# STATEMENT OF WORK

## 1.0 INTRODUCTION

The Naval Research Laboratory (NRL) investigates and provides services in the areas of information technology architecture, high-performance computing (HPC), high-performance networking and related digital streams technology. These areas include design, development and functional-deployment of information processing systems, decision support systems, database structure and mining, library services, applications of parallel and distributed computing, high-performance computing, hardware acceleration technology, high-performance networking and the design of software to efficiently use such systems. The information technology architecture includes the communications and networking research required to provide fast, reliable, robust, authenticated, assured and secure transfer of data among various parts of the overall system, incorporating assets ranging from massively parallel computing systems to Naval and Department of Defense (DoD) assets deployed in hostile military environments. Human interface capabilities ranging from voice and video to the development of interactive virtual environments are an integral part of the work. Information processing research includes traditional signal analysis and other high-performance computing applications. Information assurance and security, real-time processing, simulation and modeling, emulation, multilevel secure database structures, progressive motion imagery, and compression and decompression are also integral parts of the research thrusts. The design and development of information technology capabilities extends to practical implementation of NRL labwide services in email, web, directory services, network management, network protection, HPC user services and Library research services.

## 2.0 SCOPE

The contractor shall provide Research and Development support for a wide range of NRL research and information technology service activities. Contractor personnel will supplement the NRL staff in executing a wide variety of programs that address Navy priorities. The vast majority of the contractor's personnel will work on site at NRL Washington DC, as success will often require ongoing technical collaboration with NRL engineers and access to the specialized research equipment and facilities. The Government anticipates award of two (2) Level of Effort contracts. One contract will allow for the performance of

classified work with each task capable of being performed at a level up to and including TOP SECRET/SCI, and the other contract will be at the UNCLASSIFIED level only. Both contracts will have the same Statement of Work. Both contracts will be awarded to the same contractor. To the greatest extent possible, the contractor will be provided advance notice of task areas that require higher clearance levels and the anticipated personnel requirements for these tasks. The following task areas and descriptions indicate the specific nature of these research efforts and information technology service provisions.

## 3.0 TASKS

### 3.0.1 Resource Management Support

The contractor shall provide technical and administrative support in maintaining programmatic material, communicating with program participants, preparing technical briefings, development of work plans, annotation and promulgation of action items resulting from meetings, and general programmatic support of a technical nature. The contractor shall track and document all project and program actions and the documentation to all program participants. The contractor shall develop technical reports, briefing materials, resource tracking, and any other necessary program information. The contractor shall ensure reporting requirements are adhered to and deliverables are timely delivered to the Government. The contractor shall procure necessary hardware and support items. The contractor shall obtain prior approval for travel and travel related costs. The Contractor shall provide administrative support for the planning, negotiation, and implementation of meetings/conferences/seminars for the dissemination of scientific materials and research information. Meetings will be held in various cities and military installations within the United States. Contractor efforts shall include all facets of planning and execution of the meetings including, but is not limited to, event planning; securing meeting venues and billeting facilities; acquiring required equipment; meeting management; execution of agenda; and event management.

### 3.0.2 Program Management

The contractor shall perform as liaison with the NRL Contracting Officer's Representative (COR) and perform the following functions in support of all contract tasks: Provide task leader support along identified functional areas and coordination of task leader technical activities. Assign personnel to meet specific task requirements in the areas of staff knowledge, experience, and demonstrated

performance. Provide continual refinement of schedule, resource requirements, approach methodology, and identification and resolution of problems areas. Produce and deliver a monthly comprehensive contract status report. Contractor shall establish budgets and monitor the financial status of the individual Statement of Work tasks and the total program. Perform as liaison to subcontractors for technical tasking, technical and financial performance monitoring and compliance review of deliverable items. Deliver concise but accurate weekly e-mail summaries from participants outlining contributions made to the task, progress during that week and goals for the coming week. Final summary report will be delivered to NRL at the end of this effort to document the cumulative task effort.

