Program Announcement
To DOE National Laboratories
LAB 10-257

X-Stack Software Research

SUMMARY:

The Office of Advanced Scientific Computing Research (ASCR) of the Office of Science (SC), U.S. Department of Energy (DOE), hereby announces its interest in receiving peer-reviewable Field Work Proposals (FWPs) from Computer Science (CS) researchers in the area of **X-Stack Software Research**. The X-Stack refers to the scientific software stack that supports extreme scale scientific computing, from operating systems to development environments. Multi-Institutional proposals with cohesive emphasis on transformational computer science discoveries that address key challenges on the path to exascale computing are encouraged. In addition to other topics, this Announcement continues and extends topics of research addressed under the ASCR program on Operating and Runtime Systems for Extreme Scale Scientific Computation, http://www.sc.doe.gov/grants/LAB07_23.html and http://www.sc.doe.gov/grants/FAPN07-23.html

Exascale computer systems will be comprised of as many as a billion cores. Such systems will be capable of 10 billion-way concurrency in simultaneous operations. Industry reports indicate that data movement will be the limiting factor for exascale systems, rather than processors and computational operations, especially when power constraints are considered. At the same time, memory per core is expected to decline sharply for exaflop systems, and the performance of storage systems continues to lag far behind. Multi-level storage architectures that span multiple types of hardware are anticipated and will require new approaches to run-time data management and analysis.

This Program Announcement invites basic computer science research proposals to address a variety of challenges in creating the software stack for extreme scale computing systems, the X-Stack, including operating and run-time systems, programming models and environments, and scientific workflow systems. Awards will not be made for design or development of applications for discipline-specific science.

DATES:

Full proposals submitted in response to this Announcement must be received no later than Friday, 8:00 pm ET, April 2, 2010, to be accepted for merit review and to permit timely consideration for award in Fiscal Year 2010.

Please see the "Addresses" section below for further instructions on the method of submission for the proposal.

ADDRESSES and SUBMISSION INSTRUCTIONS:

Have your LAB administrator submit the entire LAB proposal and FWP via Searchable FWP (https://www.osti.gov/fwp). If you have questions about who your LAB administrator is or how to use Searchable FWP, please contact the Searchable FWP Support Center.

Please submit, via Federal Express, a single PDF file of the entire LAB proposal and FWP on a CD along with two hard copies to the address below. This will assist in expediting the review process.

Please send the CD and 2 hard copies via Federal Express to:

Teresa Beachley
Computational Science Research & Partnerships Division, SC-21.1
Office of Advanced Scientific Computing Research
Office of Science
19901 Germantown Road
Germantown, MD 20874-1290
ATTN: Program Announcement LAB 10-255

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SUPPLEMENTARY INFORMATION:

Critical challenges in developing the X-Stack include concurrencey, energy efficiency and resiliency, among others. Solving these problems may call for new approaches to system design, such as hardware-software co-design.

The complexity of exascale systems presents significant challenges to human understanding which must be addressed. A fundamental need is for ways to express concurrency and locality in ways that are comprehensible to scientists, who must be able to understand how codes relate to theory and experimentation in their disciplines. Burdens of managing the memory hierarchy, synchronization, resource scheduling and communication, utilizing heterogeneous processors, etc., must not fall to programmers.

Topics of interest include but are not limited to:

- System software, including operating systems, runtime systems, adaptable operating and runtime systems, I/O systems, systems management/administration, resource management and means of exposing resources, and external environments
- Fault management, both by the operating and runtime systems and by applications
- Development environments, including programming models, frameworks, compilers, and debugging tools
- Application frameworks
- Crosscutting dimensions, including resilience, power management, performance optimization, and programmability
- Design and/or development of high-performance scientific workflow systems that incorporate data management and analysis capabilities

These example research topics represent only a portion of the research challenges in developing the X-Stack that are of interest to ASCR. All interested proposers are encouraged to study the following references for additional discussion and insight:

