1. Introduction

The Federal agencies of the Large Scale Networking Coordinating Group (LSN CG) held a March 12-14 **Workshop on New Visions for Large-Scale Networks: Research and Applications** to stimulate bold thinking and to explore new directions that could revolutionize networks and applications. The objectives of the workshop were to develop a vision of the networking needed to support societal transformations over the next 10 to 20 years, discuss networking capabilities needed to enable those visions, and identify networking research needs to provide those networking capabilities. Participants with expertise and interest in large-scale and advanced networking research from the academic, commercial, research laboratory, and Federal networking communities were invited. They provided their recommendations on networking capabilities and research needed to achieve their vision for networking and applications. This serves as guidance to the LSN agencies in developing their Federal agency IT R&D networking research programs for FY 2002-2006 and beyond.

1.1 Background

Under the Federal IT R&D Program, the LSN CG coordinates large-scale networking research programs among the six LSN agencies: DARPA, NSF, DOE, NIH, NASA, and NIST. In FY 2001 the LSN CG initiated a new phase of planning and coordination for agency advanced networking research programs. These research programs address LSN agency networking mission requirements and provide networking technologies for the future growth of the Internet. They also respond to the recommendations of the President's Information Technology Advisory Committee (PITAC) and other private sector inputs.

The PITAC was established February 1997 to provide expert independent guidance to the Federal government on maintaining America's preeminence in high performance computing and communications, information technology, and the Next Generation Internet. In its influential February 1999 report, "Information Technology Research: Investing in Our Future," the PITAC called for a visionary expansion of the Federal investment in information technology R&D. The Committee cited the need for fundamental research in networking to support societal transformations such as providing scaling, reliability, and growth so that at least one billion people can simultaneously access the Internet.

1.2 Workshop Scope and Purpose

In its FY2001 planning and coordinating of advanced networking research programs the LSN CG wanted to take advantage of the existing networking knowledge and expertise available from researchers in universities, industry, and government. The LSN CG decided to hold the Workshop on New Visions for Large Scale Networking: Research and Applications to enable leading researchers to provide input into the LSN planning activity on needed advanced networking research. The LSN CG issued an announcement of the workshop and a call for white papers (Appendix 1). In the white papers, researchers, applications developers, and network users applied their vision and creativity to help define broad research needs for networking and distributed applications. The white papers formed

the basis for presentations and panel discussions at the workshop. Most of these white papers are available on the Web at: http://www.ngi-supernet.org/conferences.html.

The workshop participants were asked to envision network technology possibilities that could revolutionize the way we live and work in the decades ahead, but that are beyond the scope of today's commercial, profit-driven R&D programs, and to identify network research needs to help realize those possibilities. Emphasis was placed on identifying exciting new areas of research that are radically forward-looking and that hold the potential to yield unexpected results. The workshop asked the participants to identify critical research barriers and the limitations of existing approaches. They were encouraged to bridge the gap between the broad-scale vision and the specific technologies, however difficult to achieve, needed to realize the vision.

1.3 Workshop Format

The LSN workshop was held over a three-day period from March 12 to 14, 2001. On the first day, three panel sessions provided discussion of the white papers in the areas of:

- **Adaptive networking**: Network-aware distributed applications, proactive self-tuning systems for ubiquitous computing, and custom channel building for large-scale network systems
- **Infrastructureless networking**: Ad-hoc disposable networks; dynamically forming, self-organizing hierarchy; and precision geo-location and ultra-wideband radios to support sensornets
- **Heterogeneous networking**: Heterogeneity of future network services; hierarchical addressing to simplify switching; and improving TCP/IP with features developed for User-Level Network Interfaces (ULNI)

The first day also included 10-minute talks on papers submitted by selected participants and the presentation of the six scenarios described below.

On the second day of the workshop, six breakout sessions were each tasked to consider one networking scenario in depth to identify the networking elements of that scenario and the networking research and applications needs to enable that scenario. The breakout sessions reported on their results on the third day.