

Request for Information (RFI): Future Computing Systems Program (FCS)

IARPA-RFI-19-01

The Intelligence Advanced Research Projects Activity (IARPA) is seeking information on research efforts in the area of innovative, new computer hardware and software architectures with intelligent computer environments. This request for information (RFI) is issued solely for information gathering and planning purposes; it does not constitute a formal solicitation for proposals. The following sections of this announcement contain details on the scope of technical efforts of interest, along with instructions for the submission of responses.

Background & Scope

Future computing systems (FCS) should be a revolutionary class of advanced computers with both a new highly-capable architecture and an intelligent computational environment that “understands” its own state (as well as natural input commands), learns new concepts (which are then codified into knowledge), and uses this knowledge to skillfully deliver directed goals. FCS should enable users to focus on (rather than be distracted from) their applications, and to assist (rather than hinder) them in achieving their goals.

Over the past 60 years, computers have become orders-of-magnitude faster and both more complex and more diverse, but the computational model (i.e., the model for how algorithms/computations are executed) has not substantially changed. Consequently, the demands on users for system expertise have escalated to prohibitive levels. Concurrently, the need for real-time (or near-real-time) analysis of massive amounts of heterogeneous data in this new era of explosive data growth has dramatically broadened the application space for advanced computers beyond conventional HPC applications and has compounded the need for **ever-increasing computer capacity, capability, efficiencies, and agility**. The current volume and variety of data are already beginning to exceed the ability of today’s most advanced classical systems to deliver optimal solutions.

The time is long overdue for redesigning computers to be smarter and more self-sufficient, while continuing to deliver increasing performance to meet escalating demands. Computers need to be “intelligent systems” capable of assisting humans and other computers in executing extremely complex and data-intensive tasks, as well as of monitoring and maintaining their own operation. Such systems must be able to assist users in solving not only problems critical to national security and economic prosperity but also equally those that characterize all aspects of modern life.

To accomplish these goals, FCS should have three important new aspects: 1) a knowledge base/inference engine of cognitive and computer system management functions that is integral to system operation at all levels, 2) a machine learning capability that is integrated with the knowledge base to provide a unified “informed learning system” (i.e., the knowledge base guides learning and the newly learned concepts are then codified and incorporated into the knowledge base, and 3) a system design that enables efficient execution of these capabilities while minimizing “time to solution.” To ensure that the learned knowledge is correct and appropriate, the system for generating and growing the knowledge base system should include a monitoring subsystem that involves human oversight. The cognitive/management component is a key new feature that must provide comprehensive system-wide capabilities intrinsic and integral to system operation at every level to preclude the system from being blind-sided by partial knowledge or oversights.

An essential capability of FCS is understanding, i.e., an ability to reason and learn from “experience” so that the system improves its knowledge base, which is then used to understand and improve its computational environment. Reasoning and learning can be highly compute and memory-intensive. FCS must therefore be carefully designed and constructed to execute reasoning/learning algorithms efficiently and transparently, not only without impeding execution of the target application, **but while simultaneously providing increased capacity, capability, agility, and decreasing response times** for a representative range of data and compute-intensive applications. It is anticipated that the initial versions of FCS will be limited to specific problem domains that include the self-management of the computer and of the development and execution of optimized applications (plus additional areas that aid problem/data analysis). However, these initial versions must enable future inclusion of natural input modules and other, more advanced application-development and problem-solving subsystems.

The analysis of massive and diverse data sets requires the ability to efficiently execute algorithms for irregular data structures such as dynamic graph problems. FCS should be a class of advanced computer architectures that does for irregular time-varying data structures what classical high performance (HPC) systems have done for vectors and matrices throughout the previous six decades. Accelerated processing for such data structures should dramatically increase the performance for informatics computation and applications, including machine learning, data analytics, machine intelligence, and knowledge management. It should also improve dynamic numeric applications such as adaptive mesh refinement, particle in cell, and N-body problems critical to system modeling, materials, micro-biology, climate, chemical engineering, and manufacturing.

FCS should reduce the footprint and increase energy efficiency by several orders of magnitude over conventional platforms. The system configuration must be able to scale from desk-side systems to massive data centers. FCS must also maintain and advance the computational capabilities of the current generation of computer systems, and must have extensive methods of fault tolerance, security, and operational safety.