- *The International Exascale Software Project Roadmap*, http://www.exascale.org/iesp/Main_Page
- *Operating and Runtime Systems for Extreme Scale Scientific Computation (a.k.a. FAST OS)*, http://www.sc.doe.gov/grants/LAB07_23.html and http://www.sc.doe.gov/grants/FAPN07-23.html
- *ExaScale Software Study: Software Challenges in Extreme Scale System*, report for the DARPA Information Processing Techniques Office (IPTO), September 2009, http://users.ece.gatech.edu/mrichard/ExascaleComputingStudyReports/ECSS%20report%20101909.pdf
- *System Resilience at Extreme Scale*, http://institutes.lanl.gov/resilience/docs/IBM%20Mootaz%20White%20Paper%20System%20Resilience.pdf
- *"Software Challenges in Extreme Scale Systems*," Sarkar, Vivek; Harrod, William; and Snavely, Allan E., SciDAC 2009, http://www.cs.rice.edu/~vs3/PDF/Sarkar-Harrod-Snavely-SciDAC-2009.pdf

Interested proposers should also be aware that ASCR anticipates related Funding Opportunity Announcements on **Scientific Data Management and Analysis at Extreme Scale and on Advanced Architectures and Critical Technologies for Exascale Computing**. When available, additional information may be found on the ASCR Funding Opportunities web site at http://science.doe.gov/ascr/Misc/Funding.html. Existing ASCR programs of likely interest to proposers include the following:

- Mathematics for Complex, Distributed, Interconnected Systems, http://www.science.doe.gov/grants/LAB09_23.html
- Joint Mathematics/Computer Science Institute, http://www.sc.doe.gov/grants/LAB09_22.html

- Mathematics for Analysis of Petascale Data,
  http://www.science.doe.gov/grants/LAB09_10.html

COMMUNITY BUILDING

An important goal of this notice is to foster an active, integrated research community of versatile researchers who are committed to the common goal of achieving exascale computation for advancing scientific discovery. Accordingly,

- Each research team should plan to send representatives to a kick-off meeting and an annual PI meeting, where they will give presentations on the status and promise of their research and engage in working sessions to address shared problems. Meeting attendees will include invited participants from other relevant research communities. The objectives of these meetings include fostering a sense of community and serving as a venue for exchange of information with complementary programs.

The proposal will need to include plans for the dissemination of research results, such as:

- Publications, conferences, and educational activities for the science user community: what mechanisms will the project employ to present its work to a broader community to ensure sustained activities in the research area and promote adoption by communities of scientists?
- Code release: how will the codes be released to allow other researchers to continue building and expanding on the knowledge gained?
- Testing at scale: Will the project perform software testing at scale? If so, what are the requirements for this testing (for example, hardware, specific architecture, specific test bed, etc)?

This program requires open source software development. Proposals should identify the open source license to be used.

PROGRAM FUNDING:

It is anticipated that up to $10,000,000 will be available for awards in Fiscal Year 2010, contingent on the availability of appropriated funds. Proposals may request project support up to three years. Out-year support is contingent on the availability of funds and on the progress of research and programmatic needs. Multi-lab and/or multi-institutional proposals are particularly encouraged. Funding for this research will come from the program. DOE is under no obligation to pay for any costs associated with preparation or submission of proposals. DOE reserves the right to fund, in whole or in part, any, all, or none of the proposals submitted.

Proposals may address one or more of the topics of interest. However, there is no limitation to the number of proposals a LAB or a Principal Investigator can submit.

SUBMISSION INFORMATION:

The instructions and format described below must be followed. All submissions and inquiries about this Program Announcement must reference Program Announcement Lab 10-257.

The research project description must be 20 pages or less, exclusive of attachments. The proposals must include a one-page abstract of the proposed research. All collaborators should be listed at the top of the abstract. Attachments include curriculum vitae, a listing of all current and pending federal support and letters of intent when collaborations are part of the proposed research. Curriculum vitae should be limited to no more than two pages per individual. All proposals submitted in response to this Announcement must explicitly state how the proposed project will support program goals and the ASCR mission, including the project's impact on applications of interest to the Office of Science.