In the execution of technical and engineering programs for the research and development efforts under this contract only, the contractor shall provide technical and engineering support in maintaining programmatic material, communicating with program participants, preparing technical briefings, conducting technical conferences, symposia, workshops and other meetings, development of work testing, annotation and promulgation of action items resulting from meetings and general programmatic support of technical nature. The contractor shall track and document all project and program actions and provide to all program participants. The contractor shall provide support to all program participants. The contractor shall provide support in the development of technical reports, briefing materials, resource tracking and all other programmatic information required.

3.1.1 Research in the Management, Use and Application of High-Performance Networks, including the Development of Next-Generation Network Protocols

The contractor shall perform research and development in the area of algorithms and tools for the management of emerging high-performance networks. The research will evolve new techniques for information flow and control that will eventually lead to standards against which hardware and software will be developed, with emphasis on native stream communications channels.

Such channels include, but are not limited to, Ethernet (and all its variations), Asynchronous Transfer Mode (ATM), Synchronous Optical Networking (SONET), G.709, Packet-over-SONET (POS), Fibre Channel, InfiniBand, and wireless (802.11 and all its variations). Resultant protocols will also be integrated over transparent all-optical core network fabrics. The contractor shall investigate the routing services, addressing, network management and signaling issues, but with particular attention to reliable, low-latency and assured communication at multi-gigabit speeds. The contractor shall develop mathematical models for network performance and test suites that are appropriate for various modes of operation.

The contractor shall test these models on the NRL experimental network test bed that consists of legacy devices, slower speed 10/100/1000 Ethernet devices, ATM network fabrics ranging from Optical Carrier (OC) 3c to OC192c link speeds, and InfiniBand data links from 4x/12x Single Data Rate (SDR) and Double Data Rate (DDR) I as well as transparent multi-gigabit-per-second all-optical wavelength division networked core devices. The contractor shall ensure that the information flow is consistent with Storage Area Networks (SANs) and file servers that include Network File System (NFS), Zettabyte File System (ZFS) , Andrew File Systems (AFS), Hierarchical Storage Management (HSM) and high-performance extensions to AFS, Lustre and Clustered Distributed File System (CXFS). Common means of authentication will be utilized on networked, heterogeneous systems developed utilizing distributed key services based on Kerberos (v5), DoD Public Key Infrastructure (PKI), and the DoD Common Access Card (CAC). Network control plane research will be conducted using protocols such as the Internet Engineering Task Force's (IETF) Session Initiation Protocol (SIP). The contractor shall explore solutions for monitoring/auditing performance, scaling capability, end-to-end quality-of-service and robustness in the research environment, and subject the best developed models to rigorously test unpredictable, high traffic loads (both real and simulated) as the necessary step for evolving effective, lowest latency protocols. Successful results will be transitioned to more operational NRL components as well as other Navy and DoD systems. Protocol development under this task has SIP as a core element. Work includes SIP signaling mechanisms for IPv4 and IPv6; Voice-over-IP (VoIP) in the 3GPP/3GPP2 (3rd Generation Partnership Program) environment; deployment of SIP as an E2E control plane for deterministic packet control; Quality of Service (QoS), Quality of Protection (QoP) and Multi Level Precedence and Preemption (MLPP) over optical, copper and wireless network links. Another important area for SIP development and integration is imagery and desktop videoconferencing capabilities; this task will support development of concepts for scaling of these activities to higher bandwidth, including assigning wavelengths dynamically and/or choosing wireless paths dependent on the end user's activities.

3.1.2: Extend the Development of High-Performance End-to End (E2E) Input/Output (I/O) technology for High-Performance Computing (HPC), Server Computing and Storage and Imagery Systems

The contractor shall participate on the development teams extending OpenFabrics Alliance InfiniBand technology to OC- 768c POS (Packet-over-SONET), Gigabit Ethernet (GigE) or ATM and beyond by extending InfiniBand

