Exploiting Parallelism and Scalability (XPS)

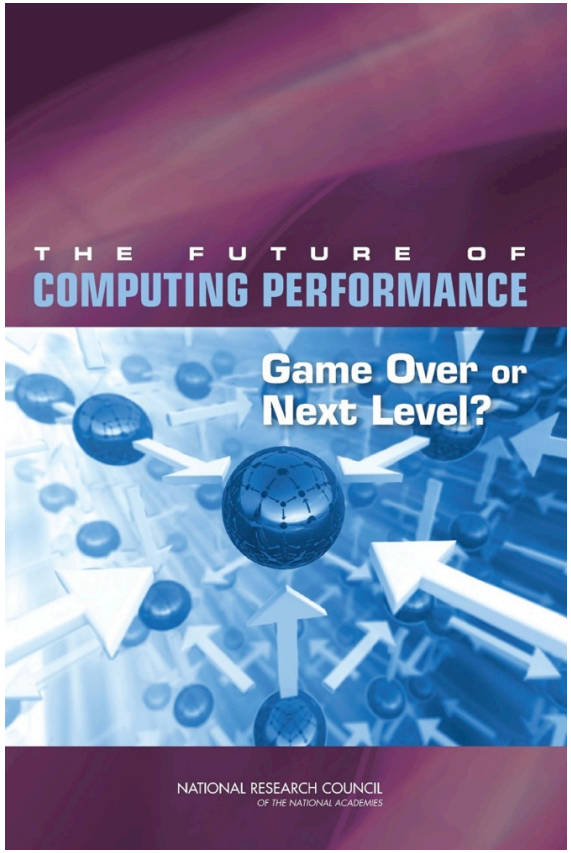
Tracy Kimbrel
Geoffrey Brown
Hong Jiang
Anindya Banerjee
Rudi Eigenmann
Frank Olken

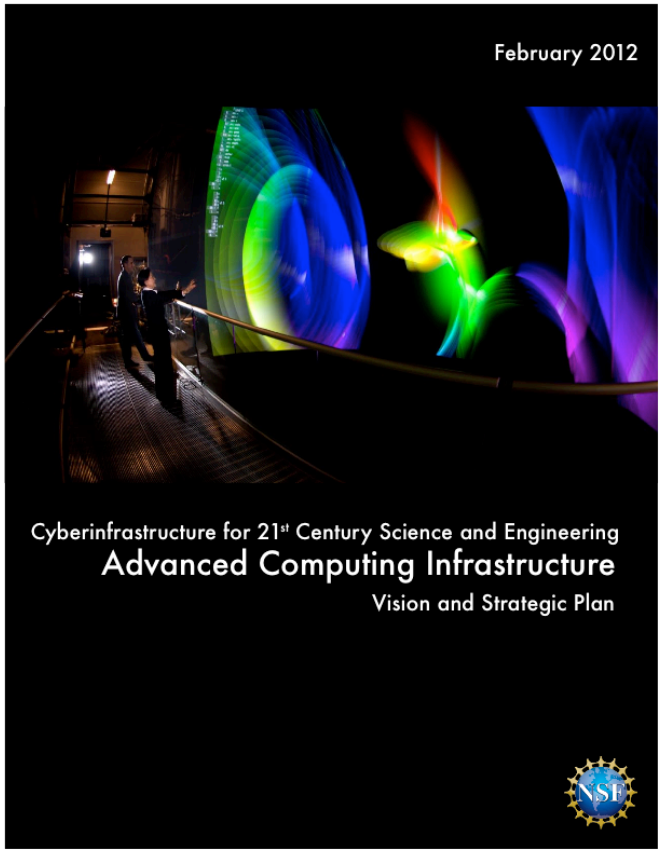
January 10, 2014

Agenda

- Overview
- Solicitation highlights
- Program focus
- FAQs
- Questions and answers

Consensus: New foundational research needed to fully exploit parallelism and concurrency and achieve scalability





COMPUTING COMMUNITY CCC CONSORTIUM

21st Century Computer Architecture

A community white paper

NSF

Computing Research Agenda on Parallelism, Concurrency, and Scalability

- **Computational models and programming languages** enabling new ways of thinking parallel and expression of parallelism at every scale.
- **Algorithms and algorithmic paradigms** for reasoning about parallel performance (time, space, communication, and energy) and scalability.
- **Compilers and synthesis tools** that generate efficient parallel codes from high-level descriptions.
- **Software systems** capable of handling both small and extreme-scale data sets and aware of communication and energy use.
- **Scalable and energy-efficient architectures** ranging from sensors to clouds while addressing programmability, reliability, and security.
- **A new cross-layer approach** integrating both software and hardware through new programming languages, models, algorithms, compilers, runtime systems and architectures.

The XPS Program

- XPS is a program in its second year that aims to support fresh ***groundbreaking*** research that will lead to a new era of parallel computing.
- The focus is on *"clean-slate"* approaches that re-imagine the traditional hardware and software stack.
- Looking to establish *new* collaborations that cut across abstraction layers.

FY14 Solicitation (NSF 14-516)

- Proposal should fit into one of four focus areas (described later).
- Each FULL-SIZE proposal must have two or more PIs providing different and distinct expertise.
- EXPLORATORY proposals do not require multiple PIs. These describe preliminary work or proofs-of-concept that could lead to future FULL-SIZE projects.
- Proposals are due February 24, 2014.
- Estimated 13-16 FULL-SIZE awards of up to $1M and 3-5 EXPLORATORY awards of up to $300k.

