperating elements.
Infrastructure management has been neglected, partly because it is a mature stage in the evolution of management strategies, and partly because there has been minimal functionality available. Intelligent management with embedded functionality will produce significant value for service providers, IT groups, and their customers.

An architecture is introduced with descriptions of the major components, followed by examples of an intelligently managed infrastructure.

**Architectural Overview**

The network infrastructure can be broken into the connectivity and service layers corresponding to Layers 3 and 4, and 1 and 2 of the OSI model, respectively.

**Application Services Layer**

The application services layer is harder to define cleanly these days since it includes basic Layer 5 to 7 functionality, IP services such as DNS, and complete on-line e-Business services such as real-time markets for e-Business commodities.

The Application Services Layer provides information about application behavior that is needed for complete Service Level Management. The application services must also be managed intelligently for acceptable performance. Correlating information on application performance with information from the intelligent network infrastructure provides a complete picture of performance and possible problem areas.
The Infrastructure Services Layer

This layer handles routing, reliable delivery, and quality of service (QoS) management. It provides substantial management value with end-to-end QoS control. Reduced operational costs are realized by leveraging management intelligence rather than stretching scarce staff resources further.

Advanced Elements--A New Entity

Advanced elements have additional functionality that allow them to participate in intelligent infrastructure management. They initiate network activities, collect baselining information, and help troubleshoot complex problems.

The advanced infrastructure elements operate autonomously after direction from a remote management center. They carry out persistent
operations over longer time intervals. They create additional flexibility by downloading new software as needed.

**Open Interfaces**

An open interface is essential for an intelligently managed network infrastructure. An open interface provides infrastructure management information to a variety of consumers, such as best-of-breed management tools, other infrastructure managers, and local managers.

No infrastructure is isolated anymore and further savings result from flow-through operations. Flow-through will be the most economical way of achieving dynamic resource control; leveraging tariff shifts, and keeping pace with e-Business demands. The open interface interconnects with other infrastructure management systems for flow-through provisioning, QoS, and policy harmonization.

The open interface allows management tools to activate coordinated measurements among a set of advanced elements. They can initiate and monitor complex activities as they maintain service levels.

XML (the eXtensible Markup Language) is a rapidly emerging standard for exchanging management information and it must be an option for any open architecture. XML allows a complete exchange of management information because the methods (ways the object is manipulated) and presentation of the information are included.

Both the enterprise and service providers want to use the best management tools for their network infrastructures and e-Business requirements. An open interface attracts a larger community of providers who benefit from an active ecosystem that rewards
innovation and speed. Infrastructure owners benefit from accelerated functionality and cost savings.

The Vertical Model

In contrast, the vertical approach of a single vendor providing a complete solution has been ineffective in delivering the best functionality, a complete solution, or the highest value to infrastructure owners. The current state of Operations Support Systems (OSS) and their integration is a notable example.

The Connectivity Layer

This is the basic physical connectivity for the network infrastructure, focusing on the physical and data-link layers of the OSI model. Element management is the focus and provides different value than the management capabilities of the Services Layer.

Basic (Traditional) Elements

Basic elements operate as single elements rather than as part of a larger fabric of cooperating elements. They respond to simple messages such as PINGs, but their capabilities are limited. Management value is in automating configuration and operations to minimize the staff time needed for each element.

A basic set of management functions must be available in every element. These functions provide consistency across the infrastructure, and they include:

- **Basic monitoring**—Minimal filtering, detecting threshold conditions, triggering real-time alerts
- **Access to element-specific information**—Providing detailed information as needed for troubleshooting or other tasks
- **Basic control** functions—Remote control of reboots and activation or deactivation of specific subfunctions
- **Local actions**—Taking steps specified by a remote management site under specified conditions
- **External communication**—With remote managers, directories, and policy servers

### Managing the Infrastructure Intelligently

One way of exploring the intelligent management of the network infrastructure is to look at the needed functions; Figure 2 is one way of organizing the elements. Basic element managers were described previously.

![Diagram](image-url)
**Advanced Element Managers**

These tools leverage the additional management capabilities embedded in the advanced elements. They initiate management activities from the element, monitor processes, ensure that the advanced elements have consistent software, and monitor their health.