12x SDR (Single Data Rate), DDR (Double Data Rate) and QDR (Quadruple Data Rate) technologies. Initial research efforts will focus on single-stream data rates in the 10's of gigabits per second (Gbps) range. Near-term efforts will move towards 100's of Gbps. Before the end of this task we expect to achieve single-stream data rates that exceed 1 terabyte per second (Tbps). Included in this task is development of Remote *Direct* Memory Access (RDMA) Sockets Direct Protocol (SDP) and Internet Small Computer System Interface (iSCSI) protocols deploying the available OpenFabrics stack; VHDL (Very High Speed Integrated Circuit) Hardware Descriptive Language) Xilinx Virtex Pro Field Programmable Gate Array (FPGA) development of firmware to augment/expedite software RDMA, Internet Protocol (IP) version 6 default support, deployment of an overarching common file system (i.e., either Lustre or CXFS) and demonstrating levels of achievement thru planned nationwide access activities such as Super Computing (SC2007/2008 and subsequent years), or Optical Fiber Conference (OFC-07/08 and subsequent years) professional tradeshows. Other activities in this area include development of equivalent SMPTE (Society of Motion Picture and Television Engineers) streams for extension of these concepts to moving of progressive motion imagery, and for development and test of new flow routing technologies.

3.1.3 Hardware and Software System Design and Maintenance, including data and file storage systems

The contractor shall maintain and participate in the evolutionary development at NRL of a variety of heterogeneous, highly distributed networked systems for the development of technical programs. These systems consist of GigE, ATM, InfiniBand, Fibre Channel, POS streams and optical networks with high-end workstations, servers and parallel processing systems. These networked systems are often clustered within a workgroup as a number of workstations running off a server with a storage farm. The contractor shall implement scalable state-of-the-art capabilities; design, reconfigure and maintain distributed systems; update older configurations and generally maintain systems at current or recent versions of the operating systems and file management systems. The overall systems include:

o GigE, SONET, Protocol G.709, POS, ATM, Fibre Channel and InifiniBand

o Multi-Protocol Layer Switching (MPLS), Internet Protocol version 4 (IPv4), IPv6 and multicast

o DWDM (Dense Wave Division Multiplex and "all-optical" ((OOO) All Optical-to-Optical-to-Optical) networks, GMPLS (Generalized Multi-Protocol Label

Switching)

o SMPTE 292M networked imagery

o Ethernet: 10/100/1000 Ethernet and 10GigE Local Area Network (LAN)/Wide Area Network (WAN)

o Remote access systems: modems, virtual private network (VPN), etc.

o NFS, AFS, ZFS, Lustre and CXFS distributed file systems

o Kerberos (v5), DoD Public Key Infrastructure (PKI), Common Access Card (CAC) and SIP (Session Initiated Protocol) distributed authentication services

o Solaris, MacOS X, Windows, Linux (SuSe, Red Hat, Fedora Core), Irix OS's, Other OS's

o Massively Parallel Processing (MPP) Systems and Servers: SGI, Sun, Cray, Intel, AMD, etc.

o Quantum Digital archives

The contractor shall design, configure, reconfigure, update and maintain individually networked groups (either by personnel, function or technology), maintain currency in operating systems versions (while matching project needs) and adapt to the full range of available local and wide area networks. The contractor shall ensure that all information is backed up at defined intervals and that future needs are planned for and reported as needed. The contractor shall develop and maintain complete site documentation for the configuration of the systems and provide on-line documentation for start-up and shutdown of all systems. The contractor shall develop growth plans based on current usage so that future system and software needs can be identified. The contractor will support development of HPC file systems including AFS, Lustre, and CXFS. The primary development focus at NRL is Open Lustre. Development efforts will focus on federated, distributed file systems; file system performance; RDMA protocol enhancements over generic transmission control protocol (TCP); real-time hardware cache coherency; System Administration of a distributed, Peer-to-Peer (P2P); and the general evolution and use of leading edge file systems.