The following is a list of essential items that a proposal must contain:

1. Field Work Proposal (FWP) Format - Complete and signed by appropriate officials.

2. Proposal Cover Page

3. Table of Contents

4. Budget Page(s) (Form DOE F 4620.1) - Complete a separate Budget Page for the entire multi-year period for each separate participating institution, if applicable.
http://www.science.doe.gov/grants/budgetform.pdf

5. Other Project Information

    a) **A one-page abstract (on a page by itself)**. The abstract should include: name of the laboratory; name of the principal investigator and the principal investigator's email address and phone number; name of the co-principal investigator(s) (if any) and their email address(es) and phone number(s); a summary of the project narrative.

    b) **Project Narrative: (limit 20 pages)** A detailed description of the proposed project (research plan), including the justification and objectives of the project, its relationship to the Office of Science program and the researcher's plan for carrying it out. The narrative should be limited to 20 pages maximum (8.5x11-inch pages of single-spaced, standard 11-point type with 1-inch margins), exclusive of attachments such as figures or references.

        i) Introduction - Should contain enough background material, including review of the relevant literature, to demonstrate sufficient knowledge of the state of the science.
        ii) Research Plan - The major part of the narrative should be devoted to a description and justification of the proposed project, including details of the method to be used. It should also include a timeline for the major activities of the proposed project, and should indicate which project personnel will be responsible for which activities. Include a plan that describes how the project results or

resources will be disseminated in a timely manner and in an accessible and usable form to the broader scientific community.

iii) Management Plan for multi-lab proposals - Should outline how the work will be coordinated among the participating institutions, the overall chain of command, the communication plan, the leads for each area, the overall allocation of resources among the various partners, etc.

c) **Curriculum Vitae:** Detailed information about the background and experience of the principal investigator and co-principal investigator (if any). Biographical sketches are limited to two pages for the principal investigator, and two pages for the co-principal investigator (if any).

d) **Long Term Measure:** The proposal must explain how the proposed research will advance the goals of the program and the ASCR mission, as well as its overall impact on applications of interest to the Office of Science.

e) **Facilities and Resources:** Include information on the experience of the proposer's organization, its facilities, and resources that would be relevant to successful operation of the project.

f) **Statement of all current and pending support** for the principal investigator and co-principal investigator (if any), including the time devoted to each project by the principal investigator and co-principal investigator (if any).

The instructions and format described should be followed. You must reference Program Announcement LAB 10-257 on all submissions and inquiries about this program.

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OFFICE OF SCIENCE
GUIDE FOR PREPARATION OF SCIENTIFIC/TECHNICAL PROPOSALS
TO BE SUBMITTED BY NATIONAL LABORATORIES

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Proposals from National Laboratories submitted to the Office of Science (SC) as a result of this Program Announcement will follow the Department of Energy Field Work Proposal process with additional information requested to allow for scientific/technical merit review. The following guidelines for content and format are intended to facilitate an understanding of the requirements necessary for SC to conduct a merit review of a proposal. Please follow the guidelines carefully, as deviations could be cause for declination of a proposal without merit review.

1. Evaluation Criteria

After an initial screening for eligibility and responsiveness to this Announcement, proposals will be subjected to a formal scientific merit review (peer review). The proposals will be evaluated against the following criteria, which are listed in descending order of importance:

1) Scientific and/or Technical Merit of the Project;
2) Appropriateness of the Proposed Method or Approach;

3) Competency of Researcher's Personnel and Adequacy of Proposed Resources; and
4) Reasonableness and Appropriateness of the Proposed Budget.

The evaluation process will include program policy factors such as the relevance of the proposed research to the terms of the Announcement and the agency's programmatic needs. Note that external peer reviewers are selected with regard to both their scientific expertise and the absence of conflict-of-interest issues. Both Federal and non-Federal reviewers may be used, and submission of a proposal constitutes agreement that this is acceptable to the investigator(s) and the submitting institution.

