White Paper | AMD EMBEDDED SOLUTIONS

Why Choose an Embedded System For Your Next Application

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ABSTRACT

Many system integrators and end customers continue to choose standard PC platforms for certain types of embedded applications. While standard PCs of the past did have some advantages over custom designed embedded platforms, especially for applications that required "PC-like" performance and capabilities at a low off-the-shelf cost. However, the embedded solutions landscape is changing dramatically to better serve these applications:

- Evolutions in embedded system technology and design including the proliferation of standards-based interfaces and platforms, coupled with rapid advancements in CPU and graphics performance have closed the gap with PCs.
- There are hidden lifecycle management costs associated with deploying typical, commercially available PCs in embedded applications that are not always well understood.

In this challenging global economy, system integrators are facing growing pressure to lower costs, accelerate Time-to-Market (TTM), and maximize profits while reducing risk. This white paper explores the hidden costs of commercially available PC platforms when used in embedded applications and why today's embedded platforms, like those being enabled by AMD, are a superior choice for your next high-end embedded application.

INTRODUCTION

Embedded is a huge market forecasted by IDC to grow globally to $2.6 trillion in revenue by the end of 2015i, with a CAGR of 10%. Most people don't realize that PC's account for only around 2% of all computing devices currently in use today. According to the Artemis Embedded Computing Systems Initiativeii, 98% of all computing devices today are embedded into other types of electronic equipment and there will be more than 40 billion embedded devices by 2020iii.

MYTHS AND MISCONCEPTIONS OF TODAY'S EMBEDDED PLATFORMS

It's important to properly frame the discussion by clarifying some common myths and misconceptions about embedded platforms. In so doing we need to clearly differentiate today's embedded solutions from those of 5 or 10 years ago and recognize the dramatic evolution that is currently taking place in embedded technology.

MYTH #1:

A PC will always have higher performance (especially in graphic and video-intensive applications) than an equivalent embedded system.

Today's mainstream PC processing subsystems (CPU, graphics, and video) feature high MHz, multiple cores, large caches, fast and wide system busses, and while it's true that most current PCs will beat an embedded platform in running typical PC applications and benchmarks, the question is how much perfor mance do you really need and what kind of performance do you really need? And at what price are you willing to pay for that level of performance in terms of size and power consumption? While many of today's embedded applications are evolving towards more interactive, connected, and multimedia-rich usage scenarios (i.e. "Intelligent Systems"), embedded CPUs and GPUs are more than keeping pace with these ever increasing performance requirements. Many devices in production today feature multiple cores, fast dedicated 2D and 3D graphics, and hardware support for multiple streams of high definition video. These devices are architected to provide a level of performance targeted at specific embedded applications and highly optimized to provide superior performance per dollar and performance per watt over traditional PCs.

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The operating system also plays a significant role in system performance. Today's mainstream PCs need to have an exceptional amount of horsepower and system memory in order to efficiently run Windows® or Linux® operating systems and to be able to execute several demanding applications and background tasks concurrently.. Because embedded systems typically have a predefined set of applications that they are required to run, the overall performance requirement of the hardware is typically less than for a PC, without sacrificing the user experience. A limited application set also allows an embedded system to run an operating system specifically architected for an embedded system such as Windows Embedded (and all of its variants) and Embedded Linux. While these operating systems are fully featured, they are also available as componentized packages that can be built to match the embedded hardware, meaning that the resulting "image" only contains the modules, resources, and drivers that are required to support the specific hardware configuration and limited application set. Embedded operating systems are also "thinner" meaning that applications have more direct control over and faster access to the hardware which can contribute significantly to overall system performance. Think about all the times installing a new device driver for your PC has significantly improved its performance running a specific application (especially a graphics-intensive application). This is one example of how multiple layers of software that reside between an application and the hardware in a typical PC can affect performance and user experience.

MYTH #2:

Embedded systems lack the standards necessary to ensure compatibility, interoperability, and upgradeability.

