Impact of Advances in Computing and Networking on DOE Labs and Future Scientific Methodologies 30 years from now

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Thirty years from now, advances in computing will not only result in computers that are orders of magnitude faster, but will also result in

(1) Advances in networking technologies that enable extremely low latency and high bandwidth access to remote resources;
(2) Availability of quantum computers that make some classes of problems trivially easy to solve;
(3) A deluge of data from both supercomputer simulations and large-scale scientific experiments;
(4) Artificial intelligence technologies that will automate many routine tasks that humans must do themselves today;
(5) Software in general becoming more sophisticated and doing things that we cannot imagine being done by software today.

These and other advances will have many implications for DOE labs and future scientific research methodologies, some of which are outlined below.

(1) Artificial intelligence technologies will be mature and available in software that is widely deployed. As a result, researchers will no longer need to do routine tasks that can be automated by AI agents. For example, researchers will no longer need to write code the way we know it today, because AI agents will be able to write many kinds of programs. Similarly, AI will automatically control many aspects of scientific experiments. Human endeavor will focus on highly creative tasks that AI will not be able to do, such as developing the next generation of AI itself.

(2) Exabytes of data will be generated by large-scale scientific experiments and supercomputer simulations. Important scientific discoveries will be hidden in the data, waiting to be uncovered. Intelligent software will be needed to find the needle in the haystack; human beings will not be able to find it on their own.

(3) Commercially available cloud computing will be highly mature, economically priced, and accessible through super-fast networks. As a result, DOE labs will need to reconsider whether they should host large-scale computing facilities on site as they do today, for both capacity and capability computing. Instead, an alternate role for facilities at the labs 30 years from now could be to host testbeds for exploring futuristic technologies, beyond what is commercially available at that time, perhaps in areas such as quantum, neuromorphic, and bio-inspired computing.

(4) In terms of workforce, advances in networking and in software for remote collaboration and remote work will enable DOE labs to employ top talent that is geographically distributed anywhere in the world (at least for open science), without the need for those employees to relocate to the lab site or even to the United States. Working remotely from anywhere in the world will be as easy and common as working together in the same room.

(5) Another aspect of workforce is that DOE labs will need to work more closely with industry because, in some areas of technology, industry will be at the forefront. We are already seeing this in areas such as artificial intelligence and cloud computing. Top talent in such areas will want to work in companies that are paving the way in their field. DOE labs will need to work out ways to enable this

top talent to also be associated with the labs. Joint appointments with industry will be needed just as they are with academia today. Associated intellectual property issues will need to be sorted out.