2. Summary of Proposal Contents

- Field Work Proposal (FWP) Format (Reference DOE Order 412.1A) (DOE ONLY)
- Proposal Cover Page
- Table of Contents
- Budget (DOE Form 4620.1) and Budget Explanation
- Abstract (one page)
- Narrative (main technical portion of the proposal, including background/introduction, proposed research and methods, timetable of activities, and responsibilities of key project personnel - 20-page limit)
- Literature Cited
- Biographical Sketch(es)
- Description of Facilities and Resources
- Other Support of Investigator(s)
- Appendix (optional)

2.1 Submission Instructions

Have your LAB administrator submit the entire LAB proposal and FWP via Searchable FWP (https://www.osti.gov/fwp). If you have questions about who your LAB administrator is or how to use Searchable FWP, please contact the Searchable FWP Support Center.

Please submit, via Federal Express, a single PDF file of the entire LAB proposal and FWP on a CD along with two hard copies to the address below. This will assist in expediting the review process.

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FOR FURTHER INFORMATION CONTACT:

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Program Manager: Dr. Lucy Nowell
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U. S. Department of Energy
Phone: 301-903-3191
E-Mail: Lucy.Nowell@science.doe.gov

3. Detailed Contents of the Proposal

Adherence to type size and line spacing requirements is necessary for several reasons. No researcher should have the advantage, or by using small type, of providing more text in his or her proposal. Small type may also make it difficult for reviewers to read the proposal. Proposals must have 1-inch margins at the top, bottom, and on each side. Type sizes must be at least 11 point. Line spacing is at the discretion of the researcher but there must be no more than 6 lines per vertical inch of text. Pages should be standard 8 1/2" x 11" (or metric A4, i.e., 210 mm x 297 mm).

3.1 Field Work Proposal Format (Reference DOE Order 412.1A) (DOE ONLY)

The Field Work Proposal (FWP) is to be prepared and submitted consistent with policies of the investigator's laboratory and the local DOE Operations Office. Additional information is also requested to allow for scientific/technical merit review.

3.2 Proposal Cover Page

The following proposal cover page information may be placed on plain paper. No form is required.

Title of proposed project
SC Program announcement title
Name of laboratory
Name of principal investigator (PI)
Position title of PI
Mailing address of PI
Telephone of PI
Fax number of PI
Electronic mail address of PI
Name of official signing for laboratory*
Title of official

Fax number of official
Telephone of official
Electronic mail address of official
Requested funding for each year; total request
Use of human subjects in proposed project:
> If activities involving human subjects are not planned at any time during the proposed project period, state "No"; otherwise state "Yes", provide the IRB Approval date and Assurance of Compliance Number and include all necessary information with the proposal should human subjects be involved.

Use of vertebrate animals in proposed project:
> If activities involving vertebrate animals are not planned at any time during this project, state "No"; otherwise state "Yes" and provide the IACUC Approval date and Animal Welfare Assurance number from NIH and include all necessary information with the proposal.

Signature of PI, date of signature
Signature of official, date of signature*

*The signature certifies that personnel and facilities are available as stated in the proposal, if the project is funded.

3.3 Table of Contents

Provide the initial page number for each of the sections of the proposal. Number pages consecutively at the bottom of each page throughout the proposal. Start each major section at the top of a new page. Do not use unnumbered pages, and do not use suffices, such as 5a, 5b.

3.4 Budget and Budget Explanation

A detailed budget is required for the entire project period and for each fiscal year. It is preferred that DOE's budget page, Form 4620.1 be used for providing budget information*. Modifications of categories are permissible to comply with institutional practices, for example with regard to overhead costs.

A written justification of each budget item is to follow the budget pages. For personnel this should take the form of a one-sentence statement of the role of the person in the project. Provide a detailed justification of the need for each item of permanent equipment. Explain each of the other direct costs in sufficient detail for reviewers to be able to judge the appropriateness of the amount requested.

Further instructions regarding the budget are given in section 4 of this guide.