Since 1982 when the VMEbus Manufacturers Group was founded (and renamed VITA in 2005), VITA has championed open system architectures for the embedded systems market. Followed by the PC/104 Embedded Consortium (1992), PCI Industrial Computer Manufacturers Group (PICMG) (1994), Khronos Group (2000), Embedded Linux Consortium (2000), and more recent entities such as the Small Form Factor Special Interest Group (2007), and ProSE (an initiative driven by the Standards Working Group of ARTEMIS in Europe established in 2008) have been attracting the industry's biggest players and driving open standards in all facets of embedded system technology. While many of these entities (or their subcommittees) are market specific (Consumer, Instrumentation, and Automotive for example), they have common goals such as establishing standards that simplify development tool creation, enabling higher performance and feature-rich software, improving testing and robustness of systems, and increasing expandability, scalability and interoperability of platforms. Also, because of the migration of PC-based CPU architectures into the embedded space, many high-end embedded systems today (predominantly x86 based) incorporate many PC technology and interface standards such as OpenGL ES (an embedded version of OpenGL) for graphics acceleration, SATA for hard drives, PCIe® for discrete graphics hardware and other expansion capabilities, USB for peripherals, 10/100base-T for Ethernet, and DDR2/3 SDRAM for system memory. This adaptation of PC technology in conjunction with the advancement of specific embedded technology standards is enabling a wider variety of commercially available operating systems and applications to more easily be migrated and optimized for embedded systems.

MYTH #3:

Embedded systems are not x86 which increases development costs and TTM.

While it's true that traditional embedded CPU architectures, such as ARM and MIPs, continue to enjoy significant market share, x86-based processors are dominating the embedded marketplace from a dollar volume shipment perspectiveiv. Also, companies like AMD and Microsoft, as well as the proliferation of open-source Linux (including Embedded Linux), are driving increased availability of sophisticated and high level development tools, including Integrated Development Environments (IDEs), and the technical support that helps accelerate TTM for x86-based architectures.

MYTH #4:

An embedded solution will always be more expensive than an equivalent PC-based solution.

While this may be true when comparing to the initial cost of some commercially available off-the-shelf PC solutions, it's important to consider Total Cost of Ownership (TCO) over the lifespan of the deployed solution. There are hidden costs associated with deploying PCs for embedded applications that can make them less cost-effective in longer lifecycle applications, a concept we will explore further in this white paper.

THE VALUE ADVANTAGE OF AN EMBEDDED SYSTEM

As mentioned, when planning a system deployment, regardless of size, it is important to look at not just the initial costs of the hardware and software, but also at the ongoing operational expenses which really constitutes the largest bulk of the TCO throughout the life of the deployment. Many factors contribute to these costs and the right embedded system usually offers superior value in the long term:

- **System Reliability:** Because embedded applications have long lifespans and systems are often required to operate in harsh environments (including elevated temperature ranges), embedded systems typically employ components rated for higher temperatures and/or higher voltages. Conversely, commercial PC system designs often employ components with lower temperature/voltage ratings because those components are inexpensive, readily available, and support the operating conditions where PCs are typically used. The lifespan of any electronic device is related to its operating temperature, and that lifespan can be increased significantly either by operating it at a lower temperature or at a lower voltage than it is rated for (i.e. de-rating). The devices we are talking about here are not limited to "primary functionality" as many are general purpose components typically used in high quantity such as aluminum electrolytic bypass capacitors. For example, an aluminum electrolytic capacitor rated for a worst-case guaranteed life of 2000 hours at 85°C but operated at 55°C (typical on a PC motherboard under normal conditions), would have an expected life of 16,000 hours or just under 2 years of continuous (24x7x365) operation. Conversely, a capacitor rated for a worst-case guaranteed life of 2000 hours at 105°C but operated at 55°C, would have an expected life of 64,000 hours or just over 7 years of continuous (24x7x365) operationv. In other words, increasing the temperature rating of the capacitor by 20°C increases its expected life by 4x. While seemingly insignificant, these capacitors are critical in maintaining steady voltage levels and suppressing noise in high speed Printed Circuit Board (PCB) designs. A typical motherboard may employ over 100 of these capacitors, increasing the likelihood of a device failure, and possibly a board failure, if the capacitors are not operated well below their rated temperature.

