Lifelong Learning Machines (L2M)
Frequently Asked Questions & Answers

Updated 6/15/2017

General

Q1: Multiple Participants and Award Size: the apparent intention to make multiple awards suggests that they will each be smaller. Any clarity you can offer concerning the sizing of awards will help me and others to properly establish the technical goals and manage the risks of our proposed research. Also, are small proposals of interest?
A1: That fact that the Government intends to make multiple awards should not be interpreted as an indication of intended proposal size/amount. The Government is seeking proposals that address all elements of each Technical Area discussed in the BAA (whether that be in the form of a small proposal or a large proposal). The BAA does not establish any constraints regarding proposal size, although it is noted that “Cost Realism” is an evaluation criterion.

Q2: Will there be another Proposers Day?
A2: Currently, there is no plan to hold a second physical event.

Q3: Foreign Participants: can non-US persons and organizations participate?
A3: Yes. As stated in the BAA, “non-U.S. organizations and/or individuals may participate to the extent that such participants comply with any necessary nondisclosure agreements, security regulations, export control laws, and other governing statutes applicable under the circumstances.”

Q4: Do we need to write separate proposals for Phase 1 and Phase 2?
A4: No. As indicated in the BAA, proposals must address phases 1 (as a base effort) and 2 (as an option). However, as a reminder, the BAA does stipulate that each proposal submitted may only address a single TA.

Q5: Can one company apply to multiple projects?
A5: Yes.

Q6: Can I include cost estimates in my abstract?
A6: You may.

Q7: Am I still on time to present a proposal even if I've not participated to the abstract evaluation and I've not participated to the proposers’ day?
A7: Yes - the due date for proposals is currently 30 June 2017 (please see the BAA).

Q8: Do you require that PIs be American?
A8: No.

General Technical

Q9: What metrics / quantitative goals for lifelong learning must proposals address?
A9: The BAA provides some quantitative goals for learning. In addition, proposers must define additional metrics and goals specific to their application area. The Center Group will have the opportunity to add new metrics as the program progresses.

Q10: Are you expecting a solution to exist at the time of writing the proposals?
A10: We are expecting solutions to be developed over the four year life of the program, with interim demonstrations of capability as outlined in the BAA. Proposals must offer a plan to develop appropriate solutions in accordance with the program timeline. Strong proposals will include credible evidence that the proposed solutions are technologically feasible.

Q11: Does this program support specialized hardware?
A11: L2M will not cover development or procurement of specialized hardware. However, some hardware-related effort is acceptable, like programming FPGAs or using hardware, robots, etc. that you already have and are familiar with.

Q12: Section B.3 (p10) says: "Incremental changes to the state of the art in AI and neural networks, including homogeneous networks—e.g., deep networks, classical spiking networks—are out of scope." What exactly is out of scope?
A12: What is out of scope are simple modifications of traditional AI / machine learning approaches, which do not have the capabilities we are seeking. In particular, homogeneous (neural) networks (i.e. with uniform structure, node type, and learning rule) and incremental tweaks of such networks (e.g. simply adding depth or spiking) are out of scope. Achieving the flexible learning outlined in the BAA is expected to require various learning rules, node types, and structures. If you believe you can achieve diverse and flexible learning behaviors as emergent properties of an underlying homogenous network with a fixed learning rule, your proposal will need to demonstrate evidence for this assertion. Proposed research directions will be assessed partly on the capabilities they can be expected to provide by the end of the L2M program, and partly on their promise for future research and development.

Q13: What is a Plastic Nodal Network?
A13: A Plastic Nodal Network (PNN) is a bio-inspired notion of a computational network, in which the network serves as the fabric for both memory storage and computation, and can change with input. The initial state of the PNN can be likened to an infant with less developed capabilities, and increased nodal group interconnectivity. We envision the following to be some attributes of a PNN:

1. The initiated PNN would have multiple types of nodes that are grouped into functional modules. These modules may introduce soft hierarchies.
2. The primary means of configuring (programming) the PNN would be through defining rules governing how the nodes interconnect, e.g., make, break, reinforce, or deemphasize connections. Furthermore, different sets of nodal connection rules would characterize a variety of nodes, allowing them to provide distinct functions within the system.
3. The PNN would start with basic, inherent, fixed properties inspired by the brain stem, including, e.g., hunger, intrinsic/external motivations, reward and punishment, warnings, global state modification (hormones), and local state modifications (i.e., affect a subset of nodes, trigger by external input).
4. The system should be asynchronous (event driven) and recurrent.
5. Nodal interconnections should be driven by sensory input.
6. Since the PNN is complex, it should have the potential to self-develop rather than having its
details being completely engineered. One possibility is to evolve its behavior through mechanisms that resemble natural selection.

