The Network Maturity Model for Internet Development

Network Maturity Model Development Team

The Internet has attracted more than 50 million users during the past four years, and there is every indication that its growth will continue at a similar rapid pace. As use of both enterprise networks and the Internet continues to grow, addressing the need for quality is an increasingly important issue. The 13 April 1998 AT&T frame relay network crash is a reminder of the dire consequences of a network failure. Business decisions that impose financial penalties for network failures further emphasize the need for quality in network engineering and operations.

QUALITY OF NETWORK

Efforts are under way in Internet 2 to offer runtime quality of service (QoS) for *user-level* performance features such as bandwidth, delay, and jitter, but little attention is being paid to *system-level* network quality. Quality of network (QoN) is the ability of an information technology (IT) system to meet user expectations by providing the intended functionality or desired information in a reliable, predictable, repeatable, and timely fashion.

Networks can use NMM to target areas for improvement.

At the heart of any IT system—and thus at the heart of the issue of quality—is the network infrastructure that comprises the IT system. Whether it is several computers in a room hooked up to a common server, a companywide intranet, or the Internet itself, QoN depends on the hardware, software, procedures, and human components comprising the entire network system.

Inattention to QoN could cause network failures to increase at a rate comparable to network growth. To ensure QoN, we need to develop standards that use network characteristics such as scalability, interoperability, security, and portability as design parameters. A quality design process provides network stability, modularity, connectivity, availability, and ease of maintenance.

Currently, the individual networks that make up the Internet use an ad hoc development approach that varies depending on the number of sub-Internet entities. Although some individual networks were built with a certain level of quality, the network of networks that comprise the Internet has evolved without an overall QoN concept. Even though an individual network has a high level of operational quality, if it was built in an unstructured fashion, it can have difficulty cooperating with other networks. For example, this incompatibility in system quality poses problems in trying to maintain even minimum end-to-end security requirements effectively and efficiently across a local or wide area network.

The Network Maturity Model reverses the ad hoc network development trend. NMM is a process for defining and implementing business decisions about allocating development resources, engineering decisions about network layout and performance, and management decisions about network operations. NMM introduces sound business and engineering practices from the disciplines of systems engineering and project and quality management to the design and operation of complex networks.

NETWORK ENGINEERING RESEARCH

Errors in development procedures are causing network outages more frequently now than in the past, and these outages have a greater impact because more people are using the Internet. These errors occur because we don't have a well-defined network engineering process. In their 1998 annual report, the Network Reliability and Steering Committee indicated that 32 percent of network failures and outages were due to procedural errors, and that trend is increasing at a rate of 3 percent a year.

The immense practical utility and impact of research and development on software and systems engineering, project management, and total quality management are the motivation for research in network engineering processes. The need to create a better design, maintain a high level of quality, and provide a path for growth is at least as essential for the Internet as it is in the software arena.

Editor: Ron Vetter, University of North Carolina at Wilmington, Department of Computer Science, 601 South College Rd., Wilmington, NC 28403; voice (910) 962-3667, fax (910) 962-7107; vetterr@uncwil.edu

Both software and networks are engineering products that

- evolve from input design requirements, which frequently change based on stakeholders' needs;
- require careful, cost-effective maintenance;
- compound in size and dimensions, with severe cost implications; and
- have a high impact because they are in widespread use.

Current status

The state of the art in network engineering is similar to the hackers' paradigm of software development. Computer networks were first developed and maintained by local gurus who understood the magic of token rings. Network operations success came through the Herculean efforts of individuals. Despite an exponential increase in the complexity of network requirements and demands (document sharing, enterprise resource planning, electronic commerce), this hero mentality still reigns. Designs are often determined on the back of an envelope, and the main focus of network operations is disaster management and recovery. Users' concerns about quality are still more centered on basic issues of network availability and speed rather than the actual content they are seeking.

Because of the strong similarities between software engineering and network engineering, we can apply the lessons learned from the software process model to develop a similar design process for quality-oriented research in the network arena. NMM is a feedback-based, iterative process designed to assess the enterprise management system, the network development process, and the network operations system against well-accepted and proven principles from systems engineering, project management, and quality control. In doing so, an organization can evaluate its network engineering practices and determine its process strengths and weaknesses as well as target areas for improvement.

Assessment process

In a typical assessment, NMM experts would perform on-site interviews to determine the state of practice in tasks such as configuration management, client management, and fault analysis and correction. Assessors would evaluate against "base practices" that describe what needs to be done to implement a specific quality process. For example, organizations need to define technology road maps that describe how their network will evolve over time and how it will incorporate technological advancements.

Written and oral reports would provide feedback for the assessed organization to use in generating specific improvement projects and to serve as input into the organization's annual strategic plan. The overall system would be characterized according to one of five possible (sequential) NMM levels: basic practices, managed processes, defined processes, measured processes, and continuously improving processes.

WHERE ARE WE HEADED?

We have structured the NMM into three high-level components: enterprise management, network engineering, and network operations. Enterprise management encompasses managerial leadership, stakeholder focus, human resources development, technological leadership, and supplier management. Network engineering includes requirements analysis, design, implementation, verification, and validation. Network operations issues include maintenance, client management, performance management, configuration control, scalability, and security. These areas are further defined by features and practices.

We are currently validating the completeness and accuracy of our identified practices, using both benchmarking and expert panels to derive a final, usable set of criteria. The benchmarks target a broad spectrum of businesses that

- perform network engineering development,
- operate data information networks,
- provide network services and business modeling, or
- are heavily dependent on or significantly impacted by information networks.

Having higher quality networks will have a positive impact on user satisfaction by improving overall Internet quality and reliability. The Network Maturity Model will ensure that processes supporting the development of quality networks are defined, established, and continuously improved. Our Web site (http://nmm.eas.asu.edu) provides further information about NMM research. ❖

The Network Maturity Model Development Team includes S. Bhattacharya, J.M. Capone, K. Dooley, S. Palangala, and H-S. Yang, Arizona State University, and W. Baumann and J. Fritsch, Motorola Inc. Contact the authors at {sourav, jcapone, kevin.dooley, srihari}@asu.edu, yangkoon@asu.edu or {William_Baumann-P12002, Jim_Fritsch-AJF002}@email.mot.com.

National Science Foundation Exploratory Workshop

The National Science Foundation is sponsoring an exploratory workshop to investigate quality and process research issues in the engineering and operations of complex information network systems. The workshop will identify possible research topics such as underlying network technology, network system engineering, and quality in network operations.

Open participation in the workshop is encouraged. Participants representing the following interests are invited: clients of enterprise networks and network services, producers of networks or network elements, network service providers, network researchers, and potential government funding agencies.

Tentative dates for the workshop are 25-26 February 2000. The workshop is hosted and cosponsored by the Telecommunications Research Center of Arizona State University, Tempe, Ariz. Limited workshop support is available. Contact Sourav Bhattacharya, Jeffrey Capone, or Kevin Dooley at {sourav, jcapone, kevin.dooley}@asu. edu for further information.