- **Power Consumption:** Lower power consumption is always better than higher power consumption but not just for the obvious reasons of saving energy costs and increasing battery life. Low power consumption leads to many other benefits that may not be intuitively obvious to the casual observer. First of all, lower power consumption of key components results in the entire system operating at a lower temperature, putting less stress on the rest of the system components, and increasing the life of the system as mentioned above. Low power consumption can often obviate the need for a fan which allows the system to run quieter, enables smaller enclosures, and lowers implementation and support costs. Low power consumption combined with power management technology built into the silicon itself, also eases the burden on software engineers who are increasingly tasked with developing sophisticated applications and techniques for managing system power.
- **Long Term Availability:** PCs are typically available in a specific model/configuration for 9-12 months. Conversely, many embedded systems are available for 5 years or longer. For large deployments that may have a lifespan of 5 years or more, a PC platform configuration would likely have to change several times over that time period requiring the purchase of additional systems up front or incurring the additional costs of supporting and maintaining multiple system configurations throughout the life of the deployment. While the long term availability of an embedded system could enable one system configuration to be available to purchase for replacements throughout the life of the deployment which would simplify and reduce the costs associated with inventory, support, and maintenance of medium and large-scale deployments.

DIGITAL SIGNAGE EXAMPLE: NOT YOUR GRANDFATHER'S EMBEDDED SYSTEM

With the ongoing proliferation of internet-based applications and services (including the emergence of Cloud computing), and consumer demand for rich multimedia experiences, many of today's embedded systems are being used in applications that are highly interactive, highly connected, visually stimulating, and in many cases, highly mobile.

Digital Signage applications are good examples of embedded systems that are becoming ubiquitous. Serving a wide range of needs in markets such as education, retail, and hospitality, they can be found just about everywhere including schools, airports, shopping malls, and hotels.

Digital Signage systems can vary broadly in size and feature set but typically have the following in common:

- A media player capable of playing back pre-recorded and live video (often high definition), flash animations, 2D/3D graphics, text tickers, Microsoft® PowerPoint files, RSS feeds, the latest web-based content, and audio.
- Support for multiple, flexible display configurations and various display connector types such as VGA, LVDS, DVI, and HDMI.
- Networking capabilities including WiFi and LAN: Many devices operate stand-alone but are most often networked to a centralized server that manages content and software updates.

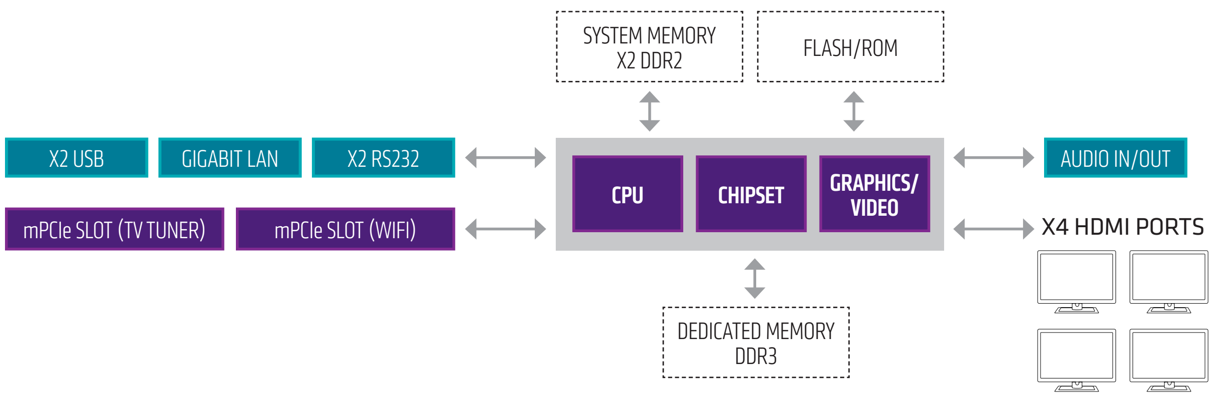

Figure 1: Block Diagram of a typical embedded Digital Signage player

Lifecycle planning and TCO are closely related in that the lifecycle planning process and decisions made during that process directly affect TCO. While lifecycle planning and TCO calculations are huge topics on their own (and have been written about extensively), we will use a simplified example in this paper to explain the basic concepts in order to compare TCO between a PC-based solution and an embedded system solution in a typical digital signage deployment. Some major factors to consider in the lifecycle planning process:

- What kinds of systems are going to be deployed?
- How long is the entire deployment expected to exist and be supported (i.e. "the lifecycle")?
- How long will each system that is being considered be available and supported?
- Will software need to be updated and how often?
- Will the size of the deployment change over time?
- What are the expected failure rates of the main components of each system?