Q14: Is a sub-symbolic TA1 solution acceptable, or must it be “programmed”?
A14: Sub-symbolic solutions are preferred, since L2M seeks to avoid point solutions to individual domain problems, but not required.

Q15: What is expectation at the end of four years? A machine, a system?
A15: This is a 6.1 funded program, so we don’t anticipate immediate transition into commercial products. We intend to have new mechanisms, such as a new type of neural net. The demonstrations are for internal consumption. Specifically, for TA1, we expect to see working prototypes that quantifiably demonstrate the five core capabilities outlined in Section C of the BAA. For example, we would expect new types of neural networks, new structures that can modify their own rules, and other new ideas and features that demonstrate that lifelong machine learning as feasible. At the end of Phase 1, each performer team must demonstrate that their system performs the five core capabilities of lifelong machine learning within their domain. At the end of Phase 2, we expect to see more generalized solutions demonstrated. We expect solutions to focus on developing lifelong machine learning, not point solutions for specific domains.

Q16: Is it in scope of the BAA to create datasets if existing datasets do not have lifelong learning features?
A16: As long as the focus of the work is to develop lifelong machine learning via the five core capabilities in Section C of the BAA, it is acceptable to spend some effort in creating datasets. If the data is to provide sensory input for the prototype system, please be sure that the data is multi-sensor.

Q17: What does “safety” mean in the context of L2M?
A17: Safety here means that the system should operate within appropriate bounds and have some built-in inhibitions to avoid catastrophic errors. Since L2M systems will continue to change over time, ensuring correct operation requires additional care. This notion of safety motivates the System Monitor capability requirement within TA1.

Q18: Why do we want human control and monitoring of our L2M systems?
A18: First, to provide a safeguard against catastrophic actions. Second, we want to allow humans to study the evolution of the system as it learns to better understand its adaptations. The System Monitor is not intended to substitute human analysis in place of algorithmic processing during normal operation.

Q19 Is the application of formal methods to safety and reliability in-scope?
A19: Yes, that is one plausible approach one could propose.

Q20: Is learning to reason/act from symbolic information (e.g., from text input) within scope of L2M, or is the focus primarily on perception (e.g., vision)?
A20: Learning from symbolic input is in-scope. It is desirable to minimize the need to hand-craft a symbolic framework for each application (see Question 9). In TA1, ingestion of more than one input modality (such as text and vision) is highly desirable.
Q21: What is a good example of an application driver to develop L2M capabilities?

A21: The intent of an application driver is to provide a framework to develop and evaluate approaches to accomplish learning in an artificial system as described in the BAA.

The application driver example is a simulation consisting of L2M driven drones moving in a three-dimensional environment. Nodal connection rules in drones are driven by sensory input provided by several sensors:

a. Visual
b. Auditory
c. Tactile for sensing ‘pain’ when bumping into obstacles
d. Vestibular or alternate sensing of its physical orientation and movement
e. Olfactory or alternate method of sensing food

The simulated environment includes:

a. Stimuli that act on the full complement of sensors
b. Gravity
c. Obstacles
d. Other drones
e. Energy supply areas that act as a motivation for drone movement

Drone behavior would evolve via a natural selection type scheme acting on PNN nodal connection rules.

The intent of the application driver is not to focus performer resources on the physics of the environment down to the level of simulating fluid-dynamics, but to provide a simulated environment just complex enough for L2M systems act on, to encourage the systems to learn, and, later, to apply learning in new situations. A fun fact is that in evolution, only agents that interacted with their environment (e.g., moved within it, used multiple sensors to understand it) and had their basic inherent needs (e.g., food, pain, pleasure) developed brains. This example incorporates these properties.

TA2

Q22: Please elaborate on the goals of TA2.

A22: TA2 is described in Section C.2 of the BAA. It is an effort to understand and study how existing systems - biological or other natural mechanisms – manage to solve the five core lifelong learning algorithmic features, which are hard to achieve as of yet in artificial systems. The study can be done in various levels – going all the way from summarizing existing studies and up to developing your own computational models and lab experiments. The playground is almost open, but with the caveat that deliverables of this study include detailed documentation of the developed algorithms that follow the natural mechanism(s) studied and that can demonstrate solving some of the core L2M properties. Under TA2, you will study mechanisms and develop them into software that will advance the state of the art in AI / Machine Learning.

