

# Foundations of Computing Processes and Artifacts (CPA)

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## Program Solicitation

NSF 07-587

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*Replaces Document(s):*

NSF 06-585

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### National Science Foundation

Directorate for Computer & Information Science & Engineering  
Division of Computing and Communication Foundations

**Full Proposal Deadline(s)** (due by 5 p.m. proposer's local time):

December 07, 2007

## REVISION NOTES

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In furtherance of the President's Management Agenda, NSF has identified programs that will offer proposers the option to utilize Grants.gov to prepare and submit proposals, or will require that proposers utilize Grants.gov to prepare and submit proposals. Grants.gov provides a single Government-wide portal for finding and applying for Federal grants online.

In response to this program solicitation, proposers may opt to submit proposals via [Grants.gov](#) or via the [NSF FastLane](#) system. In determining which method to utilize in the electronic preparation and submission of the proposal, please note the following:

**Collaborative Proposals.** All collaborative proposals submitted as separate submissions from multiple organizations must be submitted via the [NSF FastLane](#) system. Chapter II, Section D.3 of the Grant Proposal Guide provides additional information on collaborative proposals.

## SUMMARY OF PROGRAM REQUIREMENTS

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### General Information

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**Program Title:**

Foundations of Computing Processes and Artifacts (CPA)

**Synopsis of Program:**

The Foundations of Computing Processes and Artifacts (CPA) cluster supports basic research and education projects to advance discovery, learning, and application of scientific and engineering knowledge pertaining to the processes and artifacts for building computing systems.

Computing processes and artifacts range from formalisms, methods, models, algorithms and theories to

languages, architectures, technology components, and a variety of physical manifestations of computing system software and hardware. Proposals submitted in response to this solicitation should describe transformative research to advance at a fundamental level the design, verification, evaluation, utilization, and understanding of computing systems to meet the future computational needs of our society.

Research areas of interest for the CPA cluster include the following: topics concerning the foundations of software and software engineering including analysis and testing of software, components and composition, formal methods, verification and synthesis, and programming language semantics, design, and implementation; software/hardware systems and techniques for reliable and high performance computing including parallel compilers, programming models, and run-time support for resource allocation and scheduling; computer system architecture spanning memory and I/O subsystems, interconnection networks, on-chip networks, processor microarchitecture, reconfigurable and application-specific architectures; multicore, multithreaded, and systems-on-a-chip; hardware and software tools for design, simulation, benchmarking, performance measurement and tuning, including performance metrics and evaluation tools; VLSI electronic design and pertinent analysis, synthesis and simulation algorithms; architecture and design for mixed media or future media (e.g., MEMs and nanotechnology); computer graphics and visualization topics such as photorealistic and non-photorealistic rendering of geometry, lighting and materials, mathematical modeling, physically-based graphics, scientific and information visualization, graphics and display hardware, computational photography, and mixed reality.

There are three categories of proposals described in this solicitation:

- Single Investigator or Small Group projects
- Team projects
- Major Team projects

#### **Cognizant Program Officer(s):**

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#### **Applicable Catalog of Federal Domestic Assistance (CFDA) Number(s):**

- 47.070 --- Computer and Information Science and Engineering

#### **Award Information**

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**Anticipated Type of Award:** Standard Grant or Continuing Grant

**Estimated Number of Awards:** 80 to 100 , subject to availability of funds. Approximately 5 to 7 of these awards will be for Team projects, and up to two will be for Major Team projects.

**Anticipated Funding Amount:** \$40,000,000 subject to the availability of funds

## Eligibility Information

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### Organization Limit:

Proposals may only be submitted by the following:

- Academic Institutions located in the U.S.: U.S. universities and colleges located in the U.S.

### PI Limit:

None Specified

### Limit on Number of Proposals per Organization:

None Specified

### Limit on Number of Proposals per PI: 2

An investigator may participate as a PI, co-PI or Senior Personnel on at most two proposals but may participate in no more than one Single Investigator or Small Group proposal. In other words, if an investigator participates in two proposals, at least one of them must be a Team or a Major Team proposal. If an investigator fails to comply with these constraints, all proposals in which the investigator participates will be returned without review. It is therefore strongly advised that all investigators in multi-investigator proposals submitted in response to this solicitation check with their co-investigators to ensure that all are in compliance.

## Proposal Preparation and Submission Instructions

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### A. Proposal Preparation Instructions

- **Letters of Intent:** Not Applicable
- **Full Proposals:**
  - Full Proposals submitted via FastLane: Grant Proposal Guide (GPG) Guidelines apply. The complete text of the GPG is available electronically on the NSF website at: [http://www.nsf.gov/publications/pub\\_summ.jsp?ods\\_key=gpg](http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg).
  - Full Proposals submitted via Grants.gov: NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov Guidelines apply (Note: The NSF Grants.gov Application Guide is available on the Grants.gov website and on the NSF website at: <http://www.nsf.gov/bfa/dias/policy/docs/grantsgovguide.pdf/>)

### B. Budgetary Information

- **Cost Sharing Requirements:** Cost Sharing is not required by NSF.
- **Indirect Cost (F&A) Limitations:** Not Applicable

- **Other Budgetary Limitations:** Not Applicable

## C. Due Dates

- **Full Proposal Deadline(s)** (due by 5 p.m. proposer's local time):

December 07, 2007

## Proposal Review Information Criteria

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**Merit Review Criteria:** National Science Board approved criteria apply.

## Award Administration Information

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**Award Conditions:** Standard NSF award conditions apply

**Reporting Requirements:** Standard NSF reporting requirements apply

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## I. INTRODUCTION

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The Foundations of Computing Processes and Artifacts (CPA) cluster supports basic research and education projects to advance discovery, learning, and application of scientific and engineering knowledge pertaining to the processes and artifacts for building computing systems.

