Standards and specs: The ATX case and power supply

A simple tale in which commodity wins out

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The ATX standard allows power supplies and cases to be commodity parts, dramatically reducing the cost of computer design. Lessons learned from the success of this standard show why standardizing parts is important. The BTX standard builds on this, and the blade.org standards work should do likewise.

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The recent blade.org announcement heralds that IBM and Intel® are looking to standardize blade hardware designs, allowing blade systems from multiple vendors to work together. It's no surprise that Intel is interested in this -- its own ATX standard has been a massive success. The same things that have made ATX a success might well apply to the blade.org standards work.

This article looks at the history of ATX and some of the lessons learned about power supply and chassis standardization.

The simplest part of the computer

While the case and power supply are in some ways among the least technologically challenging parts of a computer, they used to be among the most persistently frustrating. The ATX specification provided a much-needed standardization of computer components which has contributed substantially to lowering prices for cases and power supplies alike.

At the same time, shortcomings of the original specification have left occasional lurking incompatibilities. There are many related standards, but the "ATX" name is the one most widely used and recognized; often people refer to other related standards as "ATX" even when they aren't.

The ATX standard is a hardware standard, not a software standard. It specifies both mechanical and electrical aspects of common computer hardware from cases to motherboards to power supplies:

- The physical aspects of the ATX specification guarantee physical fit: an ATX power supply will fit in an ATX case.
• The electrical aspects guarantee functionality: an ATX motherboard will not emit blue smoke when hooked up to an ATX power supply.

Not all computers use ATX, but many use it either in whole or in part. Some systems might use a non-standard power supply, but still use an ATX power connector, or might use an ATX form factor even though they don't use a standard ATX power supply. Development and prototype boards sometimes spend their lives in an ATX chassis. For a standard most people associate only with desktop x86 systems, ATX gets a lot of travel.

**Where did this standard come from?**

The previous PC standards, AT and Baby AT, made design assumptions that were compatible with the technology of the time -- for example, they assumed that processors and memory could fit under expansion cards (which is impractical on modern systems thanks to the heatsinks and fans required).

However, the case specifications were somewhat approximate. The only connector the case generally provided for was the keyboard port; other ports needed to use slot covers or have cables run from a header on the motherboard to a slot on the case. If your board had two serial ports but your case didn't, you needed to use up valuable expansion slot cover to provide a space for the serial ports.

The ATX standard is an outgrowth of the Baby AT standard which addresses a number of that standard's limitations.

**How did ATX become "standard"?**

The ATX standard, as the name suggests, was a development from the AT standard. The ATX standard is nearly universal among PC hardware vendors and well-represented among non-PC vendors. While there are certainly machines that don't support any of the ATX variants, they are somewhat unusual. Laptops might be the most obvious example, but then Apple's Macintosh computers, seemingly not intended for component-swapping, don't always reflect the ATX specification either.

One of the reasons the ATX grabbed a standards status is because of its terms and conditions. The pricing and terms for the ATX standard are simply unbeatable -- they are, simply, go ahead and download the spec and build for it if you want.

This very aggressive positioning that focuses on ignoring short-term capital gains in exchange for realizing long-term ones is one of the cornerstones of standardization (the short-term gain here being licensing fees and the long-term gain being making it easy for more people to build devices that are compatible with yours, ensuring yourself a larger future market of customers). Intel could perhaps have made money by charging for licensing, but the benefit to Intel of a healthy PC market appears to have won out.

Everyone else also benefits from a free and openly available standard which keeps costs low and network effects high. Because the ATX specification doesn't get into the specifics of CPU sockets
or interfaces, it's vendor-neutral; it doesn't favor Intel over AMD or x86 architectures over Power architectures.

Standardization has a way of keeping component prices fairly low (which is good for consumers). For businesses, it has a flip-side -- it also makes the PC hardware industry very competitive which makes it harder for companies to stay in business selling parts which are, after all, replaceable. Product differentiation can then only focus on four key elements -- price, features, innovation, and price. (Yes, I mentioned price twice.)

**Just what does ATX specify?**

The ATX standard distinguishes between requirements and recommended practice, striking a good balance of trade-offs. The location of back-panel I/O ports is an excellent example -- all such ports are required to be within a precisely specified area, allowing a standard size and placement for the back panel in a case. However, the exact location of ports within this area is not specified; recommendations are offered, but there is no requirement.

Many boards use one of a few very common designs. ATX cases sometimes come with standard back panel covers that match these common designs, but motherboards normally provide their own back panel cover. Since the location and size of this cover are precisely specified, the cover will almost always fit snugly in the case and line up precisely with motherboard components.

The ATX standard greatly simplifies the purchase of parts for most systems. An ATX case, motherboard, and power supply usually work together. For a while, this was always true, but technological developments forced the creation of revised standards, making it possible to have an "old" ATX power supply and a "new" ATX motherboard. But now modern power supplies are once again generally compatible. More importantly, the specific extra features that some boards need have names which can be used to check compatibility of power supplies.