3.1.4 Support for Development of Information Assurance tools and performance monitoring techniques

Using both IPv4 and native IPv6, the contractor shall develop new tools for performance assessment; control plane monitoring; network use; Service Level Agreement (SLA)validation in local and wide area networks; and, End-to-End Quality-of-Service/Quality-of-Protection (E2E QoS/QoP). This task will support NRL's role in developing native tools based on Argus (and Argus-like packages) in both software and FGPA firmware for monitoring flows to 40 Gbps today, with a need to scale to 100 Gbps in the near-term and 1 Tbps or higher by the end of this task. This task includes the development of concepts for deployment of high-speed encryption for 40-Gbps and higher that is intended to scale to terabit flows. This task will support NRL's role in pioneering new flow constructs in high performance networking.

3.1.5 Large Data Federated, Distributed Infrastructure Technology and Global Information Grid Demonstrations

The contractor shall support NRL's Advanced Concept/Joint Capabilities Technology Demonstration projects (ACTD/JCTD) including planned spirals of demonstrations of leading edge technology for the war-fighter. This will include new and continued work with NRL and its government partners: NGA (National Geospatial-Intelligence Agency), STRATCOM (United States Strategic Command), INSCOM (Army Intelligence and Security Command), DISA (Defense Information Systems Agency), DIA (Defense Intelligence Agency) and others to deploy a wide area federated, distributed storage network as the backbone of these activities. Design end-systems with NRL and equipment developers and vendors to accomplish ACTD/JCTD goals. This activity includes supporting installation and upkeep of optical networking within the Global Information Grid Evaluation Facility (GIG-EF) and, working with NRL, Defense Research and Engineering Network (DREN), National Lambda Rail (NLR), Internet2, DISN-Core (Defense Information System Network) and similar organizations; development of technology for distributed large archival sites (multi-petabyte and higher); visualization of situational awareness from multi-INT (Intelligence) data; and other activities to accomplish time-phased demonstrations of ACTD/JCTD technologies. The Contractor shall provide engineering support for experimentation and testing in laboratory and field environments. This includes hardware and software support, planning and logistics for large field demonstrations, operators for mobile communications equipment, and data analysis. Full knowledge of network protocols including IPv4, IPv6, Ethernet, ATM, InfiniBand and MPLS is essential.

3.1.6 Other Engineering Support

The contractor shall provide specialized engineering talent to augment NRL personnel in meeting other Navy RDT&E requirements that do not fall within the above task areas. As examples of such support, personnel with specialized qualifications and background may be required in order for NRL to provide support to the National Reconnaissance Office (NRO), National Security Agency (NSA), Office of Naval Intelligence (ONI) and other external organizations. Skills such as technical writing and presentation development may be crucial to providing the requisite technical support on this task. Such support may involve hardware and capability analysis, program planning and test resource planning/development. Travel and special clearances may be required. Work may be performed alone or in conjunction with NRL staff. Sponsor personnel may be involved, along with personnel from other Navy/DoD components, other U.S. Government personnel, other government contractors, and foreign government contractors.

3.2.1 Development and Support of the NRL Operational Networks

The contractor shall provide support to maintain, repair, and optimize a broadband, baseband, and fiber optic Local Area Network (LAN) in accordance with industry standards using the appropriate equipment including, but not limited to, signal generators, spectrum analyzers, signal analysis meters, time/domain reflectometers (TDRs), optical TDRs (OTDRs) and various cable scanners. Troubleshoot and resolve network hardware related problems. Install coaxial (broadband and baseband) and fiber optic cables using diagrams containing RF component symbols for correct installation of cable as part of the LAN at NRL and at sites belonging to NRL. Maintain a broadband cable television (CATV) plant, which includes tuning the video broadband segments, and the repair of Radio frequency (RF) components such as broadband amplifiers. Prepare reports and documentation on the LAN systems for use by network personnel and customers including feasibility studies for changes in the network environment due to growth or evolution of requirements. The contractor shall provide support in the design, development and maintenance of the NRL's labwide operational network components. This includes UNIX system administration (Solaris and various Linux platforms), system software development, installation and troubleshooting. The contractor shall install and maintain IPv4 and IPv6 network protocol suites on a variety of platforms including network backbone devices and workstations; Help and coordinate with NRL customers in the software installation of nodes. The contractor shall provide configuration, software implementation recommendations, general and complex troubleshooting and resolution of network problems. This includes network devices, host based hardware and software issues, Wide Area Network (WAN)