Once the lifecycle planning process is completed (or at least the major decisions are made), TCO can then be estimated for each system solution being considered. To calculate TCO, the following must be considered:

- Acquisition cost of the primary systems
- Acquisition and carrying cost of additional systems to be kept in inventory
- Energy costs based on power consumed by each system (as determined by the usage model)
- Support costs including technical support, maintenance, warranty, replacement, and repair costs (note that this can become quite complex as multiple hardware and/or software configurations are introduced)
- Cost of downtime due to a failed system being repaired or replaced

Following is an example of an embedded application deployment containing a relatively small network of 100 digital signage systems. Let's compare how the solution would be deployed and supported over the first 5 years of operation using a standard commercially available PC-based solution and a true embedded solution.

Table 1 below shows the assumptions we will use in this example:

	PC-Based System	Embedded System
Availability	1 Year	5 Years
Failure Rate[1]	10% / year	5% / year
Unit Price (Acquisition Cost)[2]	$500	$700
Energy Cost[3]	181 / year	$63 / year
Service Cost Per Failure (Non-warranty)[4]	**$300**	**$300**

Table 1: Key parameters to consider when comparing TCO between a PC-based system and an Embedded system for a typical Digital Signage Application deployment.

Note 1: Failure rate assumptions are based on embedded player solutions being designed for reliable 24/7 operation in a typical digital signage environment while a typical PC is not designed for 24/7 operation in this same environment. A typical digital signage environment often includes enclosed cabinets to block out dust, and installation in areas that are not temperature controlled. Actual failure rates may vary.

Note 2: Unit price reflects typical cost for player hardware only not including the display(s), software, network bandwidth, or content licensing costs.

Note 3: Energy costs are based on U.S. commercial energy cost average of $.01/kwh as per U.S. Department of Energy guidelines. Typical PC system power consumption assumed to be 190w (150w for system components plus 40w based on energy star power supply rated at 80% efficiency)vi. Typical AMD-based embedded system power consumption assumed to be 66w (60w for system components plus 6W based on typical DC/DC power supply at 90% efficiency).

Note 4: Aberdeen Group, The Evolution of Remote Product Service - April 2009. Found an average cost of a service dispatch to be $276.

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Hard drive for local storage of media play lists At the end of Year 1, the PC-based system would have 10 devices replaced due to failures and the Embedded system would have 5 devices replaced.

At the end of Year 3 however, the situation has changed significantly. For the PC-based system, additional failures in years 2 and 3 (10/year) and unavailability of the original platform after the first 12 months contribute to having a total of 30 systems that have been replaced and 3 unique HW/SW configurations that now have to be supported within the network. Conversely, for the Embedded system, failures result in only 15 systems being replaced and all with the original HW/SW configuration.

At the end of Year 5, the PC-based deployment is now comprised of only half of its original systems and 5 unique configurations to maintain, whereas the Embedded deployment retains 75 of its original systems and all systems still have the same configuration.

