Evolving Server Architectures Challenge Standardization Efforts

A Study for the SSI Forum

Michael Feldman, Intersect360 Research

The dynamic tension between standardization and innovation is played out in many computer industry domains, not the least of which is the server segment. Standardization is generally perceived as a good thing, creating stable expectations for both vendors and users. But the rapid advancement of server componentry, especially microprocessors, and the diversification of server applications has led to new types of architectures that challenge the orthodoxy of standards.

The Case for Standardization

Having standard parts and interfaces for servers offers a couple of important advantages:

- Standard components like x86 processors, DDR memory, SATA disks, power supplies, and so on, leads to greater competition and lower costs by supporting a larger number of vendors
- Accepted industry interfaces, like PCI, Ethernet and USB, enables interoperability and avoids vendor lock-in, which again lowers costs

In general, as parts become interchangeable, the hardware ecosystem become more robust, and conversely, allows for greater innovation at the component level. It also allows for innovation at the system design level since standard components can be combined in unique ways. Finally, it enables the same software to run on different platforms, which relieves software makers of creating and maintaining different versions for different platforms.

Since the 1970s, 1U rack-mount server – the 19-inch “pizza box” – was standard fare for practically every data center in the world. The internals consisted of a fairly homogeneous set of parts, for the most part, x86 processors, DDR memory, network controllers (Ethernet, InfiniBand and Fibre Channel), and disk drives (SATA or SAS), and power supplies. Each box represented a complete computer, with PCI or Ethernet acting as a conduit to other computers or external devices. Even without formal specifications, many component providers could rely on these basic de facto standards for their product offerings.

Servers Diversify

But beginning in the early 2000s, blade servers appeared, condensing servers into vertically-aligned boards that slide into a chassis, which incorporates shared power, cooling, networking and system management. This allowed for much denser server configurations and energy savings compared to rack-mounted systems. This architecture was often more efficient for applications that could be hosted on clusters of specific sizes.

Although individual blades were hot-swappable, since server infrastructure was shared, they did not have the general-purpose versatility of rack-mounted, systems. More importantly, each vendor's componentry was different, confounding any sort standard that could be taken advantage of by parts vendors. As a result, blade systems tended be priced at a premium compared to rack-based systems since they shut out independent suppliers.

Then starting in the 2010s came microservers, an even denser architecture than blades and one that relied on ultra-low-powered processors. The goal here was to rebalance compute and data performance in the desire for extreme energy, space and cost efficiencies. As in blades, microservers employ shared infrastructure, but with a more complete integration of cluster components (like networking and storage) within the enclosure, as well as additional integration offered by System-on-a-Chip (SoC) technology

In essence, SoCs present the prospect of a server on a processor, integrating network controllers, I/O controllers, and in some cases, compute accelerators like encryption circuitry, GPUs and DSPs. The remaining real estate on the microserver motherboard/card is related to main memory and interfaces to external I/O. Like blades, things like power supplies and networking are integrated into the microserver chassis.

Theoretically, this simplifies the design, which would encourage standardization. But again, each system vendor was committed to their own designs. In some cases, proprietary interprocessor communication fabrics are being used (for example, AMD's "Freedom Fabric") to hook together server nodes in the chassis. Finally, competing processor architectures (x86 and ARM) in the microserver space will further tend to complicate standards-making.

Specific architectures aside, the overarching trend is toward the cluster in a box – some would say, data center in a box – where individual server nodes cohabitate with other nodes in the same enclosure. Thus the new "server" is a multi-node cluster in a standard (42U) rack or chassis sub-rack (2U, 4U, or whatever)

Application Drivers

Driving much of the architectural evolution are a handful of high-growth application areas, namely, cloud/web-based computing, big data applications, and high performance computing. All of these areas are growing at much faster rates than generic enterprise computing and, together, already represent a very large share of the server market.

With some exceptions, data movement for these application is more important than compute performance; most are memory- or I/O-bound. This is even the case for many HPC workloads that are traditionally perceived as compute-bound.

Most of these application also require computing at scale, typified by the ultra-scale data centers maintained by the likes of Google, Amazon, and Facebook. Although, the application set is diverse, highly scalable web environments point toward leaner server designs with greater density and energy efficiencies. Individual players, such as the three aforementioned companies, are so large that they find it economical to design and build their own servers.

Even though microservers are the logical endpoint for this application profile, both rack and blade servers are also evolving along these same line. Note that this leaner, meaner architecture, are not just applicable for lightweight applications like web hosting, but also heavy-duty applications like big data analytics and HPC codes that can be decomposed into many lightweight tasks.

This is not to say the all data center workload requirements are homogeneous. In fact, one attribute for these fast-growing application sets are their diverse needs with regards to compute, memory, and I/O performance. For example, streaming media applications, physics simulations and business analytics workloads all have different choke-points, which suggest very different architectures.