connectivity and remote access services. Networking technologies include Ethernet, GigE, Wireless and ATM. The contractor shall research, deploy, configure and manage networking services, including domain name service (DNS), remote access, web services and e-mail. Requirements include: Support of Apache and CAC access services integration. Remote access services using radius and OpenLDAP (Lightweight Directory Access Protocol) servers for authorization/authentication. Provide support in Sendmail, MIMEDefang, Spamassasin, Trend Micro and ClamAV *in* a Solaris environment; IPv6 configuration for all services, including BIND, Apache, Sendmail, ssh, tcpd. Deployment and configuration of Real Server for UNIX and Real Producer for windows, for on demand live video feeds. Maintain MS-SQL, Intrusion Detection System (IDS) and Intrusion Protection System (IPS) services. Research, test and evaluate new communications software and tools. Have demonstrated ability to develop networking software for the Unix platform in Perl, C, C++ and other languages as required. The contractor shall provide monthly status reports to document work performed. Out-of-hours work will be required.

3.2.2 Design, Development and Support of Information Security Capabilities

The contractor shall provide support in the design and development of a variety of information security capabilities. The contractor shall perform analysis and deployment of security vulnerability assessment tools. The contractor shall perform tracking of security advisories and develop software for security assessments on a wide range of platforms. The contractor shall perform vulnerability scans on NRL systems and work with system administrators to resolve a variety of security issues.

3.3 Research in the Organization, Management and Application of High-Performance Computing Systems, Massively Parallel Processors and Progressive Motion Imagery

The contractor shall perform research in the development of reliable, heterogeneous, high-performance computing environments including desktop workstations, massively parallel computers, high-performance networked infrastructure (SONET, G.709, Packet-over-SONET (POS), ATM, Ethernet (including 10-GigE and higher), InfiniBand, SMPTE, CWDM, Dense Wave Division Multiplexing (DWDM) and all-optical (OOO); a variety of storage media: cache, primary, secondary, tertiary and archival; and uncompressed/compressed progressive motion imagery systems: HD0 (High Definition) for 480/60p and HD1 for 720/60p form as baseline systems linked in uncompressed mode or compressed (MPEG2, MPEG4, etc.). Advances in HD coding (such as 4:4:4),

compression (such as layered and multi-resolution algorithms) and format (such as 1080p/24) will be investigated as this technology matures. The contractor shall investigate optimal data flow among the various components of the experimental facility. Since many of the components are emerging systems of research grade, the contractor shall develop new algorithms for linking the systems and test those algorithms on the existing facilities. In many cases, the commercial standard devices will have to be interfaced with emerging systems that do not support such devices. In such cases, the contractor shall develop solutions that provide reliable flow of data between all types of devices that can be used in background mode. The research may be either engineering or algorithmic in nature, but in combination must result in an integration of systems that would otherwise not operate consistently with each other. The contractor shall also serve as an interface with the NRL and the DoD communities as needed to introduce users to new capabilities that result from the research.

3.4.1 Research and Development in Parallel-Processing Applications and Support of High-Performance Computing Infrastructure

The contractor shall develop new techniques for exploring parallel decomposition of scientific and engineering models in such areas as acoustics, signal processing, weather prediction, ocean circulation, fluid dynamics, electromagnetics, image understanding and simulations. The contractor shall develop solution methods that account for optimal or near-optimal data flow, memory access and scalable distribution of processing. The contractor shall test resulting solutions using NRL's distributed high-performance computing facility. The contractor shall support and assist other HPC users in porting and running their scientific programs and code on NRL and other DoD High Performance Computing Modernization Program (HPCMP) resources available to NRL. The facility is continually being upgraded and currently includes a variety of distributed MPP computational platforms (SGI: SGI/IA-64 SuSe Linux cc:NUMA , and Sun: Solaris, Cray: XD1 Dual-core AMD Opteron, with Xilinx Field Programmable Gate Arrays (FPGA)). Storage includes Fiber Channel SAN and InfiniBand technology with Lustre and/or CXFS, and large associated archival systems. High-performance experimental InfiniBand links systems, GigE and ATM network authenticated end-to-end with Kerberos (v5), DoD PKI/CAC and support the IETF SIP control plane. SMPTE-encoded imagery streams are also carried across the infrastructure. The HPC infrastructure at NRL includes archival storage with data and databases used by the NRL Library, HPC users and Labwide Services.