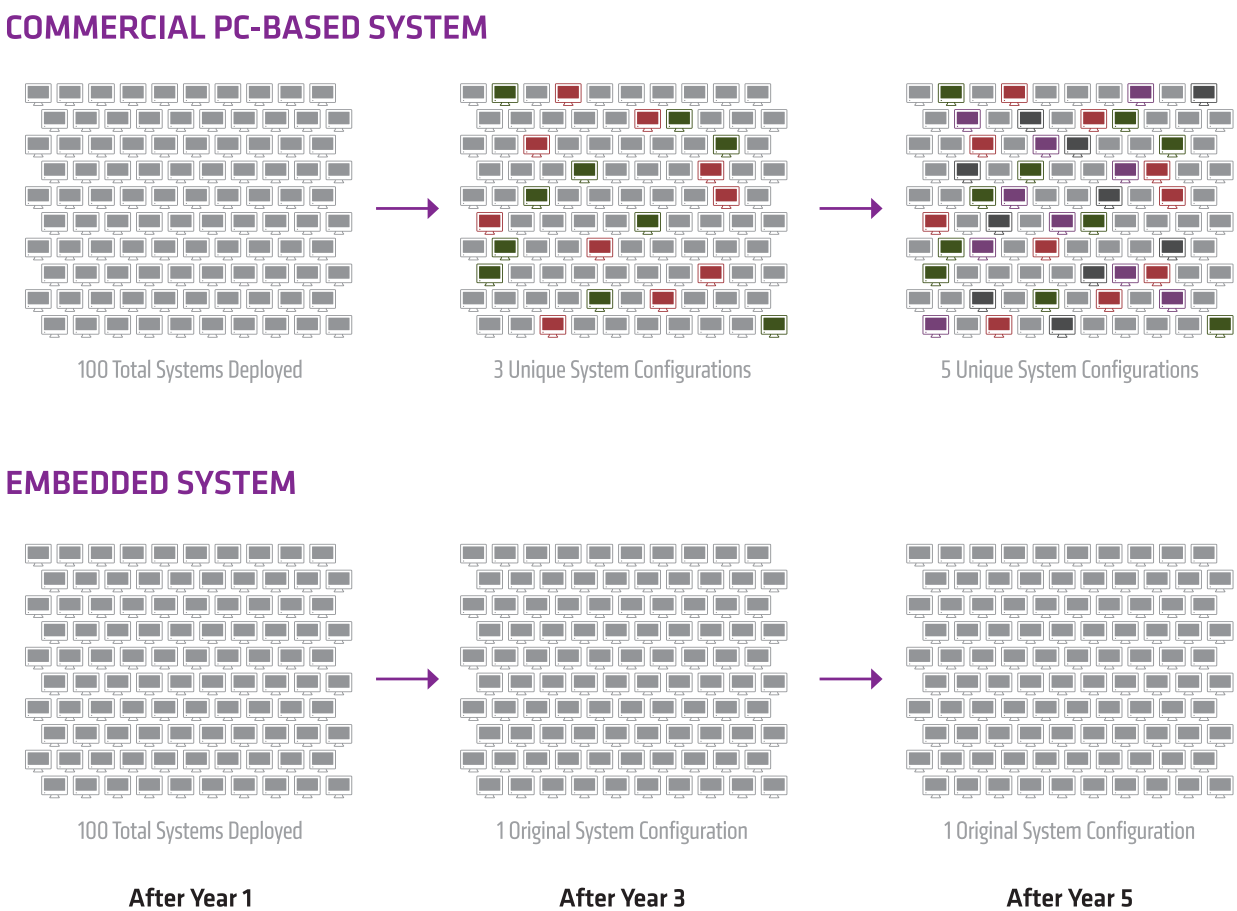

Figure 3: 5-year Deployment Comparison between a Commercial PC and Custom Embedded Solution

Figure 4 and 5 below illustrate a simplified cost comparison and demonstrate the potential cost savings an embedded solution can provide over 5 years:

		Year 1	Year 2	Year 3	Year 4	Year 5
Embedded	Acquisition Cost	$70,000	0	0	0	0
	Service Calls	$1,500	$1,500	$1,500	$1,500	$1,500
	Replacement Cost	$3,500	$3,500	$3,500	$3,500	$3,500
	Energy Cost (66w)	$5,781	$5,781	$5,781	$5,781	$5,781
	Total	$80,781	$10,781	$10,781	$10,781	$10,781
	Total Cumulative	$80,781	$91,562	$102,343	$113,124	$123,905
PC-Based	Acquisition Cost	$50,000	0	0	0	0
	Service Calls	$3,000	$3,000	$3,000	$3,000	$3,000
	Replacement Cost	$5,000	$5,000	$5,000	$5,000	$5,000
	Energy Cost (190w)	$16,644	$16,644	$16,644	$16,644	$16,644
	Total	$74,644	$24,644	$24,644	$24,644	$24,644
	Total Cumulative	$74,644	$99,288	$123,932	$148,576	$173,220

Figure 4: Simplified Yearly Cost Comparison between a network of 100 PC-based Digital Signage systems and 100 Embedded System-based Digital Signage systems.

