Emerging Computing Technologies: Hewlett-Packard's "The Machine" Project

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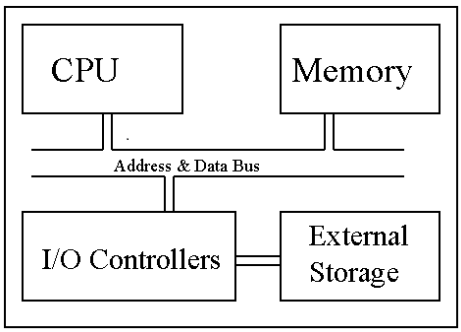
Abstract: The following white paper is part of a quarterly series developed by Willdan Energy Solutions. The intent of the series is to provide the intelligence we have collected through implementation of data center energy efficiency programs nationally. We seek to identify technologies and strategies that can become actionable items in utility-run data center programs. This quarter's white paper focuses on Hewlett-Packard's research and development into next generation computing architecture, a project that has been dubbed "The Machine". This effort aims to combine high density universal memory, photonic data transfer, new operating systems, and a new configuration into a scalable computing device that offers greater data processing and storage while using much less energy. The project was announced by CEO Meg Whitman and CTO Martin Fink at the HP Discover 2014 conference held in Las Vegas June 10-12, 2014.

Overview

The explosion of cloud computing, internet applications, big data, and automation is resulting in the need to process and store enormous and ever growing amounts of data. The demand for energy, space, and capital calls into question how sustainable this growth can be using current technology. According to HP, cloud computing now uses as much energy as the whole country of Japan[1].

To satisfy the need for huge amounts of servers and to control costs, large internet firms such as Google, Amazon, and Microsoft have in recent years begun assembling their own servers using commodity parts. This has decreased the server market share of large traditional "systems" companies such as HP, Dell, and IBM. In response to these trends, HP is making a large investment in building a new computing platform from the ground up.

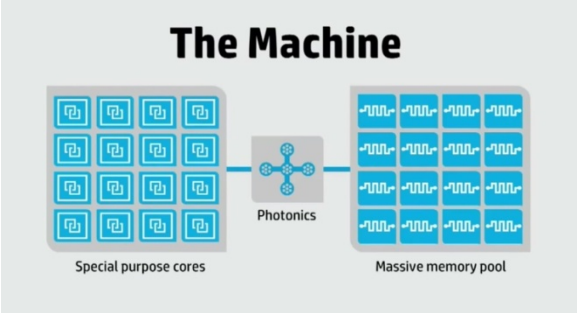
The fundamentals of computer architecture have remained largely unchanged since the 1940's. There have been major improvements along the way and different architectures used for special applications, but just like the massive mainframes of the past, computing in today's data center consists of processors communicating with multiple tiers of memory via copper conductor.



Simplified Computer Architecture Diagram

These memory tiers are comprised of system memory (where information is processed) and data storage (where programs and files are kept). Computers spend up to 80% of their time

and energy moving electrons from one memory tier to another through copper channels[2]. This energy use is necessary under current designs, but HP proposes a redesign to accomplish the same computing tasks with much less energy. To do this they propose a technology capable of acting as cache, memory, and storage all in one and use a more efficient means of moving electrons than copper conductors. This is what HP's "The Machine" project is attempting to accomplish, albeit in the face of difficult technical challenges.

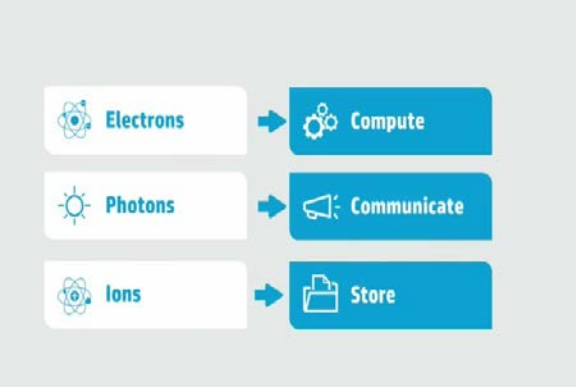


Simplified Diagram of "The Machine"[3]

"The Machine" Solution

The new architecture incorporates a "Universal Memory" concept based on a technology called the memristor (a combination of the terms "memory" and "resistor"). A memristor is a circuit element whose electrical resistance depends on the current that has previously flowed through it. Central to project's success is the claim that memristor memory can be created that has the speed and performance of cache as well as the permanence of storage.

