Computer Systems Research Program
in the
Computer and Network Systems Division
Computer and Information Science and Engineering (CISE) Directorate

Dr. Frederica Darema
Senior Science and Technology Advisor
CISE/NSF
Growth in NSF Total Budget FY 2000-2006
(millions)

FY 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006
---|---|---|---|---|---|---
(REQUEST) | (REQUEST) | (REQUEST) | (REQUEST) | (REQUEST) | (REQUEST) | (REQUEST)
CISE Cluster Organization

Office of the Assistant Director (OAD)

Division of Computing & Communication Foundations (CCF)
- Emerging Models & Technologies for Computation Cluster
- Foundations of Computing Processes and Artifacts Cluster
- Theoretical Foundations Cluster

Division of Computer & Network Systems (CNS)
- Computer Systems Cluster
- Computing Research Infrastructure Cluster
- Education & Workforce Cluster
- Network Systems Cluster

Division of Information & Intelligent Systems (IIS)
- Data, Inference & Understanding Cluster
- Science & Engineering Informatics Cluster
- Systems in Context Cluster

Clusters
CNS Division Goals

• Develop a better understanding of the fundamental properties of computer and network systems

• Create better tools for designing, building, analyzing, and measuring future systems

• Support the computing infrastructure required for experimental computer science

• Coordinate cross-divisional activities that foster the integration of research, education, and workforce development
CNS Solicitations

- FY 2004
  - about 2035 proposals
  - Success rates: CAREER & Infrastructure 18%, others 10-15%
- FY 2005
  - CAREER: 2005 competition complete, success rate ~ 25%
  - Computer Systems: November 2004 due date, received ~ 440 proposals.
  - Networking Technology and Systems (NeTS): December 2004 due date, received ~ 500 proposals
  - Computing Research Infrastructure: July/August 2004 due date, received ~ 250 proposals
  - Education and Workforce: REU Site competition complete, IGERT ongoing
  - Dynamic Data Driven Applications Systems – Cross-NSF and Cross-Agency Solicitation (all NSF Directorates, NSF/OISE, NSF/SBIR, NIH, NOAA; & International Co-operation)
- FY 2006 - see FY2005 (numbers being compiled)
## CNS Division: CNS Proposal & Award Activity: 2003-2005

<table>
<thead>
<tr>
<th>FY</th>
<th>Data</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td># of Proposals</td>
<td>1,345</td>
</tr>
<tr>
<td></td>
<td>Average of Annual Dollars</td>
<td>$228,620</td>
</tr>
<tr>
<td></td>
<td>Average of Award Duration</td>
<td>2.98</td>
</tr>
<tr>
<td>2004</td>
<td># of Proposals</td>
<td>2,068</td>
</tr>
<tr>
<td></td>
<td>Average of Annual Dollars</td>
<td>$161,331</td>
</tr>
<tr>
<td></td>
<td>Average of Award Duration</td>
<td>3.07</td>
</tr>
<tr>
<td>2005</td>
<td># of Proposals</td>
<td>2,057</td>
</tr>
<tr>
<td></td>
<td>Average of Annual Dollars</td>
<td>$151,277</td>
</tr>
<tr>
<td></td>
<td>Average of Award Duration</td>
<td>2.69</td>
</tr>
<tr>
<td></td>
<td>Total # of Proposals</td>
<td>5,470</td>
</tr>
<tr>
<td></td>
<td>Total Average of Annual Dollars</td>
<td>$178,605</td>
</tr>
<tr>
<td></td>
<td>Total Average of Awd Duration</td>
<td>2.90</td>
</tr>
</tbody>
</table>
OVERVIEW
of:
Computer Systems Research (CSR)
CAREER
CPATH
Programs
CPATH
CISE Pathways to Revitalized Undergraduate Computing
NSF 06-608
January 23, 2007
CAREER Program

