

# Chapter 1

## Extensibility and Multi-Tenancy

Since the end of Dennard scaling, disaggregation has become the norm in the datacenter. Applications are typically broken into a compute and storage tier separated by a high speed network, allowing each tier to be provisioned, managed, and scaled independently. However, this approach is beginning to reach its limits. Applications have evolved to become more data intensive than ever. In addition to good performance, they often require rich and complex data models such as social graphs, decision trees, vectors [4, 3] etc. Storage systems, on the other hand, have become faster with the help of kernel-bypass [5, 1], but at the cost of their interface – typically simple point lookups and updates. As a result of using these simple interfaces to implement their data model, applications end up stalling on network round-trips to the storage tier. Since the actual lookup or update takes only a few microseconds at the storage server, these round-trips create a major bottleneck, hurting performance and utilization. Therefore, to fully leverage these fast storage systems, applications will have to reduce round-trips by pushing compute to them.

Pushing compute to these fast storage systems is not straightforward. To maximize utilization, these systems need to be shared by multiple tenants, but the cost for isolating tenants using conventional techniques is too high. Hardware isolation requires a context switch that takes approximately 1.5 microseconds on a modern processor [2]. This is roughly equal to the amount of time it takes to fully process an RPC at the storage server, meaning that conventional isolation can hurt throughput by a factor of 2 (Fig 1).

# Bibliography

- [1] Aleksandar Dragojević, Dushyanth Narayanan, Edmund B. Nightingale, Matthew Renzelmann, Alex Shamis, Anirudh Badam, and Miguel Castro. No compromises: Distributed transactions with consistency, availability, and performance. In *Proceedings of the 25th Symposium on Operating Systems Principles, SOSP '15*, page 54–70, New York, NY, USA, 2015. Association for Computing Machinery.
- [2] Chinmay Kulkarni, Sara Moore, Mazhar Naqvi, Tian Zhang, Robert Ricci, and Ryan Stutsman. Splinter: Bare-metal extensions for multi-tenant low-latency storage. In *13th USENIX Symposium on Operating Systems Design and Implementation (OSDI 18)*, pages 627–643, Carlsbad, CA, October 2018. USENIX Association.
- [3] Mu Li, David G. Andersen, Jun Woo Park, Alexander J. Smola, Amr Ahmed, Vanja Josifovski, James Long, Eugene J. Shekita, and Bor-Yiing Su. Scaling distributed machine learning with the parameter server. In *11th USENIX Symposium on Operating Systems Design and Implementation (OSDI 14)*, pages 583–598, Broomfield, CO, October 2014. USENIX Association.
- [4] Rajesh Nishtala, Hans Fugal, Steven Grimm, Marc Kwiattkowski, Herman Lee, Harry C. Li, Ryan McElroy, Mike Paleczny, Daniel Peek, Paul Saab, David Stafford, Tony Tung, and Venkateshwaran Venkataramani. Scaling memcache at facebook. In *10th USENIX Symposium on Networked Systems Design and Implementation (NSDI 13)*, pages 385–398, Lombard, IL, April 2013. USENIX Association.
- [5] John Ousterhout, Arjun Gopalan, Ashish Gupta, Ankita Kejriwal, Collin Lee, Behnam Montazeri, Diego Ongaro, Seo Jin Park, Henry Qin, Mendel

Rosenblum, and et al. The ramcloud storage system. *ACM Trans. Comput. Syst.*, 33(3), August 2015.