FCS should be transformative in their computing model and architecture structure (proposed architectures may be heterogeneous or homogeneous). This RFI does not include research on new materials, new fabrication technologies, and neuromorphic or quantum computers, but promising results from any of these areas may be included as part of the proposed FCS architecture if sufficient justification of their maturity is provided. The systems should also eliminate the communication barriers imposed by von Neumann architectures (and their derivatives) for superior throughput, operation, utilization of resources, and algorithmic performance. It is necessary to lay the foundations now for a revolutionary change in the design and usage of future computers that will shift software and hardware architectures from their current focus on compute-intensive only to include data-intensive and, most importantly, intelligence – through knowledge and learning – as integral to the system.

We seek responses to this RFI that provide a technical description of system architectures that enable the capacity and capabilities described in this RFI and that identify the required hardware- and software-enabling technologies. Responders must demonstrate expertise and experience in both computing architectures (hardware and software) and AI systems (knowledge base and machine learning technologies). The eventual goal is to build high performance computing systems in the future that address the above-stated challenges. In October 2015, the Office of Science and Technology Policy (OSTP) proposed “[A Nanotechnology-Inspired Grand Challenge for Future Computing.](#)” It is likely FCS will utilize

some of the technologies that result from the OSTP effort and other efforts that develop additional enabling technologies. One of the purposes of this RFI is to initiate discussions concerning the system hardware and software architecture for future computer systems.

Responses to this RFI should answer any or all of the following questions:

1. Is it possible to develop a computer system that provides the above-described features of FCS within the next 20 years? Specifically, what is the design of the system capability, “understanding”; what is the computational model for FCS; and what hardware and software innovations are required to achieve the FCS challenges? What are the barriers that must be overcome?
2. What is the time frame for the development of an FCS and what is the timeline for its development? The timeline should include a reasonable R&D path for the development of an FCS that leads to the required hardware and software technologies.
3. What are the approximate power and environmental specifications for the FCS?
4. What proxy applications, benchmarks and metrics can be used to drive the development of the FCS?

Preparation Instructions to Respondents

IARPA requests that respondents submit ideas related to this topic for use by the Government in formulating a potential program. IARPA requests that submittals briefly and clearly describe the potential approach or concept, outline critical technical issues/obstacles, describe how the approach may address those issues/obstacles and comment on the expected performance and robustness of the proposed approach. If appropriate, respondents may also choose to provide a non-proprietary rough order of magnitude (ROM) estimate regarding what such approaches might require in terms of funding and other resources for one or more years. This announcement contains all of the information required to submit a response. No additional forms, kits, or other materials are needed.

IARPA appreciates responses from all capable and qualified sources from within and outside of the US. Because IARPA is interested in an integrated approach, responses from teams with complementary areas of expertise are encouraged.

Responses have the following formatting requirements:

1. A one page cover sheet that identifies the title, organization(s), respondent's technical and administrative points of contact - including names, addresses, phone and fax numbers, and email addresses of all co-authors, and clearly indicating its association with RFI-19-01;
2. A substantive, focused, one-half page executive summary;
3. A description (limited to 10 or fewer pages in minimum 12 point Times New Roman font, appropriate for single-sided, single-spaced 8.5 by 11 inch paper, with 1-inch margins) of the technical challenges and suggested approach(es);
4. A list of citations (any significant claims or reports of success must be accompanied by citations);
5. Optionally, a single overview briefing chart graphically depicting the key ideas.

Submission Instructions to Respondents

Responses to this RFI are due no later than 4:00 p.m., Eastern Time, on January 14, 2019. All submissions must be electronically submitted to dni-iarpa-rfi-19-01@iarpa.gov as a PDF document. Inquiries to this RFI must be submitted to dni-iarpa-rfi-19-01@iarpa.gov. Do not send questions with proprietary content. No telephone inquiries will be accepted.

Disclaimers and Important Notes

This is an RFI issued solely for information and planning purposes and does not constitute a solicitation. Respondents are advised that IARPA is under no obligation to acknowledge receipt of the information received, or provide feedback to respondents with respect to any information submitted under this RFI.

Responses to this notice are not offers and cannot be accepted by the Government to form a binding contract. Respondents are solely responsible for all expenses associated with responding to this RFI. IARPA will not provide reimbursement for costs incurred in responding to this RFI. It is the respondent's responsibility to ensure that the submitted material has been approved for public release by the information owner.

The Government does not intend to award a contract on the basis of this RFI or to otherwise pay for the information solicited, nor is the Government obligated to issue a solicitation based on responses received. Neither proprietary nor classified concepts nor information should be included in the submittal. Input on technical aspects of the responses may be solicited by IARPA from non-Government consultants/experts who are bound by appropriate non-disclosure requirements.

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