Computing processes and artifacts range from formalisms, methods, models, algorithms, and theories to languages, architectures, technology components, and a variety of physical manifestations of computing system software and hardware. Proposals submitted in response to this solicitation should describe transformative research to advance at a fundamental level the design, verification, evaluation, utilization, and understanding of computing systems to meet the future computational needs of our society. Proposals may also address the development of innovative curricula or educational materials to help advance the training of new experts in the areas covered by this solicitation.

The CPA cluster promotes integrated research in advanced computation, compilers, computer system architecture, design automation for micro and nano systems, graphics and visualization, and software engineering and languages. Research topics of interest to the CPA cluster include the following: topics concerning the foundations of software and software engineering including analysis and testing of software, components and composition, formal methods, verification and synthesis, and programming language semantics, design, and implementation; software/hardware systems and techniques for reliable and high performance computing including parallel compilers, programming models, and run-time support for resource allocation and scheduling; computer system architecture spanning memory and I/O subsystems, interconnection networks, on-chip networks, processor microarchitecture, reconfigurable and application-specific architectures; multicore, multithreaded, and systems-on-a-chip; hardware and software tools for design, simulation, benchmarking, performance measurement and tuning including performance metrics and evaluation tools; VLSI electronic design and pertinent analysis, synthesis and simulation algorithms; architecture and design for mixed media or future media (e.g., MEMs and nanotechnology); computer graphics and visualization topics such as photorealistic and non-photorealistic rendering of geometry, lighting and materials, mathematical modeling, physically-based graphics, scientific and information visualization, graphics and display hardware, computational photography, and mixed reality.

The CPA cluster promotes and strongly encourages research that transcends the artificial confines of the topics described herein.

## II. PROGRAM DESCRIPTION

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Virtually all fields of science and engineering (and society at large) depend on fundamental advances in computing. Progress toward achieving robust, reliable computing in traditional and non-traditional system environments is enabled by breakthroughs in electronic design and design tools, architectures and hardware for a broad spectrum of computer systems, and algorithms and software for utilizing them effectively. Such breakthroughs are causing a sea change in computing from systems primarily based on sequential uncore processors to systems ubiquitously based on parallel multicore processors. This paradigm shift significantly impacts the way in which cyber-enabled systems of all kinds are designed, programmed, and used.

Foundational research on architectures and software that exploit parallelism in a scalable manner, hybrid architectures and software tools that map/integrate abstractions and algorithms onto reconfigurable hardware, systems-on-a-chip architectures that encompass multiple or many cores, and domain-specific programming languages that efficiently express parallelism are all challenges to be undertaken. There is a compelling need to stimulate research in promising new design automation methods and tools, parallel architectures, parallel programming models, parallelizing compilers, languages, and associated algorithms and system software to substantially improve computation platforms along several critical axes including performance, energy/power efficiency, reliability, security, programmability, and reduced design complexity. Graphics and visualization research is also needed to develop novel algorithms and tools to better enable photorealistic and non-photorealistic rendering, physics-based modeling and simulation, new display technologies, and visual techniques for extracting knowledge from large, complex data sets.

The CPA cluster solicits proposals that advance at a fundamental level the understanding, design, verification, operation, utilization, and evaluation of computer systems. These typically involve novel software and/or hardware, algorithms to create new or enhanced functionality, and formal methods and tools for the design and implementation of computer systems. Novel component and system architectures, their design principles, and analytical or simulation-based evaluation are also included.

The CPA cluster emphasizes integration of research and education in all areas of interest. Principal investigators can range from individual faculty members beginning their careers to teams of both senior and junior investigators working on novel directions within a multidisciplinary mode. Collaborations between computer scientists, computer engineers, and other disciplinary investigators are encouraged as cross-disciplinary research projects have the potential to strengthen the foundations of computing processes and artifacts. Proposals for larger projects should provide demonstrable evidence of the existence, quality, and growth potential of precursor research.

This cluster also supports development of innovative curricular materials that have the potential to greatly improve higher education in the topics covered in this solicitation. Such activities are typically proposed as one component in a broader research and education project. Curriculum development activities must include strong justification of the need for the new

materials and must include plans for disseminating them to the community as well as for evaluating their effectiveness.

While each topical area described below deals with a set of topics of specific interest to the CPA cluster, research issues inevitably transcend artificially imposed topical boundaries. Consequently, the CPA cluster encourages proposals that transcend the confines of each of the elaborated topical areas.

### **Advanced Computation**

This area encompasses high-performance hardware and software research and education projects for advancing the state-of-the-art in computational science and engineering. In addition to sheer compute power, observation- and simulation-driven applications fundamentally require high throughput input/output (I/O) capabilities, large data storage capacities, and tools for efficiently organizing, locating, and moving data. Data management challenges include the need to access large volumes of data, possibly produced by different applications in numerous locations and in various formats. This sub-area supports research and education projects in I/O, file, and storage system design for efficient, high-throughput data storage, retrieval, and management in high-performance computing environments.

Specific research topics of interest include, but are not limited to: design of multi-level (hierarchical, layered) parallel algorithms and libraries; scalable and latency tolerant computational/numeric algorithms; performance modeling of scalable algorithms; management of large-scale distributed file systems and data; novel storage devices, architectures, and middleware for high-throughput I/O; software and hardware processes and artifacts for design, simulation, benchmarking, tracing, performance measurement and tuning of I/O, file, and storage systems in high-performance computing environments.