Although the exact locations of processors are not specified, in practice there's a great deal of uniformity. I have a machine with a special air guide in the case which just happens to align precisely with the CPU fan on the motherboard I put in it, even though I doubt the vendors had even heard of each other.

Interoperability of parts is really what ATX has to offer most vendors and hardware developers. The cost of a generic ATX case and power supply is fairly low and it's not unheard of to end up with a spare after a computer fails. An evaluation board which works in any standard ATX case and uses a standard ATX power supply is cheaper to use than one which requires a custom case and power supply.

**Some "power"-ful considerations**

You can't discuss a power supply spec without talking about power concerns. While the input to the average power supply is generally either 120V or 240V AC power, it must provide a variety of voltages; generally, the key numbers are 3.3, 5, and 12 volts. All three voltages are fairly well represented in modern systems, although the exact usage demands vary widely from one system to another.
Modern systems often have greater demands at lower voltages than older systems; one motherboard I used was perfectly stable with hardware available at its release, but prone to crashes when using an AGP card that was a few months newer because the new card required more power at 3.3V than the motherboard’s voltage regulator could handle.

The ATX power supply specification offers a basic set of guidelines and requirements for available power to give motherboard vendors some confidence in what power is deliverable. Smaller power supplies, unfortunately, are often a little wobbly in predicting the exact voltage they produce under load. It’s not unheard of for a crash-prone system to become rock solid given a stronger and more stable power supply.

The ATX specification has a number of interesting requirements for power supplies. For instance, a power supply must be able to maintain stable voltages for at least 17ms during a power interruption. 17ms may not seem like much, but it provides a full cycle for those of us with 60Hz power. The guarantees made about the availability and stability of power are crucial from the point of view of a hardware vendor or system integrator because they reduce the engineering effort of building a compatible motherboard that won't go up dramatically in clouds of smoke (too often).

Most ATX power supplies are designed for use with "soft power" -- the motherboard controls the power supply. Some provide an additional hard power switch which can be used to disable the power supply, but not to forcibly enable it (turn it on). If you find yourself with a motherboard which doesn't correctly implement soft power, or you want to use an ATX power supply to power other devices (such as hard drives), you can short the green wire to one of the black wires. Before you do this with a real motherboard attached, make sure you've isolated the problem, and be aware that it can void warranties.

On the other hand, it's a great way to verify the exact nature of the problem. Some vendors will sell ATX power supplies with the soft power feature disabled, for use with boards that don't support soft power.

By the way, in the event of a component failure, an ATX power supply should not produce a "startling noise." I do not believe the standard formally specifies which noises may be considered "startling," but it is an amusing phrase to see on the pages of a specification.

The great thing about standards

The great thing about standards, runs the old saw, is that there are so many of them to choose from. The ATX family of standards is unusually broad, containing four motherboard form factors and five power supply form factors. The recommendations add another layer onto this, providing a number of very sensible recommendations.

The evolution of the various ATX standards offers an insight into a standard which is driven primarily by a single market’s needs. The multiple standards reflect the evolution of PCs and other computers. In particular, the ATX form factor, while conveniently small compared to a full-size AT system, was not small enough for the really tiny systems that some users want. Since then, the ATX spec has evolved, adapted, and branched out based on developments in motherboard,
processor, and fan technology. Many of these concerns apply just as well to people developing evaluation boards or custom server platforms.

For instance, some motherboards started needing additional power beyond that provided by a standard ATX power supply. There are a few common variants of this, and many power supplies provide several different connectors with additional pins that might be needed. These are particularly common on dual-processor motherboards. To add insult to injury, some video cards even require additional power sources.

The main ATX specification has reacted by incorporating needed features and extensions; what was once an unusual special requirement is now a fairly standard feature you can get off the shelf. In fact, the auxiliary power connectors that used to be part of the spec are now deprecated in favor of a 24-pin main connector, replacing the 20-pin main connector from the original ATX standard. If I am correctly reading the specs, in fact, this happened twice, once with a 6-pin "auxiliary" connector, then later with a 4-pin connector used mostly on dual-processor boards.

For users targeting smaller computers, the microATX specification describes smaller boards, allowing case vendors to build smaller cases and have a reliable specification for which boards can fit in them. Going even further, the FlexATX specification (defined in terms of microATX) provides for even smaller boards.

Some vendors, especially those selling server motherboards with onboard SCSI and other additional features, use the "extended ATX" form factor which is a 12-by-13-inch motherboard. The additional mounting holes needed for these boards tend to be unpredictable. One common variant is an extended ATX board with one corner missing, which fits in some cases by avoiding the drive cage. In other cases, it might not fit so well.