* Form 4620.1 is available at web site: http://www.science.doe.gov/grants/budgetform.pdf

3.5 Abstract

Summarize the proposal in one page. Give the project objectives (in broad scientific terms), the approach to be used, and what the research is intended to accomplish. State the hypotheses to be tested (if any). At the top of the abstract give the lead DOE national Laboratory, project title, names of all the investigators and their institutions, and contact information for the principal investigator, including e-mail address.

3.6 Narrative (main technical portion of the proposal, including background/introduction, proposed research and methods, timetable of activities, and responsibilities of key project personnel).

The narrative comprises the research plan for the project and is limited to **20 pages (maximum)**. It should contain enough background material in the Introduction, including review of the relevant literature, to demonstrate sufficient knowledge of the state of the science. The major part of the narrative should be devoted to a description and justification of the proposed project, including details of the methods to be used. It should also include a timeline for the major activities of the proposed project, and should indicate which project personnel will be responsible for which activities. It is important that the 20-page technical information section provide a complete description of the proposed work, because reviewers are not obliged to read the Appendices. Proposals exceeding these page limits may be rejected without review or the first 20 pages may be reviewed without regard to the remainder.

All proposals submitted in response to this LAB Announcement must explicitly state how the proposed project will support the accomplishment of the program goals and the ASCR mission, including the project's impact on applications of interest to the Office of Science.

If any portion of the project is to be done in collaboration with another institution (or institutions), provide information on the institution(s) and what part of the project it will carry out. Further information on any such arrangements is to be given in the sections "Budget and Budget Explanation," "Biographical Sketches," and "Description of Facilities and Resources."

3.7 Literature Cited

Give full bibliographic entries for each publication cited in the narrative. Each reference must include the names of all authors (in the same sequence in which they appear in the publication), the article and journal title, book title, volume number, page numbers, and year of publication. Include only bibliographic citations. Principal investigators should be especially careful to follow scholarly practices in providing citations for source materials relied upon when preparing any section of the proposal.

3.8 Biographical Sketches

This information is required for senior personnel at the institution submitting the proposal and at all subcontracting institutions (if any). The biographical sketch is limited to a maximum of two pages for each investigator and must include:

Education and Training. Undergraduate, graduate and postdoctoral training, provide institution, major/area, degree and year.

Research and Professional Experience. Beginning with the current position list, in chronological order, professional/academic positions with a brief description.

Publications. Provide a list of up to 10 publications most closely related to the proposed project. For each publication, identify the names of all authors (in the same sequence in which they appear in the publication), the article title, book or journal title, volume number, page numbers, year of publication, and website address if available electronically. Patents, copyrights and software systems developed may be provided in addition to or substituted for publications.

Synergistic Activities. List no more than five professional and scholarly activities related to the effort proposed.

To assist in the identification of potential conflicts of interest or bias in the selection of reviewers, the following information must also be provided in each biographical sketch.

> *Collaborators and Co-editors*: A list of all persons in alphabetical order (including their current organizational affiliations) who are currently, or who have been, collaborators or co-authors with the investigator on a research project, book or book article, report, abstract, or paper during the 48 months preceding the submission of the proposal. Also, include those individuals who are currently or have been co-editors of a special issue of a journal, compendium, or conference proceedings during the 24 months preceding the submission of the proposal. Finally, list any individuals who are not listed in the previous categories with whom you are discussing future collaborations. If there are no collaborators or co-editors to report, this should be so indicated.

> *Graduate and Postdoctoral Advisors and Advisees*: A list of the names of the individual's own graduate advisor(s) and principal postdoctoral sponsor(s), and their current organizational affiliations. A list of the names of the individual's graduate students and postdoctoral associates during the past five years, and their current organizational affiliations.

3.9 Description of Facilities and Resources

Facilities to be used for the conduct of the proposed research should be briefly described. Indicate the pertinent capabilities of the institution, including support facilities (such as machine shops), that will be used during the project. List the most important equipment items already available for the project and their pertinent capabilities. Include this information for each subcontracting institution (if any).