• Foundation-wide activity that offers the National Science Foundation’s most prestigious awards for new faculty
• NSF supports the early career development activities of those faculty members who are most likely to become the academic leaders of the 21st century
• CAREER awards have a 5-year duration
• In FY’06, the minimum CAREER award (including indirect costs) is $400,000 for all NSF directorates
Computer Systems Research Program

NSF07-609
Announced on Oct 12, 2006
Deadlines: January 17, 2007
2nd Fri of Nov Thereafter

Program Officers:
Frederica Darema
Brett Fleisch
Helen Gill
Computer Systems Cluster

Program Officials

• Dr. Frederica Darema
  - Advanced Execution Systems
  - Systems Modeling and Analysis
  - Cross-Systems Integration

• Dr. Brett D. Fleisch
  - Distributed Operating Systems
  - Virtualization for Configuration Management

• Dr. D. Helen Gill
  - Embedded and Hybrid Systems
  - Cyber Physical Systems

{CORE AREAS - YEARLY THEMATIC AREAS}
Core Components of CSR Program:

- *(EHS)* Embedded and Hybrid Systems
- *(PDOS)* Parallel and Distributed Operating Systems
- *(AES)* Advanced Execution Systems
- *(SMA)* System Modeling and Analysis

Programs and Models

- Prog. Models
- Compilers
- Libraries
- Tools

Parallel and Distributed Operating Systems

- Scalable I/O
- Data Management
- Archiving/Retrieval Services

Authentication
Authorization
Fault Recovery Services

Distributed Applications

- Visualization
- Collaboration Environments

Distributed Systems Management

Distributed, Heterogeneous, Dynamic, Adaptive Computing Platforms and Networks

- Memory Technology
- CPU Technology
- Device Technology
- ...
Core Components:

* (EHS) Embedded and Hybrid Systems (Helen Gill)
* (PDOS) Parallel and Distributed Operating Systems (Brett Fleisch)
* (AES) Advanced Execution Systems (Frederica Darema)
* (SMA) System Modeling and Analysis (Frederica Darema)
Embedded and Hybrid Systems (EHS)

Seeks to develop the scientific foundations and systems technology that will revolutionize the design and development of embedded and real-time systems.

EHS emphasizes temporal and hybrid (discrete and continuous) aspects of computational control for this class of systems.

EHS systems pertain single application - customized hardware

Topics of Interest

• Embedded systems software composition
  – algorithms, middleware, virtual machines, and system services; new concepts for distributed real-time and light-weight operating systems; component technology for functional and non-functional aspects
Embedded and Hybrid Systems (EHS)

Topics of Interest (cont’d)

• Foundations and technology for distributed software control
  – hybrid discrete and continuous models; new concepts to support and secure future generation supervisory control and data acquisition (SCADA) systems and process control systems (PCS)

• Methods for modeling and design of embedded software and systems
  – foundations, design, implementation, synthesis, analysis, and certification methods; and, innovative approaches for failure modes, self-test, and recovery and reconstitution

• Resource management and optimization
  – methods and tools for allocating, scheduling, and managing real-time, power-aware, distributed embedded systems; and, static and real-time dynamic scheduling for real-time guarantees, power, clock frequency, thermal gain, RF emission and interference
Parallel and Distributed Operating Systems (PDOS)

Advance the state of the art in operating systems software for the range of computer systems include uniprocessors, shared-memory multiprocessors, mobile devices and applications, local area distributed systems, clusters, wide area distributed systems, and computational grids.

Main goals are to improve the capabilities, reliability, and efficiency of existing systems, to create new ways to utilize current technologies, and to harness the potential of emerging technologies.