### **Compilers**

This area covers foundations in compilers research and education for enabling robust computer systems. Processes for specifying properties of high-level abstractions to the compiler and for automating the mapping of code to the architectural features of a target platform remain elusive. As such, automatic algorithm mapping, code and data transformation, translation to hardware description language (for reconfigurable architectures) and optimization (both static and dynamic) remain open areas of research. Research on compilers capable of advanced analysis to verify program correctness and improve programmer productivity is also needed, as is research on compiler support for automating the exploitation of parallelism (i.e., parallelizing compilers). As the emergence of multicore architectures mainstream parallel computing, effective compiler support for automatically parallelizing sequential programs to fully utilize the potential of multicore processors and multiprocessor systems built from multicores is an important challenge.

Specific research topics of interest include, but are not limited to: parallelizing compilers and infrastructure for optimizing compilers for multiple platforms; parallelization techniques for exploiting parallelism at multiple levels applicable to multiple programming models; software and compiler support for mapping and scheduling multiple threads on (possibly heterogeneous) multicore and multiprocessor systems; compiler techniques for managing on-chip communication, power consumption, temperature and fault tolerance in multicore architectures; compiler techniques to guarantee safety from potential deadlocks, memory leaks, race conditions and other forms of correctness in parallel programs.

### **Computer System Architecture**

This area covers foundations in computer system architecture research and education for enabling robust, high-performance and power-aware computer systems. Computer architectures that provide enhanced functionality and scalable performance to meet the growing demands of diverse applications while meeting stringent constraints on energy and power consumption, reliability, design complexity, and so on are needed. Such functionality includes architectural support for facilitating programmability, real-time computation, security, power and thermal management; soft and hard error detection and recovery; dynamic adaptation and self repair of systems implemented in nano-scale technologies that provide giga-scale integration.

Specific research topics of interest include, but are not limited to: computer system architecture including processor microarchitecture, memory, interconnection networks and I/O; high-level design and analysis of computer systems including methods, tools, processes, and artifacts for automated design space exploration, modeling, benchmarking, simulation, synthesis and performance evaluation; design and performance modeling of multithreaded, multicore, many-core and multiprocessor architectures including chip multiprocessors, heterogeneous and systems-on-a-chip processors; low-power, low-latency on-chip network architectures and circuits, distributed register and cache structures; parallel programming and memory models; multi-objective optimizations including performance, energy and power, temperature, reliability, security, area and complexity; application-specific processors and reconfigurable computing including tools and techniques to facilitate application-to-hardware mapping and fault-induced reconfiguration; novel architectures and hardware primitives that facilitate concurrency and exploit parallelism at multiple levels (e.g., fine-grained, instruction, data, thread, stream, task and coarse-grained).

## **Design Automation for Micro and Nano Systems**

This area covers foundations in design automation research and education for micro and nano systems. Design methodologies for VLSI continue to be challenged by rapid miniaturization consisting of millions to billions of transistors on a chip. This, together with advances in novel MEMs, optical and nano-scale devices, presents new opportunities for design in both conventional CMOS technologies as well as other novel technologies. This area supports basic research and education projects underlying the science and methodologies for designing integrated systems comprised of micro systems in traditional silicon VLSI technology, MEMS technologies, 3-D technologies, and other emerging computing media of the future. While device related research is not a focus, molecular and nano-computing as it relates to the circuits/architecture-level interface will be given due consideration. More specifically, this area will explore fundamental questions of how to design in future computing media, stimulate crossover activities between electronic design automation research and micro/nano/molecular technology research in order to meet challenges of VLSI design as geometries shrink, and provide the basic science for design of next generation VLSI chips using deep submicron technologies. This includes digital as well as analog VLSI design.

Specific research topics of interest include, but are not limited to: physical design (routing & layout, power optimization, logic synthesis, network-on-chip communication, modeling & device simulation); system-level design (systems-on-a-chip, multicore systems, embedded systems, application-specific processor design, hardware/software co-design); test and verification (testing of analog, digital mixed-signal systems, built-in self-test, design for testability, formal proof of correctness); investigation of design methods for technologies such as optical, MEMS, 3-D integration, and mixed signal systems.

## **Graphics and Visualization**

This CPA cluster area sponsors integrated research and education projects to advance the scientific foundations and engineering practices that underlie the ability to perform visual information transfer, address models of physical events, develop mechanisms for image production, and utilize visualization to represent and explore information such as computer system performance and security, large, disparate data sets, and data from specific application domains. This requires the ability to model, render, and display data and to understand the forms of visualization that can best communicate particular types of information. The CPA cluster seeks fundamental advances that will enhance the numerous activities that utilize computer graphics and visualization, including science, engineering, medicine, entertainment, education, business, and homeland security. Proposals that utilize techniques from digital imaging and machine vision must clearly seek solutions to fundamental problems in computer graphics and visualization to merit consideration.

Specific research topics of interest include, but are not limited to: mathematical models for representing geometric and non-geometric data, algorithms for the photorealistic and non-photorealistic rendering of geometry, lighting, and materials, physical-based modeling and graphical simulation, animation techniques, multi-resolution algorithms for graphics modeling and applications, visibility algorithms, scientific visualization algorithms and systems, visualization aspects of visual analytics, visualization aspects of location-aware computing, virtual and augmented reality, novel hardware for graphics processing, and graphics issues in computational photography and video. Innovative multidisciplinary proposals that join visualization with other computer-science domains, and, in particular, other cluster area topics are also welcome.