An even larger form factor, WTX, was developed for "workstation" boards; the Web site for it went down sometime around 2003 and the last archived version I was able to find said "It is NOT recommend that NEW IA32 based workstations be designed to the WTX- form-factor." [sic]

In general, the ATX standard has adapted fairly well to new demands. The maintenance of multiple versions has made it easier for new development to proceed without wrecking compatibility for older parts. The change from a single power connector to two, back to a single (larger) connector, reflects the need for new power supplies to work with old boards during the conversion; many motherboards are compatible either with the newer 24-pin power supplies or with an older power supply using the supplementary power connector.

**When the standard won't work**

Although the ATX specification has generally kept up with technological needs, there have been exceptions. A few years back I built a system with a pair of big, heavy processors. The motherboard was an ATX board, but it couldn't be used with just any old case because the processors had huge heatsinks and were very tall. The net result was that if the processors were installed in a regular case, they would risk breaking the motherboard under normal use (to say nothing of shipping). The solution? Custom cases with extra holes to bolt the processor support...
struts onto. Unfortunately, it was very hard to get information in advance about which cases would work.

Similarly, the first boards to require additional power were basing this on simple technical needs, not on the formal specification. The standard has since adopted new power requirements, but not new supports. The need for extra supports has been addressed primarily by the switch to active cooling, reducing the need for giant hunks of aluminum.

Vendors working on rackmount systems, especially one-unit designs, often play fast and loose with bits of the ATX standard. A 2U design can use off-the-shelf parts. A 1U design is very likely to need a power supply which conforms to the ATX spec electrically, but which wouldn't fit in a standard ATX desktop case. Even so, the interoperability of power connectors offers economies of scale to vendors and developers. The need for multiple form factors of power supplies is reflected in the multiple power supply specifications provided for ATX systems.

Exceptions and outliers

**Slash and backslash**

A curious quirk of all the official ATX documentation and sites is the persistent use of backslashes where slashes are called for. For example the downloadable specs are named “developer\specs\atx2_2.pdf” and the BTX specification directs people to “http:\\www.formfactors.org.”

I don’t know where this thing of using backslashes and slashes interchangeably comes from. It is not a formal standard that I know of.

Most cases provide a number of holes for attaching motherboard spacers. Spacers come in two standard heights... well, one standard height and one which I can’t easily explain. Most of these locations are consistent from one board or case to another, but not all -- I have a motherboard in which 12 of the 13 holes provided line up with a standard case, but one is about 1/16” off. (It’s an EATX motherboard, though, so there doesn’t seem to be a formal standard involved.) This does not seem to be the standard’s fault, but rather a side-effect of the tendency of vendors to make interesting decisions in board layout.

My favorite example (which I have never seen explained) involved a model of a motherboard which would only line up in a specific case using taller than usual spacers, but which worked fine in other cases. The mystery is that none of my other boards had problems in that case (I have no idea why).

I have also had a few cases where the back panel connectors lined up beautifully, but the PCI slots were either too low or too high. I honestly don’t know how this stuff happens -- the specification is not particularly ambiguous about these issues, but it could be that in some cases (no pun intended), the vendors are careless.

Nonetheless, the exceptions remain just that -- exceptions. Most hardware works.
ATX + The Future = BTX

The future of ATX is mostly BTX. The BTX specification (Balanced Technology Extended, a retronym if I ever heard one) provides a single specification covering multiple form factors. Unlike the ATX specification, it provides more detailed analysis of component layout and cooling requirements with the apparent intent of allowing more efficient (and thus perhaps quieter and lower-power) system design. In essence, it places the core heat-generating components in line with the airflow with the idea of minimizing the fan count while maximizing thermal efficiency.

It's good that these matters are being considered, but the history of change in system cooling makes me worry that developments in motherboard and peripheral technology might make these decisions impractical in the future.

The BTX specification is in many aspects compatible with the ATX specification and it seems most likely that ATX parts and designs will stay relevant for some time. The widespread availability of ATX components seems unlikely to change. For the next few years, it seems it will probably remain true that you can generally buy a motherboard, case, and processor for PC-compatible hardware without significant worry about whether they will work together, leaving you to focus on features and not just on whether the cables will fit.

Beyond the specifics of the BTX standard, the ATX standard has provided a lot of lessons about standardization of the commodity parts of computer hardware. ATX machines gain a huge amount of effective reliability from the knowledge that in the event of a problem with the power supply, you can simply go to any computer store and pick up a replacement. This is, quite simply, cheaper than anything you can do with a custom one-off power supply, no matter how technically excellent that power supply is.

These benefits extend past the desktop x86 computers the ATX specification is primarily designed for and offers benefits to anyone trying to put together computers on any platform. I hope that blade.org does as aggressive a job in promoting a standard, making it available, and letting everyone build compatible hardware as cheaply as possible.
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- Check out the [home page for the ATX and BTX specs](http://www.ibm.com/developerWorks/).
- This article demonstrates that [power supplies shenanigans](http://www.ibm.com/developerWorks/) are statistically the most common way (26%) to kill your computer.

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