This is driving a number of purpose-built server designs that target, if not specific applications, at least specific application profiles. Efficiency costs, of which power and cooling is a large component, are driving these new architectures, and for these large and growing application segments, such designs offer a large enough market to attract vendors.

Vendor Activity

Server makers and processor firms are scrambling to keep up with the changing landscape. Chipmaker Intel, which dominates the server space, is putting significant effort into low-power server CPUs (both Atoms and Xeons) and on-chip network controller integration. It's also looking to move up the food chain with its own server motherboards and chassis.

Similarly, AMD is providing servers (the SeaMicro SM15000) for the emerging microserver market, as well as developing APUs, CPU-GPU integrated processors. In addition, it will start sampling 64-bit ARM SoCs (Opteron A1100 Series) in the first quarter of 2014, devoting a significant effort to its first non-x86 set of offerings. With the recent demise of Calexda, AMD looks to have an early lead in the nascent 64-bit ARM market.

Meanwhile, ARM licensees Applied Micro and Marvell are also developing 64-bit microserver chips, while Texas Instruments already has a low-power 32-bit ARM-DSP server offering aimed as specialized applications (HPC and pattern recognition). Also, companies like Samsung and Qualcomm could segue into the server business from the ARM side, based on expertise developed in the mobile space.

At the system level, IBM has renewed its focus on POWER-based servers and in the process has opened up the processor architecture for third-party providers. The company is also partnering with NVIDIA to co-develop GPU-accelerated servers for big data applications, while shunting off its x86 server business to Lenovo. All of this points to a much more adversarial relationship between IBM and Intel.

Meanwhile, Dell and HP are testing the microserver waters. Dell is offering a microserver variant of its x86-based PowerEdge line (C5220), while also developing ARM-based server prototypes "Zinc" and "Copper." HP is even more heavily invested in the microserver paradigm via its new "Moonshot" systems; they are powered by low-power x86 processors today, but are designed to incorporated ARM, GPUs, DSPs or other SoCs in future.

Whither Standards?

All this diversification and experimentation tends to be at odds with standards. That being said, there is a still a demand for such solutions. Even at a time when the server is rapidly evolving into different forms and functions, the need for standard hardware remains. And with the rapid growth of large-scale applications in cloud computing, big data and HPC, there is plenty of economic incentive to leverage standard hardware to drive down costs and boost efficiencies.

As mentioned before, standards are favored by users who want to minimize up-front costs via hardware commoditization and want the flexibility of vendor-neutral hardware for running their software. OEMs, ODMs, and component providers have mixed feelings for standards. On one hand, more customized solutions offer higher margins and encourage customer loyalty; on the other hand, standard solutions offer better sales volume.

Today there are two major standards-making efforts for servers: the Open Compute Project (OCP) and the Server System Infrastructure (SSI) Forum. OCP has the highest profile, having been spearheaded by Facebook to target large-scale cloud computing applications. SSI is a more vendor-focused group for defining server standards across industry segments.

Because of its application focus, OCP is mainly concerned with defining standards for bare-bones server hardware – as well as corresponding storage, switches, racks, and other data center hardware. By implicitly limiting the application set to Facebook-like environments, OCP is able to focus its standards effort and reduce the complications offered by more diverse applications.

However, OCP still maintains multiple server and motherboard standards to serve the diversity of users and vendors in the ultra-scale space. It provides designs for both x86 and ARM servers, as well as system management, modules, storage servers, network switches. One of their more interesting initiatives is the Open Rack standard, a specification that considers the rack as a holistic system build up from standard components.

Perhaps even more compelling is the new "Group Hug" standard, a Facebook-contributed specification for motherboards that defines a common slot architecture. Its significance is that it enables boards to be produced that could theoretically host any processor architecture or processor generation. The spec is based on a PCIe connector to link the chip to the board.

The SSI Forum, sponsored by Intel and Supermicro, has a somewhat different set of goals in that it's basically an industry consortium that wants to establish a server standards for its industry members-- tier 2 OEMs, ODMs, and component makers. The membership is weighted heavily toward Asian suppliers, like Dawning, Fujitsu, Samsung, and Tyan.

SSI has published specs on rack servers, blade systems and microservers, which includes standards for motherboards, chassis, mezzanine cards, power supplies and management modules. It also provides Product Development Kits (PDKs) for compliance and interoperability.

Given the complementary nature of OCP and SSI missions, collaboration would offer some interesting possibilities, include a unified set of supported standards and a more global reach. If a critical mass of big users like Google, Baidu, eBay, and Amazon (Microsoft and Facebook are already in the OCP camp), could be attracted to support global standards, that could signal a tipping point for many server and component providers.