## **Software Engineering and Languages**

This area sponsors integrated research and education projects to advance scientific foundations, engineering practice and education in topics related to software engineering and programming languages. Relevant projects may concern any of the artifacts and processes involved in software engineering, including notations, languages, theories, models, techniques, methods, tools and environments relating to requirements, specification, transformation, architecture, design, programming, analysis, verification, testing, maintenance, adaptation and evolution and other activities of software development. Research in this area should contribute to new understanding of software and software development issues, with an objective of significantly increasing productivity of software development, as well as attaining the highest quality of software-based products and services. Proposals should emphasize lasting principles, robust theories, high-leverage tools and novel approaches. Proposals should include plans for validation through proofs of concept, empirical evaluation, and/or other scientific methods. Projects should address issues such as usability and scale.

In addition to the above, the following are specific emphasis areas where research advances are encouraged: exploration of programming methodologies to exploit parallelism/concurrency, including research toward new programming models and methods to produce scalable, efficient software for multicore/manycore machines and novel/advanced architectures, where advances may address synthesis, analysis, verification, performance and other theoretical and applied issues; recognizing that citizens who are end-users will increasingly need software engineering knowledge and capabilities to ensure correct, reliable and safe behaviors in their own environments, research is needed to better understand the needs of end-user software development, migration of appropriate languages and tools to end-user scenarios, the design of supporting infrastructure, and the role of computational thinking in everyday software development; and, constructive methods for software development and evolution to go beyond the investigation of individual methods and tools, with an emphasis on how methods and tools can be combined synergistically to achieve advanced software engineering goals (e.g. hybrid static and

dynamic software analysis, combined verification and testing strategies, linkages between requirements and runtime.)

## Relation to Other Programs

Computing processes and artifacts range from formalisms, methods, models, algorithms, and theories to languages architectures, technology components and a variety of physical manifestations of computing system software and hardware. Consequently, many projects will address topics described above that have aspects in common with related programs. If the major emphasis of a proposal is one of the types of topics described in this solicitation, then it should be submitted to the CPA program. Otherwise, the proposal may be more appropriate for submission to another program. The following NSF programs are most closely related to the CPA program:

Computer Systems Research (CSR in CNS Division);

Cyber Trust (CT Emphasis Area in CISE Directorate);

Foundations of Data and Visual Analytics (CISE and MPS Directorates);

Research in Networking and Technology (NeTS in CNS Division);

Software Development for Cyber Infrastructure (SDCI in Office of Cyberinfrastructure); and

Theoretical Foundations (TF in CCF Division).

Attention should be paid to where proposals are submitted. For example, a proposal that develops new compiler technology to support dynamic and adaptive runtime tuning support of applications executing on complex, heterogeneous, and distributed platforms should be submitted to the Computer Systems Research (CSR) program, but a proposal that addresses parallelizing compiler technology should be submitted to the Computing Processes and Artifacts (CPA) program. Similarly, a project that develops programming languages, models, or software tools to facilitate programming parallel applications should be submitted to CPA, whereas a project that develops systems software for parallel computing should be submitted to CSR or some other related program. Proposals exploring system services and resource management for local area distributed systems, clusters, and computational grids should be directed to the CSR program at CNS. If the major emphasis of the proposal is computer networks, then it should be submitted to the Research in Networking Technology and Systems (NeTS) program or Theoretical Foundations of Computing (TF) program. If the major emphasis is making systems more secure, then the proposal should be submitted to the Cyber Trust (CT) program. A project that hardens computational science systems software, including software for high performance computing, software development tools, and software for graphics and visualization, may be more appropriate for submission to Software Development for Cyber Infrastructure (SDCI). Proposals exploring system services and resource management for local area distributed systems, clusters, and computational grids should be directed to the CSR program in CNS. Proposals that explore the mathematics and computational aspects of data transformations to enable visual analytics should be directed to the joint NSF/DHS sponsored Foundations of Data and Visual Analytics (FODAVA) program. As other programs become active, PIs are encouraged to contact the cognizant program directors for discussion.

## III. AWARD INFORMATION

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There are three categories of proposals that may be submitted to this solicitation:

1. Single Investigator or Small Group projects - These projects include one or more PIs at the same or different institutions, with project durations up to three years, and budgets of up to a maximum \$500,000 total over all years. The majority of awards in this category are expected to have annual budgets of about \$100,000 to \$125,000 for three years. Approximately 70-95 of these awards are anticipated.
2. Team projects - These projects include two or more PIs at the same or different institutions, for durations of three or four years, with budgets ranging from \$500,001 to \$1,500,000 total over all years. These projects will support well-integrated investigations that cross topical areas described in this solicitation. Approximately 5 to 7 Team awards are anticipated.
3. Major Team projects - These projects include two or more PIs at the same or different institutions, for durations of three or four years, with budgets ranging from \$500,000 to \$900,000 per year. Awards will support well-integrated investigations of larger scope that cross topical areas described in this solicitation and/or extend beyond those



topical areas to include related research and education challenges in other science and engineering fields. Awards supported at this level are expected to promise significant national or international impact. Principal investigators considering the submission of proposals in this category should consult a cognizant Program Director before submission. Up to two Major Team awards are anticipated.

## IV. ELIGIBILITY INFORMATION

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### Organization Limit:

Proposals may only be submitted by the following:

- Academic Institutions located in the U.S.: U.S. universities and colleges located in the U.S.

### PI Limit:

None Specified

### Limit on Number of Proposals per Organization:

None Specified

### Limit on Number of Proposals per PI: 2

An investigator may participate as a PI, co-PI or Senior Personnel on at most two proposals but may participate in no more than one Single Investigator or Small Group proposal. In other words, if an investigator participates in two proposals, at least one of them must be a Team or a Major Team proposal. If an investigator fails to comply with these constraints, all proposals in which the investigator participates will be returned without review. It is therefore strongly advised that all investigators in multi-investigator proposals submitted in response to this solicitation check with their co-investigators to ensure that all are in compliance.