HP researchers have been able to create functional memristors using titanium dioxide film. This approach uses ions to store information instead of electrical charge. Storing information at the atomic level allows dramatic increases in memory density, between a 64 and 128 fold density increase over existing DRAM memory[4] and in addition, it greatly increases the speed of storing and retrieving information. To communicate this volume of information with current designs would require large amounts of copper conductors and thus large amounts of energy. To address this, HP proposes using photons (light) instead of copper. This is akin to employing fiber optics, but at the nano level. The increase in communication speed allows scalability of the technology, allowing large increase in data processing within a data center while reducing energy consumption.



Photons Replace Copper Communication and Ions Allow for High Density Memory Pools[3]

Much of the technology used in "The Machine" is being pioneered right now. Past delays in getting memristor technology to the market suggest serious difficulties in manufacturing[5]. Inventing manufacturing processes to produce the memory cheaply and at scale will be vitally important to its success. Standards will need to be developed for the new technologies as well.

Perhaps the biggest technological hurdle the project faces is on the software side. Operating systems have not been designed for this new architecture. Even though HP proposes open source development and university research to

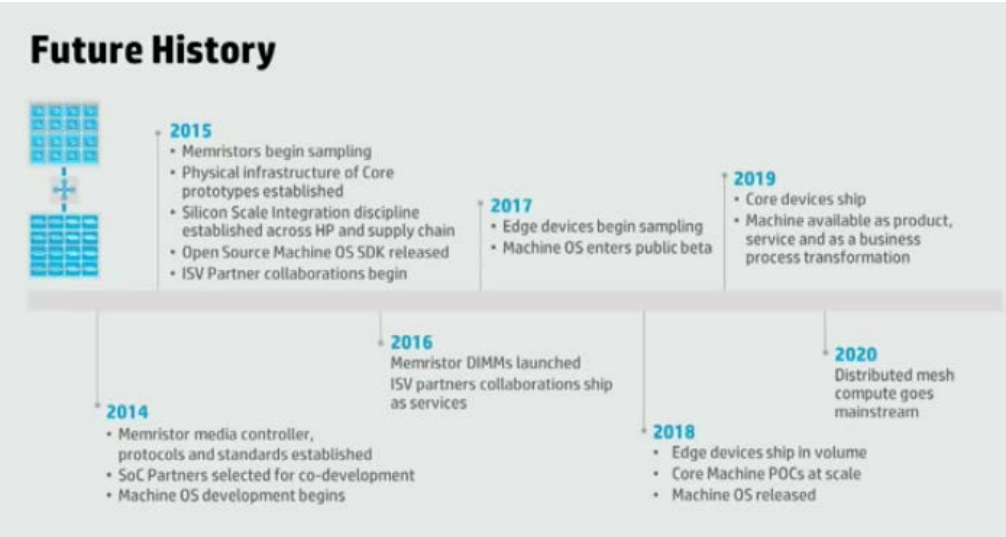
build the technology needed to run the new architecture, a solution could prove elusive or end up marrying a proprietary software/hardware combination which is against current market trends. In addition, any new operating software would need to be compatible with legacy systems for widespread adoption.

HP intends to have Machine based products to market by the end of the decade. By HP's estimation, a Machine-based system could compute over five times faster than the current record-holding supercomputer while using just over one percent of the power[3].

Conclusion

The data center industry and thus utility data center programs may be impacted if these claims come to fruition at an affordable cost. It's possible that a large, sudden growth in computer hardware power would dampen the growth of new data centers that the industry is currently experiencing. For this to happen though, the growth in computing capabilities would have to outpace the growth in demand for data processing and storing. This is far from certain. It is possible that expansions in computing power will spur the creation and storage of ever more data. Akin to server virtualization, this may be a way for data centers to increase their operations with the power and cooling infrastructure they have in place. Hence, a few years from now, utility data center programs may choose to incentivize the switch from a traditional server environment to one based on HP's new technology.

While the energy savings potential for "The Machine" has lofty claims, there are a number of technological breakthroughs that need to take place before a commercial product can be available. In the timeline HP has presented, production may be 6-10 years away, and with the ever-changing landscape of the IT industry, the true impact of the technology remains to be seen. Given the likely cost and potential complications with any emerging technology, the early adaptors will likely be companies HP partners with to promote "The Machine" as well as high-compute intensive research labs, likely at the university or governmental level.



HP's Proposed Development Timeline[3]

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