Communication Protocols for Future Scientific Use Cases

Jason Zurawski
Lawrence Berkeley National Laboratory / Energy Sciences Network (ESnet)
zurawski@es.net

Computer networks, including those used by DOE/SC labs and facilities, have benefited from a universal communication protocol suite for nearly 40 years: Transmission Control Protocol & Internet Protocol (TCP/IP). These concepts have influenced generations of application development by providing a transparent and resilient mechanism to control the communication between endpoints, thus un-burdening developers and simplifying deployment across networks and end systems. Despite the benefits, there are challenges to this aging infrastructure: namely how to increase performance for high-profile use cases, namely bulk data movement between experimental facilities, analysis centers, and custodial storage, as well as take advantage of emerging functionality embedded in networks that have advanced since the early days of system design[1]. End-users and operators have grown accustomed to the shortcomings, and have developed techniques and strategies for coping with the weaknesses[2]. Instead of implementing new protocols to use new infrastructure, we configure new infrastructure to cope with the shortcomings of old protocols.

Advancement in hardware and software design has now bestowed an environment where middle box systems are just as capable as the edge systems that populate them, and this untapped potential is appealing to the design of future protocols and applications. There are numerous questions[3] regarding the future direction of network research, many of these alluding to barriers to advancement due to the use of legacy processes and morays. Future protocols may differ in key ways:

- Centralized, versus distributed, control and management to facilitate higher-profile use cases and resource management
- Integration directly with end systems of value (e.g. computation and storage)
- Performance that is agnostic to the underlying changes to topology and addressing
- Ability to adjust to communication and network disruption (e.g. parallelism, delay, loss, corruption, and duplication, etc.)

DOE/SC should be prepared for a future where TCP/IP is not the dominant communication mechanism, and in doing so can think about larger capabilities and use cases that are not constructed on the prior generation of functionality. In doing so, the network will become an integral part of experimentation, and open new opportunities for scientific use cases. This readiness can take the form of new exploration of protocols, or joining national efforts to research and develop.

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[1] J. H. Saltzer, D. P. Reed, D. D. Clark, “End-to-End Arguments in System Design,” 2nd International Conference on Distributed Computing Systems, Paris, (April 1981), pp. 509-512.
[2] Mathis, Matthew & Heffner, John & Reddy, Ranjeeth. (2003). Web100: Extended TCP instrumentation for research, education and diagnosis. Computer Communication Review. 33. 69-79. 10.1145/956993.957002.
[3] Partridge, Craig. “Forty data communications research questions.” Computer Communication Review 41 (2011): 24-35.