## V. PROPOSAL PREPARATION AND SUBMISSION INSTRUCTIONS

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### A. Proposal Preparation Instructions

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**Full Proposal Preparation Instructions:** Proposers may opt to submit proposals in response to this Program Solicitation via Grants.gov or via the NSF FastLane system.

- Full proposals submitted via FastLane: Proposals submitted in response to this program solicitation should be prepared and submitted in accordance with the general guidelines contained in the NSF Grant Proposal Guide (GPG). The complete text of the GPG is available electronically on the NSF website at: [http://www.nsf.gov/publications/pub\\_summ.jsp?ods\\_key=gpg](http://www.nsf.gov/publications/pub_summ.jsp?ods_key=gpg). Paper copies of the GPG may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from [pubs@nsf.gov](mailto:pubs@nsf.gov). Proposers are reminded to identify this program solicitation number in the program solicitation block on the NSF Cover Sheet For Proposal to the National Science Foundation. Compliance with this requirement is critical to determining the relevant proposal processing guidelines. Failure to submit this information may delay processing.
- Full proposals submitted via Grants.gov: Proposals submitted in response to this program solicitation via Grants.gov should be prepared and submitted in accordance with the NSF Grants.gov Application Guide: A Guide for the Preparation and Submission of NSF Applications via Grants.gov. The complete text of the NSF Grants.gov Application Guide is available on the Grants.gov website and on the NSF website at: (<http://www.nsf.gov/bfa/dias/policy/docs/grantsgovguide.pdf>). To obtain copies of the Application Guide and Application Forms Package, click on the Apply tab on the Grants.gov site, then click on the Apply Step 1: Download a Grant Application Package and Application Instructions link and enter the funding opportunity number, (the program solicitation number without the NSF prefix) and press the Download Package button. Paper copies of the Grants.gov Application Guide also may be

In determining which method to utilize in the electronic preparation and submission of the proposal, please note the following:

**Collaborative Proposals.** All collaborative proposals submitted as separate submissions from multiple organizations must be submitted via the NSF FastLane system. Chapter II, Section D.3 of the Grant Proposal Guide provides additional information on collaborative proposals.

The following information supplements or deviates from the GPG or the NSF Grants.gov Application Guide.

To assist NSF staff in sorting proposals for review, proposal titles should begin with "CPA-key: " where "key" provides information about the topical area the PI would like to see the proposal directed to. The following are the keys to be used:

- \* ACR --- Advanced Computation Research
- \* CPL --- Compilers
- \* CSA --- Computer System Architecture
- \* DA --- Design Automation for Micro and Nano Systems
- \* G&V --- Graphics and Visualization
- \* SEL --- Software Engineering and Languages

For example, a proposal could have the title "CPA-SEL: Techniques for Verifying Code Correctness" to indicate that its primary emphasis is in the Software Engineering and Languages area. If a proposal addresses topics in more than one area, it should be directed to whichever one of the areas is most appropriate.

For Team proposals, "-T" must be added after the keyword. For example, a proposal title "CPA-SEL-T: Techniques for Verifying Code" designates that the proposal is a Team project.

For Major Team proposals, "-MT" must be added after the keyword. For example, a proposal title "CPA-SEL-MT: Techniques for Verifying Code" designates that the proposal is a Major Team project.

Proposals that fail to include the appropriate acronyms in the title may be returned without review.

Proposals whose budgets do not conform to the proposal category designated by the proposal title may be returned without review. For a Single Investigator or Small Group project, the cumulative budget must not exceed the maximum of \$500,000. For a Team project, the cumulative budget must exceed \$500,000 but not exceed \$1,500,000. Major Team projects must have annual budgets between \$500,000 and \$900,000.

CPA proposals should describe how the project will yield significant research and education outcomes, e.g., by validating theories on actual systems, by demonstrating the utility of new tools and making them available to the community, and/or by disseminating and evaluating new educational materials or curricula.

Every proposal must include a discussion of Broader Impacts. Broader Impacts include the integration of education and research, broadening participation in the computing workforce, developing substantial experimental research educational experiences, and developing curriculum and supporting material in emerging areas of computing. Broader impacts also include the scientific and other societal impacts that would occur if the research is successful. Examples of activities likely to demonstrate broader impacts are available on the NSF website at <http://www.nsf.gov/pubs/gpg/broaderimpacts.pdf>. The CPA cluster emphasizes the importance of thinking about and communicating these connections.

**Collaboration Plan** - For all proposals in the Team or Major Team categories, up to three additional pages are required as a supplemental document titled Collaboration Plan. This should be included in the "Special Information and Supplemental Documentation" section of the proposal submission. The purpose of this section is to provide detailed information about the roles of key project personnel and plans for coordinating project tasks among multiple institutions and disciplines, as applicable. The Collaboration Plan will be reviewed for clarity of task definitions, effectiveness of task assignments, and

achievability of project objectives.

## B. Budgetary Information

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**Cost Sharing:** Cost sharing is not required by NSF in proposals submitted to the National Science Foundation.

## C. Due Dates

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- **Full Proposal Deadline(s)** (due by 5 p.m. proposer's local time):

December 07, 2007

## D. FastLane/Grants.gov Requirements

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- **For Proposals Submitted Via FastLane:**

Detailed technical instructions regarding the technical aspects of preparation and submission via FastLane are available at: <https://www.fastlane.nsf.gov/a1/newstan.htm>. For FastLane user support, call the FastLane Help Desk at 1-800-673-6188 or e-mail [fastlane@nsf.gov](mailto:fastlane@nsf.gov). The FastLane Help Desk answers general technical questions related to the use of the FastLane system. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this funding opportunity.