Topics of Interest

• Resource management:
  – Scheduling, virtual memory management and protection; management of multiple levels of memory hierarchy and file systems; process and data migration, etc
Parallel and Distributed Operating Systems (PDOS)

Topics of Interest (cont’d)

• System services:
  – Mechanisms that enable dynamic coalitions, such as peer-to-peer or ad-hoc groups; membership, naming, and authorization services; local and remote resource discovery and resource requests etc

• System architecture:
  – New ways to organize systems, such as peer-to-peer; software architectures that scale to handle thousands of components; software architectures addressing changing hw technology trends, etc

• System properties:
  – Fault-tolerance and reliability; efficiency; security; scalability; and, ability to cope with unexpected events.
Advanced Execution Systems (AES)

Systems Modeling and Analysis (SMA)
Dynamically Link & Execute

Application Model

Application Program

Application Intermediate Representation

Dynamically Link & Execute

Distributed Programming Model

Compiler Front-End

Compiler Back-End

Application Components & Frameworks

Performance Measurements & Models

Distributed Computing Resources

Adaptable computing Systems Infrastructure

Distributed Platform

MPP NOW SP
Advanced Execution Systems (AES)

*Seeks to create systems software to facilitate the development and runtime support of complex applications executing on large, heterogeneous high-end computing and grid platforms*

AES emphasizes runtime compiling systems and application composition systems interface with the underlying operating systems services and incorporating systems modeling and analysis methods and tools.

**Topics of Interest**

- Runtime compiling system (RCS) technology
  - extends the standard static notion of a compiler by embedding a portion of the compiler in the runtime system and endowing the RCS system with resource awareness and adaptive mapping capabilities;
  - new compiler techniques for determining functional and data dependencies across platforms and across multiple levels of memory hierarchy;
  - mechanisms for matching an application’s resource needs to underlying resources when both are changing as the application executes.
Advanced Execution Systems (AES)

Topics of Interest

• Programming models and tools
  – expressing application partitioning across distributed, heterogeneous computing platforms; application-level checkpointing and recovery

• Application composition system (ACS) technology
  – constructing applications to fit the available resources and to adapt to changes in the underlying execution environment;
  – methods for automatically selecting application components;
  – creating knowledge bases for application components; interfacing with the underlying computing platform models to determine suitable application components;
  – and developing appropriate application component libraries and interfaces so the run-time portion of the RCS can link to such libraries.
System Modeling and Analysis (SMA)

Seeks to develop methods and tools for modeling, measuring, analyzing, evaluating, and predicting the performance and correctness of complex computing and communications systems.

SMA emphasizes the development of methods and tools for modeling, measuring, analyzing, evaluating, and predicting the performance and correctness of complex computing and communications systems.

Topics of Interest

- Hardware and Software modeling
  - methods tools and measurements, providing multimodal, hierarchical or multilevel modeling and analysis capabilities of such systems;
  - methods that describe components of the system, but also the system as a total, and enable assessment of the effects of individual hardware and software layers and components of these systems;
  - ability to describe the system in multiple levels of detail (characteristics and time-scales);
  - combine different methods of describing components and layers
System Modeling and Analysis (SMA)

Topics of Interest (cont’d)

• Novel modeling and measurement approaches
  - Develop capabilities to describe, analyze and predict the behavior of the components as well as the systems; Analysis and prediction due to changes in the application, system software, hardware; multilevel approaches and multi-modal approaches

• Performance Frameworks
  - combine tools in “plug-and-play” fashion
  - multiple views of the system
Multiple views of the system
The Operating Systems’ view
YEARYL Thematic Areas:

* (CSI) Cross Systems Integration  
  (Frederica Darema)

* (VCM) Virtualization for Configuration Management  
  (Brett Fleisch)

(CPS) Cyber Physical Systems  
  (Helen Gill)
YEARLY Thematic Area:

CSI: Cross Systems Integration (Frederica Darema)
(CSI) Cross Systems Integration

