Review of Xen and the Art of Virtualization [1]

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This paper describes Xen, an approach for virtualization. Because of increasing processing power of modern processors, a machine can be better utilized if multiple users can share a machine. Virtualization is a way to give users flexibility of running whatever they want in their own machine, while it is actually running on a single physical machine among others. However, existing virtualization techniques came with large performance overhead or other limitations such as decreased level of security. The Xen proposed in this paper is a solution to such limitations.

The basic approach that Xen follows is what has been previously proposed as para-virtualization. Para-virtualization sacrifices the ability to run existing OSes as it is for additional performance. Virtualization techniques that can run OSes without modification is called full-virtualization. Both types of virtualization allows user applications to run without modification.

The need to modify kernels may be the biggest problem in then, or para-virtualization as a whole. The paper reports the cost of modifying kernels to work in Xen to be few thousand lines of code, which may not be too much compared to the size of the OS code. However, other problems such as maintaining two versions of an OS so that updates are reflected to Xen version, can add extra complexity. In addition, the users now have to install additional kernels just to start Xen, which can be a lot of work (and it has been in my experience). Since Microsoft was involved, they were able to modify Windows XP, but the difficulty of using non-open source OSes is another limitation.

However, with the above costs paid, the performance of then looks very good in their extensive evaluation. They showed Xen posed only a few percent overhead compared to native linux, and it can scale up to 128 instances. Since they are already using half of their pages to evaluation, this is too much to ask, but it would be interesting to see how Xen works with different physical machines and different OSes running. Their evaluation also tested mostly on uniform workloads, and it would be interesting to see how it works with 128 OSes, some running compute-bound and some running I/O-bound computations.

Although they have designed Xen to reduce overhead, there are still some questionable pieces in their description of details. One thing that they do acknowledge is its simple scheduling algorithms seen in multiple places such as network or disk interface. They have partially considered dynamic load changes by allowing GuestOSes to acquire or release memories according to their needs. However, passing around memories over 100 OSes over a long period of time may result in a defragmented memory allocations. It is unclear if they handle this, but it did not seem like they have tested running Xen for a long time.

It is probably very difficult to take hardware prefachers into account, but modern processors have prefetchers that can prefetch memory ahead of time when it sees some pattern. However, the amount of prefetching stream that limits the number of concurrent prefetchings are around 6 or 8. With 100 OSes, there won’t be enough prefetching streams, and some applications may be written with prefetching in mind, and would resultin poor performance.

In the context of cloud computing, Xen can allow users with different OS requirements to share the same cluster. However, an extension to virtualization that would help even more is the idea of parallel virtual machines (which had been brought up by Michelle in class). If Xen can virtualize across multiple machines, and place GuestOSes in machines in a cluster it becomes a very powerful tool to distribute computation over a cluster. The user can create domains for their task, and each domain gets mapped to some machine in the cluster, so that if a user creates multiple domains, it gets distributed.
References

[1] Paul Barham, Boris Dragovic, Keir Fraser, Steven Hand, Tim Harris, Alex Ho, Rolf Neugebauer, Ian Pratt, and Andrew Warfield. Xen and the art of virtualization. In SOSP ’03: Proceedings of the nineteenth ACM symposium on Operating systems principles, pages 164–177, New York, NY, USA, 2003. ACM.