**Submission of Electronically Signed Cover Sheets.** The Authorized Organizational Representative (AOR) must electronically sign the proposal Cover Sheet to submit the required proposal certifications (see Chapter II, Section C of the Grant Proposal Guide for a listing of the certifications). The AOR must provide the required electronic certifications within five working days following the electronic submission of the proposal. Further instructions regarding this process are available on the FastLane Website at: <https://www.fastlane.nsf.gov/fastlane.jsp>.

- **For Proposals Submitted Via Grants.gov:**

Before using Grants.gov for the first time, each organization must register to create an institutional profile. Once registered, the applicant's organization can then apply for any federal grant on the Grants.gov website. The Grants.gov's Grant Community User Guide is a comprehensive reference document that provides technical information about Grants.gov. Proposers can download the User Guide as a Microsoft Word document or as a PDF document. The Grants.gov User Guide is available at: <http://www.grants.gov/CustomerSupport>. In addition, the NSF Grants.gov Application Guide provides additional technical guidance regarding preparation of proposals via Grants.gov. For Grants.gov user support, contact the Grants.gov Contact Center at 1-800-518-4726 or by email: [support@grants.gov](mailto:support@grants.gov). The Grants.gov Contact Center answers general technical questions related to the use of Grants.gov. Specific questions related to this program solicitation should be referred to the NSF program staff contact(s) listed in Section VIII of this solicitation.

**Submitting the Proposal:** Once all documents have been completed, the Authorized Organizational Representative (AOR) must submit the application to Grants.gov and verify the desired funding opportunity and agency to which the application is submitted. The AOR must then sign and submit the application to Grants.gov. The completed application will be transferred to the NSF FastLane system for further processing.

## VI. NSF PROPOSAL PROCESSING AND REVIEW PROCEDURES

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Proposals received by NSF are assigned to the appropriate NSF program and, if they meet NSF proposal preparation requirements, for review. All proposals are carefully reviewed by a scientist, engineer, or educator serving as an NSF Program Officer, and usually by three to ten other persons outside NSF who are experts in the particular fields represented by the proposal. These reviewers are selected by Program Officers charged with the oversight of the review process. Proposers are invited to suggest names of persons they believe are especially well qualified to review the proposal and/or persons they would prefer not review the proposal. These suggestions may serve as one source in the reviewer selection process at the Program Officer's discretion. Submission of such names, however, is optional. Care is taken to ensure that reviewers have no conflicts with the proposer.

## A. NSF Merit Review Criteria

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All NSF proposals are evaluated through use of the two National Science Board (NSB)-approved merit review criteria: intellectual merit and the broader impacts of the proposed effort. In some instances, however, NSF will employ additional criteria as required to highlight the specific objectives of certain programs and activities.

The two NSB-approved merit review criteria are listed below. The criteria include considerations that help define them. These considerations are suggestions and not all will apply to any given proposal. While proposers must address both merit review criteria, reviewers will be asked to address only those considerations that are relevant to the proposal being considered and for which the reviewer is qualified to make judgements.

### **What is the intellectual merit of the proposed activity?**

How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields? How well qualified is the proposer (individual or team) to conduct the project? (If appropriate, the reviewer will comment on the quality of the prior work.) To what extent does the proposed activity suggest and explore creative and original concepts? How well conceived and organized is the proposed activity? Is there sufficient access to resources?

### **What are the broader impacts of the proposed activity?**

How well does the activity advance discovery and understanding while promoting teaching, training, and learning? How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)? To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships? Will the results be disseminated broadly to enhance scientific and technological understanding? What may be the benefits of the proposed activity to society?

NSF staff will give careful consideration to the following in making funding decisions:

### ***Integration of Research and Education***

One of the principal strategies in support of NSF's goals is to foster integration of research and education through the programs, projects, and activities it supports at academic and research institutions. These institutions provide abundant opportunities where individuals may concurrently assume responsibilities as researchers, educators, and students and where all can engage in joint efforts that infuse education with the excitement of discovery and enrich research through the diversity of learning perspectives.

### ***Integrating Diversity into NSF Programs, Projects, and Activities***

Broadening opportunities and enabling the participation of all citizens -- women and men, underrepresented minorities, and persons with disabilities -- is essential to the health and vitality of science and engineering. NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports.

## B. Review and Selection Process

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Proposals submitted in response to this program solicitation will be reviewed by Ad hoc Review and/or Panel Review.

Reviewers will be asked to formulate a recommendation to either support or decline each proposal. The Program Officer assigned to manage the proposal's review will consider the advice of reviewers and will formulate a recommendation.

After scientific, technical and programmatic review and consideration of appropriate factors, the NSF Program Officer recommends to the cognizant Division Director whether the proposal should be declined or recommended for award. NSF is striving to be able to tell applicants whether their proposals have been declined or recommended for funding within six months. The time interval begins on the date of receipt. The interval ends when the Division Director accepts the Program Officer's recommendation.

A summary rating and accompanying narrative will be completed and submitted by each reviewer. In all cases, reviews are treated as confidential documents. Verbatim copies of reviews, excluding the names of the reviewers, are sent to the Principal Investigator/Project Director by the Program Officer. In addition, the proposer will receive an explanation of the decision to award or decline funding.

In all cases, after programmatic approval has been obtained, the proposals recommended for funding will be forwarded to the Division of Grants and Agreements for review of business, financial, and policy implications and the processing and issuance of a grant or other agreement. Proposers are cautioned that only a Grants and Agreements Officer may make commitments,

obligations or awards on behalf of NSF or authorize the expenditure of funds. No commitment on the part of NSF should be inferred from technical or budgetary discussions with a NSF Program Officer. A Principal Investigator or organization that makes financial or personnel commitments in the absence of a grant or cooperative agreement signed by the NSF Grants and Agreements Officer does so at their own risk.