Q23: In TA2, how are performers expected to measure success?

A23: Per Section C.2 in the BAA, performers are expected to implement a biological mechanism for lifelong learning into a new algorithm for machine learning and demonstrate that the new algorithm
measurably improves performance on at least one of the five core capabilities specified for L2M in Section C.1 of the BAA. TA2 proposals must include additional project specific metrics and milestones for assessing progress towards this goal. See also Q/A6 in this FAQ.

Q24: Is L2M interested only in biological mechanisms for TA2, or are ideas from other areas also welcome?
A24: Ideas are welcome from any appropriate domain as long as they demonstrate a mechanism for lifelong learning that you will ultimately transfer to provide a solution for some of L2M’s core capabilities as specified in Section C.1 of the BAA. TA2 proposals must address the relevant TA2 questions as posed in Section C.2 of the BAA.

Q25: May TA2 performers have experimental collaborators? Can we do experiments in biology? In particular, can we do wet neuroscience?
A25: Yes, if experimentation is needed to understand the mechanisms and the results are applicable to L2M AI in terms of providing the information required to create new lifelong machine learning algorithms that improve the performance of at least one of the five core capabilities specified in Section C.1 of the BAA.

Q26: Is there a specific computing platform for TA2?
A26: The computing platform for software solutions is not constrained by the BAA. Note, however, the restrictions on hardware development and purchase as described in Q/A8.

Specific Approaches / Domains

Q27: Approach XX already solves the L2M problem. Is this a good answer?
A27: Proposals to TA1 must address all five core capabilities as specified in Section C.1 of the L2M BAA. If you have something that you believe already achieves these capabilities, this would be a good answer. A reminder that the abstract process allows feedback on proposed approaches.

Q28: Does the program expect domain specific or general learning solutions?
A28: The idea is that performers will start with their own domains and progressively extend toward general solutions. At the close of the program, we want general systems.

Q29: Which domains would DARPA like to see? Would XX count as an acceptable domain?
A29: The specific domain is less important than demonstrating flexible, generalizable lifelong learning capabilities. We are interested in creating a new chapter of AI. Our primary focus is on creating the lifelong machine learning that works in not fully predicted realistic environments. Demonstrations are important to show that the performers’ techniques work. Domains are useful in providing initial context for a given application, but then you will generalize the solution. Generalizable learning mechanisms are more important than point solutions on a “DoD” domain. You are welcome to use existing software environments to run your solution.
**Q30: Is field XX TA1 or TA2?**
A30: If the proposed work aims to build a solution system that addresses all of the core capabilities specified in Section C.1 of the BAA, it is TA1. TA1 focuses on system capability. If the proposed work is more exploratory (i.e., for investigating and implementing new mechanisms- taken from any L2 system of another field - that can improve the performance of one or more of the five core capabilities), then you should propose toward TA2.

**Q31: Is L2M interested in systems that actively probe their environment?**
A31: Yes. Please be sure to consult Section C of the BAA to be sure you are proposing to the correct TA.

**Center Group**

**Q32: What is the role and purpose of the Center Group?**
A32: As stated in section I.C.3 of the BAA, the Center Group will master the L2M field. The Center Group will include a representative from each performer group, as well as a few leaders from the Government. Learning together what is necessary from various fields – computer science, biology, possibly physics, medicine, math – the Center Group will be in a situation to lead the new chapter of AI. The group will further help preventing stove-piping, enhance cross-pollination across projects and TAs, and ensure coordination for evaluation purposes.

L2M is a 6.1 level program, which implies that the majority of its developments should be at a pre-competitive stage. Participation in the Center Group does not require an organization to share any intellectual property against its will. At the same time, the members will share insights into a world-leading collective, as they do in technical conferences, and members will be assessed on their effectiveness in contributing to this mission. To this end, DARPA does not foresee there being any need for non-disclosure agreements for Center Group members.

**Q33: Must my team’s representative to the Center Group be the Principal Investigator (PI)?**
A33: You may designate anyone from your team who has a solid understanding of the full technical scope of your effort and the interest, skill, and availability for working collaboratively with other experts from diverse projects. Since the time commitments for Center Group participation may be infeasible for many PIs, designating a Co-PI, postdoc, or similar technically-competent representative is acceptable. For consistency, ideally the same person would serve in this role throughout the program, though we recognize that circumstances may require occasional changes.