- Systems Software to seamlessly support dynamically integrated computational and real-time data acquisition environments.
  - The emphasis here is on the integrative aspects of systems software across the spectrum of such environments. Measurement processes involve instruments or sensors and sensor networks, and data acquisition, storage and access, and have become an important aspect extending the traditional computational grids. Traditionally, computation and data acquisition aspects of an application have been considered as separate processes. In the emerging environments considered here, they are dynamically correlated, with data dynamically streamed into an executing application and in reverse the executing application controlling and steering the measurement process.
  - These emerging environments go beyond the traditional control systems, which typically deal with special purpose applications and customized data acquisition, and where the interaction between model and measurement entails an analytic function representing the application model, with an ensuing simple relation between model and measurement. In distinction in the dynamic systems addressed here, there is a simulation representing the application model.
  - Such environments also provide a unique opportunity for architecting and for adaptive control of sensor networks and methods to enable such capabilities to be supported under this focus area.

- Example Environments:
  - Dynamic Data Driven Applications Systems
  - Sensor Networks
Dynamic Data Driven Application Systems (DDDAS)

New Direction for applications/simulations and measurement methodologies

www.cise.nsf.gov/dddas
(Frederica Darema)

**DDDAS:**
ability to dynamically incorporate additional data into an executing application, and in reverse, ability of an application to dynamically steer the measurement process

**Challenges:**
Application Simulations Methods
Algorithmic Stability
Measurement/Instrumentation Methods
Computing Systems Software Support

**Key aspect:**
Synergistic, Multidisciplinary Research
Research Challenges
in the scope of the CSI Thematic Area

• Programming Environments to support, in an integrated manner, the differing programming models satisfying the respective requirements across such a spectrum of underlying platforms, that include computing, communications, data systems as well as instruments and distributed sensor systems. These include application embedded sensing and actuating mechanisms for specifying, discovering, negotiating, and adapting to policies and constraints, dynamic workflow support, dynamic application composition and invocation of application components driven by dynamic data inputs.

• Integrated Runtime Management: end-to-end integrated methods and tools for resource management and optimization that satisfy the differing requirements of mission critical and traditional computational systems. Software architecture and support of dynamic resource requirements, adaptive real-time response at the application level and at the data acquisition level, and dynamic allocation and mapping across computational and instrumentation systems. Technologies include compilers, debuggers, and other system software that span the diverse spectrum of underlying systems. Capabilities sought include: support for adaptive real-time response.

• Integrated System Services: End-to-end across-system services in order to seamlessly and simultaneously satisfy requirements of the real-time and the computational components of an application. Such integrated services include: system-level end-to-end performance optimization, performance guarantees over a wide range of system capabilities including real-time, just in-time resource allocation, system-wide time-synchronization, event/data logging, just in-time data transport, power-awareness, efficiency, reliability, fault-tolerance, recovery and security.
Programmatic Aspects

For the Core Component Areas, the CSR program will make two types of awards:

- **Small.** These awards include one or two PIs, have budgets of up to $800,000, and durations of two or three years. Approximately 35-45 small awards will be given in each annual CSR competition, with an estimated average award size of approximately $450,000.

- **Team.** These awards include three or more PIs, have budgets of up to $2,000,000, and durations of three or four years. Approximately 6-12 team awards will be given in each annual CSR competition, with an estimated average award size of $1,000,000.

For the Thematic Areas, the CSR program will make seeding awards:

- Range of about $200,000 for about two years

The CSR program will also accept proposals for workshops and Small Grants for Exploratory Research (SGER).
Programmatic Aspects (cont’d)

• In limited cases, the CNS Division will entertain proposals that are beyond the scope and funding levels noted elsewhere in this solicitation.
  – Such proposals would be expected to explore groundbreaking or paradigm-changing ideas or to pursue a grand challenge requiring the work of a substantial number of researchers. Projects of this type might include multidisciplinary investigators and cover topics in more than one CNS or CISE program.
  – For such proposals PIs must first brief the appropriate program officers and the CNS Division Director. PIs may submit a full proposal only after being given permission to do so.

• Eligibility Limitations:
  – An individual may appear as a PI, co-PI or Senior Personnel on no more than two proposals per annual CSR competition.
QUESTIONS ?