## VII. AWARD ADMINISTRATION INFORMATION

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### A. Notification of the Award

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Notification of the award is made to *the submitting organization* by a Grants Officer in the Division of Grants and Agreements. Organizations whose proposals are declined will be advised as promptly as possible by the cognizant NSF Program administering the program. Verbatim copies of reviews, not including the identity of the reviewer, will be provided automatically to the Principal Investigator. (See Section VI.B. for additional information on the review process.)

### B. Award Conditions

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An NSF award consists of: (1) the award letter, which includes any special provisions applicable to the award and any numbered amendments thereto; (2) the budget, which indicates the amounts, by categories of expense, on which NSF has based its support (or otherwise communicates any specific approvals or disapprovals of proposed expenditures); (3) the proposal referenced in the award letter; (4) the applicable award conditions, such as Grant General Conditions (GC-1); \* or Federal Demonstration Partnership (FDP) Terms and Conditions \* and (5) any announcement or other NSF issuance that may be incorporated by reference in the award letter. Cooperative agreements also are administered in accordance with NSF Cooperative Agreement Financial and Administrative Terms and Conditions (CA-FATC) and the applicable Programmatic Terms and Conditions. NSF awards are electronically signed by an NSF Grants and Agreements Officer and transmitted electronically to the organization via e-mail.

\*These documents may be accessed electronically on NSF's Website at [http://www.nsf.gov/awards/managing/general\\_conditions.jsp?org=NSF](http://www.nsf.gov/awards/managing/general_conditions.jsp?org=NSF). Paper copies may be obtained from the NSF Publications Clearinghouse, telephone (703) 292-7827 or by e-mail from [pubs@nsf.gov](mailto:pubs@nsf.gov).

More comprehensive information on NSF Award Conditions and other important information on the administration of NSF awards is contained in the NSF *Award & Administration Guide* (AAG) Chapter II, available electronically on the NSF Website at [http://www.nsf.gov/publications/pub\\_summ.jsp?ods\\_key=aag](http://www.nsf.gov/publications/pub_summ.jsp?ods_key=aag).

### C. Reporting Requirements

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For all multi-year grants (including both standard and continuing grants), the Principal Investigator must submit an annual project report to the cognizant Program Officer at least 90 days before the end of the current budget period. (Some programs or awards require more frequent project reports). Within 90 days after expiration of a grant, the PI also is required to submit a final project report.

Failure to provide the required annual or final project reports will delay NSF review and processing of any future funding increments as well as any pending proposals for that PI. PIs should examine the formats of the required reports in advance to assure availability of required data.

PIs are required to use NSF's electronic project-reporting system, available through FastLane, for preparation and submission of annual and final project reports. Such reports provide information on activities and findings, project participants (individual and organizational) publications; and, other specific products and contributions. PIs will not be required to re-enter information previously provided, either with a proposal or in earlier updates using the electronic system. Submission of the report via FastLane constitutes certification by the PI that the contents of the report are accurate and complete.

## VIII. AGENCY CONTACTS

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General inquiries regarding this program should be made to:

- Sankar Basu, Program Director, Directorate for Computer & Information Science & Engineering, Division of Computing and Communication Foundations, 1106 N, telephone: (703) 292-8910, email: [sabasu@nsf.gov](mailto:sabasu@nsf.gov)
- Almadena Chtchelkanova, Program Director, Directorate for Computer & Information Science & Engineering, Division of Computing and Communication Foundations, 1115 N, telephone: (703) 292-8910, fax: (703) 292-9059, email: [achtchel@nsf.gov](mailto:achtchel@nsf.gov)
- Sol Greenspan, Program Director, Directorate for Computer & Information Science & Engineering, Division of Computing and Communication Foundations, 1108N, telephone: (703) 292-8910, fax: (703) 292-9059, email: [sgreensp@nsf.gov](mailto:sgreensp@nsf.gov)
- Alan Hevner, Program Director, Directorate for Computer & Information Science & Engineering, Division of Computing and Communication Foundations, 1115N, telephone: (703) 292-8910, fax: 703-292-9059, email: [ahevner@nsf.gov](mailto:ahevner@nsf.gov)
- Timothy Pinkston, Program Director, Directorate for Computer & Information Science & Engineering, Division of Computing and Communication Foundations, 1115 N, telephone: (703) 292-8910, fax: (703)292-9059, email: [tpinksto@nsf.gov](mailto:tpinksto@nsf.gov)
- Lawrence Rosenblum, Program Director, Directorate for Computer & Information Science & Engineering, Division of Computing and Communication Foundations, 1115 N, telephone: (703) 292-8910, fax: (703) 292-9059, email: [lrosenbl@nsf.gov](mailto:lrosenbl@nsf.gov)
- Joseph Urban, Program Director, Directorate for Computer & Information Science & Engineering, Division of Computing and Communication Foundations, 1115 N, telephone: (703) 292-8910, fax: (703) 292-9059, email: [jurban@nsf.gov](mailto:jurban@nsf.gov)

For questions related to the use of FastLane, contact:

- FastLane Help Desk, telephone: 1-800-673-6188; e-mail: [fastlane@nsf.gov](mailto:fastlane@nsf.gov).

For questions relating to Grants.gov contact:

- Grants.gov Contact Center: If the Authorized Organizational Representatives (AOR) has not received a confirmation message from Grants.gov within 48 hours of submission of application, please contact via telephone: 1-800-518-4726; e-mail: [support@grants.gov](mailto:support@grants.gov).