3.10 Other Support of Investigators

Other support is defined as all financial resources, whether Federal, non-Federal, commercial, or institutional, available in direct support of an individual's research endeavors. Information on

active and pending other support is required for all senior personnel, including investigators at collaborating institutions to be funded by a subcontract. For each item of other support, give the organization or agency, inclusive dates of the project or proposed project, annual funding, and level of effort (months per year or percentage of the year) devoted to the project.

3.11 Appendix

Information not easily accessible to a reviewer may be included in an appendix, but do not use the appendix to circumvent the page limitations of the proposal. Reviewers are not required to consider information in an appendix, and reviewers may not have time to read extensive appendix materials with the same care they would use with the proposal proper.

The appendix may contain the following items: up to five publications, manuscripts accepted for publication, abstracts, patents, or other printed materials directly relevant to this project, but not generally available to the scientific community; and letters from investigators at other institutions stating their agreement to participate in the project (do not include letters of endorsement of the project).

4. Detailed Instructions for the Budget
(DOE Form 4620.1 "Budget Page" may be used).

4.1 Salaries and Wages

List the names of the principal investigator and other key personnel and the estimated number of person-months for which DOE funding is requested. Proposers should list the number of postdoctoral associates and other professional positions included in the proposal and indicate the number of full-time-equivalent (FTE) person-months and rate of pay (hourly, monthly or annually). For graduate and undergraduate students and all other personnel categories such as secretarial, clerical, technical, etc., show the total number of people needed in each job title and total salaries needed. Salaries requested must be consistent with the institution's regular practices. The budget explanation should define concisely the role of each position in the overall project.

4.2 Equipment

DOE defines equipment as "an item of tangible personal property that has a useful life of more than two years and an acquisition cost of $50,000 or more." Special purpose equipment means equipment which is used only for research, scientific or other technical activities. Items of needed equipment should be individually listed by description and estimated cost, including tax, and adequately justified. Allowable items ordinarily will be limited to scientific equipment that is not already available for the conduct of the work. General purpose office equipment normally will not be considered eligible for support.

4.3 Domestic Travel

The type and extent of travel and its relation to the research should be specified. Funds may be requested for attendance at meetings and conferences, other travel associated with the work and subsistence. In order to qualify for support, attendance at meetings or conferences must enhance the investigator's capability to perform the research, plan extensions of it, or disseminate its results. Consultant's travel costs also may be requested.

4.4 Foreign Travel

Foreign travel is any travel outside Canada and the United States and its territories and possessions. Foreign travel may be approved only if it is directly related to project objectives.

4.5 Other Direct Costs

The budget should itemize other anticipated direct costs not included under the headings above, including materials and supplies, publication costs, computer services, and consultant services (which are discussed below). Other examples are: aircraft rental, space rental at research establishments away from the institution, minor building alterations, service charges, and fabrication of equipment or systems not available off- the-shelf. Reference books and periodicals may be charged to the project only if they are specifically related to the research.

a. Materials and Supplies

The budget should indicate in general terms the type of required expendable materials and supplies with their estimated costs. The breakdown should be more detailed when the cost is substantial.

b. Publication Costs/Page Charges

The budget may request funds for the costs of preparing and publishing the results of research, including costs of reports, reprints page charges, or other journal costs (except costs for prior or early publication), and necessary illustrations.

c. Consultant Services

Anticipated consultant services should be justified and information furnished on each individual's expertise, primary organizational affiliation, daily compensation rate and number of days expected service. Consultant's travel costs should be listed separately under travel in the budget.

d. Computer Services

The cost of computer services, including computer-based retrieval of scientific and technical information, may be requested. A justification based on the established computer service rates should be included.

e. Subcontracts

Subcontracts should be listed so that they can be properly evaluated. There should be an anticipated cost and an explanation of that cost for each subcontract. The total amount of each subcontract should also appear as a budget item.

4.6 Indirect Costs

Explain the basis for each overhead and indirect cost. Include the current rates.