Focus Areas

- ***Foundational Principles***
  - Models to guide algorithm design
  - Optimization for various resources
  - Languages designed for parallelism
- ***Cross-layer and Cross-cutting Approaches***
  - Re-thinking the "stack"
  - Coordination across all layers
  - Application to system to hardware
- ***Scalable Distributed Architectures***
  - People/things connected everywhere
  - Computing power in cloud
  - New "reference model" needed
- ***Domain-specific Design***
  - Exploiting domain-specific knowledge
  - Libraries to allow generalization
  - Hardware/software co-design

Foundational Principles (FP)

- New computational models for parallelism.
- Algorithmic reasoning about parallel computation and resource uses.
- New and novel parallel programming languages that lower the barrier of entry for parallel and concurrent programming.
- Compilation techniques for mapping high-level parallel languages to efficient parallel code.

Cross-layer and Cross-cutting Approaches (CCA)

- General principles for future parallel computer architectures and systems ("re-thinking the stack").
- Models and abstractions to expose energy use, communication costs, etc. across all layers.
- Software and systems architectures that use locality to improve latency, bandwidth, and energy use.
- New methods and metrics for evaluating, verifying and validating correctness, reliability, resilience, performance, and scalability.

Scalable Distributed Architectures (SDA)

- Languages and tools for programming warehouse-scale computing systems.
- Platforms and tools that allow computations to be partitioned between mobile devices and the cloud.
- Novel approaches to smart sensor design in the context of ubiquitous access to data and compute resources.
- Support from hardware to user level for resiliency and robustness of these systems while requiring minimal retraining of software developers.

Domain-specific Design (DSD)

- Parallel domain-specific languages that provide both high-level programming models and performance.
- Program synthesis tools for domain-specific computations.
- Domain-specific hardware-software co-design.
- Foundational work on exploiting domain-specific knowledge for parallelism, such as tools and implementation frameworks.

FAQ 1

- Q: How can I tell whether my proposed research is a good fit for the XPS program?

- A: The XPS program aims to support **groundbreaking research** leading to a new era of parallel computing. This program seeks **transformative proposals** on **new and visionary approaches** **that re-examine the traditional computer hardware and software stack** for today's heterogeneous parallel systems and explore new cross-layer approaches. Achieving these **breakthroughs** will require a **collaborative effort** among researchers representing different areas, so each FULL-SIZE proposal is required to have two or more Principle Investigators (PIs) providing different and distinct expertise relevant to the program's focus areas.

FAQ 1 cont.

- Q: How can I tell whether my proposed research is a good fit for the XPS program?

- Proposals that focus on the **extension of existing approaches**; proposals that seek to solve **domain science problems**; and proposals that seek to build **software infrastructure** are **not appropriate** for XPS. Such proposals may be appropriate for other NSF Programs, such as the Computer & Information Science & Engineering (CISE) Core Programs, Computational and Data-Enabled Science and Engineering (CDS&E), and Software Infrastructure for Sustained Innovation (SI2).

FAQ 1 cont.

- Q: How can I tell whether my proposed research is a good fit for the XPS program?

- "Note: *parallel computing (*or *parallelism)*, *concurrent computing (*or *concurrency)*, and *distributed computing* are closely related and overlapping terms without universally accepted definitions. Where one or more of these terms appear in this solicitation, they should be interpreted broadly so as to include the others whenever appropriate."

FAQ 2

- Q: I work in field A and my co-PI works in field B. Does this count as "different and distinct expertise?"

- A: There is not a hard-and-fast rule about this question. It is up to the proposers to make the argument that the PIs provide different and distinct expertise relevant to the program's focus areas. Each FULL-SIZE proposal is required to have a collaboration plan as a separate supplementary document, which must describe the backgrounds and different expertise of the PIs, how they relate to the proposed work, and how the PIs plan to collaborate. This plan will be evaluated by the panelists or reviewers as part of the proposal review process.

FAQ 3

- Q: Should I discuss my proposal with NSF Program Directors?

- A: Yes, PIs are encouraged to discuss planned proposals with Program Directors to assist them in determining whether XPS is a suitable program for the work. Please be considerate of Program Directors' time and refrain from scheduling separate meetings with multiple Program Directors in the same program. Once submitted, the substance of proposals will not be discussed by NSF Program Directors, as this would constitute unfair competition, or the perception thereof.

FAQ 4

- Q: Who are the XPS Program Directors, and which one should I talk with?

- A: The list of current XPS Program Directors is available on the NSF web pages for the program http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504842. PIs should discuss potential proposals with the Program Directors whose areas are closest to that of the proposed research.

FAQs 5-6

- Q: Do XPS proposals count against the CISE Core program limits on number of proposals allowable per year?

- A: No. The limits imposed by the CISE Core programs do not apply. No person, however, can be PI, co-PI, or senior personnel on more than two XPS proposals.

- Q: Will there be future XPS solicitations?

- A: The Computer and Information Science and Engineering (CISE) Directorate has a strong commitment to support research in this area, and we anticipate continued funding.

- Slides and script available at: http://www.nsf.gov/events/

Program Director email:

- tkimbrel@nsf.gov Tracy Kimbrel, CCF
- abanerje@nsf.gov Anindya Banerjee, CCF
- gebrown@nsf.gov Geoffrey Brown, CNS
- reigenma@nsf.gov Rudi Eigenmann, ACI
- hjiang@nsf.gov Hong Jiang, CCF
- folken@nsf.gov Frank Olken, IIS

Exploiting Parallelism and Scalability (XPS)