The primary contacts for the various components are:

- Advanced Computation: Almadena Chtchelkanova
- Compilers: Almadena Chtchelkanova
- Computer System Architecture: Timothy M. Pinkston
- Design Automation for Micro and Nano Systems: Sankar Basu
- Graphics and Visualization: Lawrence Rosenblum
- Software Engineering and Languages: Sol Greenspan, Joseph Urban, and Alan Hevner

Administrative support contact persons:

- Ms. Laurin Battle, Program Analyst, [lbattle@nsf.gov](mailto:lbattle@nsf.gov), (703) 292-8910
- Ms. Willette Goodine-Moseley, Integrative Activity Specialist, [wgoodine@nsf.gov](mailto:wgoodine@nsf.gov), (703) 292-8910
- Ms. Charmain Woods, Project Specialist, [cwoods@nsf.gov](mailto:cwoods@nsf.gov), (703) 292-8910

## IX. OTHER INFORMATION

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The NSF Website provides the most comprehensive source of information on NSF Directorates (including contact information), programs and funding opportunities. Use of this Website by potential proposers is strongly encouraged. In addition, MyNSF (formerly the Custom News Service) is an information-delivery system designed to keep potential proposers and other interested parties apprised of new NSF funding opportunities and publications, important changes in proposal and award policies and procedures, and upcoming NSF Regional Grants Conferences. Subscribers are informed through e-mail or the user's Web browser each time new publications are issued that match their identified interests. MyNSF also is available on NSF's Website at <http://www.nsf.gov/mynsf/>.

Grants.gov provides an additional electronic capability to search for Federal government-wide grant opportunities. NSF funding opportunities may be accessed via this new mechanism. Further information on Grants.gov may be obtained at <http://www.grants.gov>.

## ABOUT THE NATIONAL SCIENCE FOUNDATION

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The National Science Foundation (NSF) is an independent Federal agency created by the National Science Foundation Act of 1950, as amended (42 USC 1861-75). The Act states the purpose of the NSF is "to promote the progress of science; [and] to advance the national health, prosperity, and welfare by supporting research and education in all fields of science and engineering."

NSF funds research and education in most fields of science and engineering. It does this through grants and cooperative agreements to more than 2,000 colleges, universities, K-12 school systems, businesses, informal science organizations and other research organizations throughout the US. The Foundation accounts for about one-fourth of Federal support to academic institutions for basic research.

NSF receives approximately 40,000 proposals each year for research, education and training projects, of which approximately 11,000 are funded. In addition, the Foundation receives several thousand applications for graduate and postdoctoral fellowships. The agency operates no laboratories itself but does support National Research Centers, user facilities, certain oceanographic vessels and Antarctic research stations. The Foundation also supports cooperative research between universities and industry, US participation in international scientific and engineering efforts, and educational activities at every academic level.

*Facilitation Awards for Scientists and Engineers with Disabilities* provide funding for special assistance or equipment to enable persons with disabilities to work on NSF-supported projects. See Grant Proposal Guide Chapter II, Section D.2 for instructions regarding preparation of these types of proposals.

The National Science Foundation has Telephonic Device for the Deaf (TDD) and Federal Information Relay Service (FIRS) capabilities that enable individuals with hearing impairments to communicate with the Foundation about NSF programs, employment or general information. TDD may be accessed at (703) 292-5090 and (800) 281-8749, FIRS at (800) 877-8339.

The National Science Foundation Information Center may be reached at (703) 292-5111.

The National Science Foundation promotes and advances scientific progress in the United States by competitively awarding grants and cooperative agreements for research and education in the sciences, mathematics, and engineering.

To get the latest information about program deadlines, to download copies of NSF publications, and to access abstracts of awards, visit the NSF Website at <http://www.nsf.gov>

- **Location:** 4201 Wilson Blvd. Arlington, VA 22230
- **For General Information** (NSF Information Center): (703) 292-5111
- **TDD (for the hearing-impaired):** (703) 292-5090
- **To Order Publications or Forms:**

Send an e-mail to: [pubs@nsf.gov](mailto:pubs@nsf.gov)

or telephone: (703) 292-7827

• **To Locate NSF Employees:** (703) 292-5111

## PRIVACY ACT AND PUBLIC BURDEN STATEMENTS

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The information requested on proposal forms and project reports is solicited under the authority of the National Science Foundation Act of 1950, as amended. The information on proposal forms will be used in connection with the selection of qualified proposals; and project reports submitted by awardees will be used for program evaluation and reporting within the Executive Branch and to Congress. The information requested may be disclosed to qualified reviewers and staff assistants as part of the proposal review process; to proposer institutions/grantees to provide or obtain data regarding the proposal review process, award decisions, or the administration of awards; to government contractors, experts, volunteers and researchers and educators as necessary to complete assigned work; to other government agencies or other entities needing information regarding applicants or nominees as part of a joint application review process, or in order to coordinate programs or policy; and to another Federal agency, court, or party in a court or Federal administrative proceeding if the government is a party. Information about Principal Investigators may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004), and NSF-51, "Reviewer/Proposal File and Associated Records," 69 Federal Register 26410 (May 12, 2004). Submission of the information is voluntary. Failure to provide full and complete information, however, may reduce the possibility of receiving an award.

An agency may not conduct or sponsor, and a person is not required to respond to, an information collection unless it displays a valid Office of Management and Budget (OMB) control number. The OMB control number for this collection is 3145-0058. Public reporting burden for this collection of information is estimated to average 120 hours per response, including the time for reviewing instructions. Send comments regarding the burden estimate and any other aspect of this collection of information, including suggestions for reducing this burden, to:

Suzanne H. Plimpton  
Reports Clearance Officer  
Division of Administrative Services  
National Science Foundation  
Arlington, VA 22230

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