3.4.2 High Performance Computing (HPC) Archive and Emergency Recovery

The contractor shall provide support for the operation, management and maintenance of the archival storage and database systems at NRL that supports the HPC infrastructure and includes data and databases used by the NRL Library, HPC users and Labwide Services. An additional component of the HPC infrastructure includes a COOP (Continuity of Operations Plan) system for the DoD High Performance Computing Modernization Program's database application: "The Portal to the Information Environment".

3.5 Development and Support of Web-Based Applications

The contractor shall develop and maintain web related documents and applications. Projects can potentially support any NRL function and will range from simple web pages to labwide web-accessible e-mail systems to more complicated application programs utilizing backend databases. Web service integration requires application of LDAP, DoD PKI/CAC authentication and access techniques, and Kerberos. Development of web services will require the development and integration of individual applications in coherent web architecture, using open source programming tools and open source server platforms. This effort requires that the contractor have the ability to interact and communicate with individuals (managers, customers, users, team members and support staff) that have a broad range of technical expertise. For each project, the contractor shall ascertain requirements, develop an implementation plan (including a break down of required resources and timelines), provide weekly status updates through email during execution, and upon completion produce documentation that details any code, maintenance procedures or usage requirements.

3.6 Support of Library Services

The contractor shall provide research and support in the design, development and implementation of a variety of information technology solutions to support NRL library digital services. Support includes the analysis, development, testing and documentation of customized data formats and profiles for use with internally developed web and COTS applications and systems. The contractor shall perform integration and normalization of multiple licensed scientific data sources with COTS software to allow data migration between multiple applications. This effort will require the contractor to support WINDOWS and UNIX system administration (Solaris and Linux platforms), installation and troubleshooting of database and search engine technologies, support of Integrated Library Systems (ILS), Local Area Network (LAN)/Wide Area Network (WAN) services, NFS and

CXFS file systems, authentication and authorization services and remote user access services.

4.0 Deliverables

The primary deliverable under this contract is the technical support for NRL's research, development and test programs and operational services. All work must be performed in a manner that is consistent with good engineering practice and commercial standards. The contractor is expected to reasonably document research efforts as the work is being performed. Documentation shall be produced in a manner that is consistent with commercial practices, NRL's funding and the project schedule. In some cases a research program may require a manual, presentation or report and the contractor may be requested to provide supporting information to enable the NRL staff to generate this end product. The Contractor shall prepare and submit periodic reports on the management, control, and reporting functions in accordance with Enclosure (1), DD 1423. The Monthly Status Report (MSR) shall provide a brief narrative status of the technical process and status of each major task effort, any significant technical or project specific problems, and the proposed resolution of the identified problem areas. The MSR shall identify any items that have affected or will affect schedule performance, cost, or task schedules. The reports shall be in the Contractor's format once approved by the COR. Submission in electronic formats compatible with MS Office are acceptable. The contractor shall submit Monthly Financial Status Reports (MFSR) in accordance with Enclosure (1) and shall contain a detailed financial report. The monthly cost shall be broken down by task. The MFSR shall show the number of hours for each employee and/or sub Contractor with loaded labor costs. Details for the current period and total accrued cost shall be given. Expenses (e.g., travel, materials, and training) shall be reported separately for each employee and/or sub Contractor. If an employee 'and/or 'sub Contractor worked on more than one task (as defined by the COR), then the accounting for each task shall be shown separately. The MFSR shall include a listing of all materials, services, and supplies procured by the Contractor, along with a physical description and actual price. The report shall be in the Contractor's format as approved by the COR. Submission in electronic formats compatible with MS-Office is acceptable. Hard copy and electronic submission are both required.