**Advanced Element Agents**

These agents play a more sophisticated role. They must have sufficient processing and storage resources to avoid degrading element performance. Agents today also access external information sources such as directories and policy servers. Other specific components for infrastructure management are described below.

**An Operating System**

Flexibility and robust operation dictate a set of common services and protection of management resources within the element, the characteristics of an operating system. Some of these functions include:

- **Scheduling** management tasks (data collection or measurements) on a periodic basis or on demand
- **Managing internal resources** such as memory, persistent storage, or processing
- **Coordinating** a set of different management functions within the element

**Value-Added Management Functions**

Elements supplement core management functions with value-added modules. Monitoring and measurements for specific flows, active functions that generate network traffic for baselining, security filters,
or tracking changes are a few possibilities. Some value-added modules are element-specific, while others are generic and only use a specific element as a host.

**Data Management**

Persistence is required for some information; for example, billing data must be preserved through failures and reboots. Real-time data is aged and consolidated into historical traces for later analysis.

**Co-Existence**

All elements have basic element management functions; others also have advanced infrastructure management capabilities. Basic element managers may be agent-centric in design with limited functionality. In contrast, advanced elements are designed as OS-centric management functions.

**Fig3**: All Elements have basic management functionality, both basic and advanced elements co-exist within the infrastructure.
Both elements co-exist within the infrastructure and advanced elements add additional management value without forcing abrupt infrastructure changes. Over time, larger numbers of advanced elements will increase the granularity of measurements (more points) and offer finer end-to-end control.

**Command and Control**

This level controls and coordinates the (potentially large) set of advanced elements. It has up-to-date topology and service flow information as well as the intelligence for automating management tasks that are too complex or time-consuming for most management staffs. This information is combined to coordinate activities throughout the network infrastructure. For instance, an infrastructure management tool would ask for advanced nodes in a particular path to be activated for measuring delays. The command and control layer would use its topology and element information to identify the elements and activate the appropriate processes.

**Infrastructure Management Suite**

Infrastructure-specific management tools reside at the top layer, using the command and control level for specific detailed steps to collect information. These tools carry out a variety of essential management tasks, including:

- End-to-end QoS management
- Real-time troubleshooting
- Historical data collection for provisioning and optimization
- Ongoing measurements and baselining
- Billing
- External communications with other network infrastructure managers, systems and applications infrastructure managers
- Flow-through processes
Leveraging Management Intelligence

Once advanced elements and infrastructure management tools are in place new types of management operations are activated. For example, two demarcation points in the figure below are remotely instructed to exchange traffic periodically and measure the round-trip delay. More sophisticated traffic measurements use packets with different DiffServ or MPLS settings to give round-trip delays for each traffic class. Both points automatically build baselines and send an alert when performance begins to degrade.

Fig 4- Using Embedded Intelligence for Troubleshooting. -When end-end measurements (top) indicate a potential problem, more detailed measurements are activated (bottom) to pinpoint the bottleneck.

When a real-time alert is received, troubleshooting tools gather information about the physical path between the two demarcation points. Intermediate advanced elements are activated to measure
delays through different segments of the infrastructure. These measurements isolate the particular leg that is beginning to congest and affect overall end-to-end performance. This process can be automatically initiated and tracked until it produces a finding that guides the management staff toward resolution.

Detailed information collected from intermediate measurements also provides a richer information source for capacity planning and optimization. Finer granularity allows administrators to adjust and fine-tune their planning and modeling tools for greater accuracy.

**Summary**

Managing the network infrastructure intelligently is essential in a demanding e-Business environment. Service providers, IT groups and their customers are all demanding a management solution that delivers. Embedded management intelligence focusing on managing the infrastructure itself is the next level for describing intelligent network infrastructures.

An intelligently managed infrastructure must also have the necessary intelligent management applications. Administrators need sophisticated tools that oversee the infrastructure management elements, automatically activate and track management processes, and leverage information for more effective management. An open interface encourages a wide variety of participants and brings more value to the infrastructure owner than closed proprietary solutions.