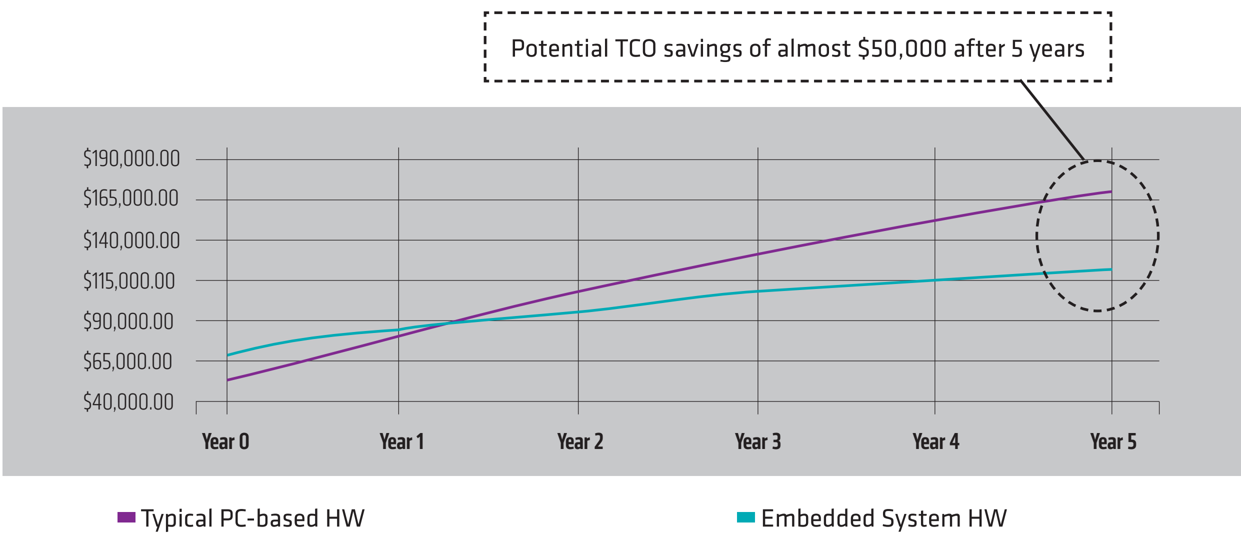

Figure 5: Cumulative cost comparison between a network of 100 PC-based Digital Signage systems and 100 Embedded Digital Signage systems shows that TCO could be lower for the Embedded system starting as early as Year 2 and reach a savings of over $49,000 after 5 years.

As you can see, the embedded system could offer a lower TCO as early as year 2 simply because it is more reliable and consumes less power. When you start factoring in the expenses associated with managing and supporting multiple configurations, and increasing failure rates of PCs as they approach 5 years of continuous operation, the TCO advantage of the embedded system becomes even more apparent.

Why Choose AMD For Your Next Embedded Application?
AMD recently transitioned from owning fabs to operating as a fab-less semiconductor company, in fact, AMD is now the third largest fab-less semiconductor company in the worldvii. This has enabled AMD to focus more energy on technology and product innovation including high value embedded products, rather than just trying to keep a fab at full capacity with low margin PC processors. AMD is the only company in the world that designs and produces industry-standard x86 microprocessors in volume and also designs and delivers leading-edge graphics technology enabling you to deliver innovative and differentiated products to your customers. AMD is committed to the long term success of their customers that serve the embedded market and demonstrates this commitment on a daily basis by offering a unique combination of technology, products, services, and support that enable customers to quickly bring to market competitive and cost-effective platforms across a broad spectrum of applications.

Delivered through:

- Ensuring that embedded application requirements are fully "baked in" to the overall product planning and development processes within AMD. Building in embedded requirements in a centralized planning process allows the resulting embedded products to take advantage of current state-of-the-art high performance / low power CPU and GPU cores, chipsets, and other I/O modules as they are developed for other markets. AMD currently offers a broad portfolio of products for the embedded market ranging from the very low power AMD GeodeTM LX processors, 64-bit embedded CPUs, new AMD Fusion APUs, and high-end discrete AMD RadeonTM graphics processors.
- Investing heavily on the front end of product lifecycles. AMD has a worldwide support organization focused on meeting the unique needs of embedded customers. Working to relieve much of the burden of downstream system integration issues by shifting the integration work towards the front of the development process before the solution gets to the OEM and/or ISV. Dedicated to collaborating with and supporting key component and software suppliers, and design and integration partners. This helps to ensure high quality designs that achieve maximum reliability and minimal support costs on the back end. Figure 6 below illustrates where AMD supports and collaborates with technology partners and customers to ensure success.

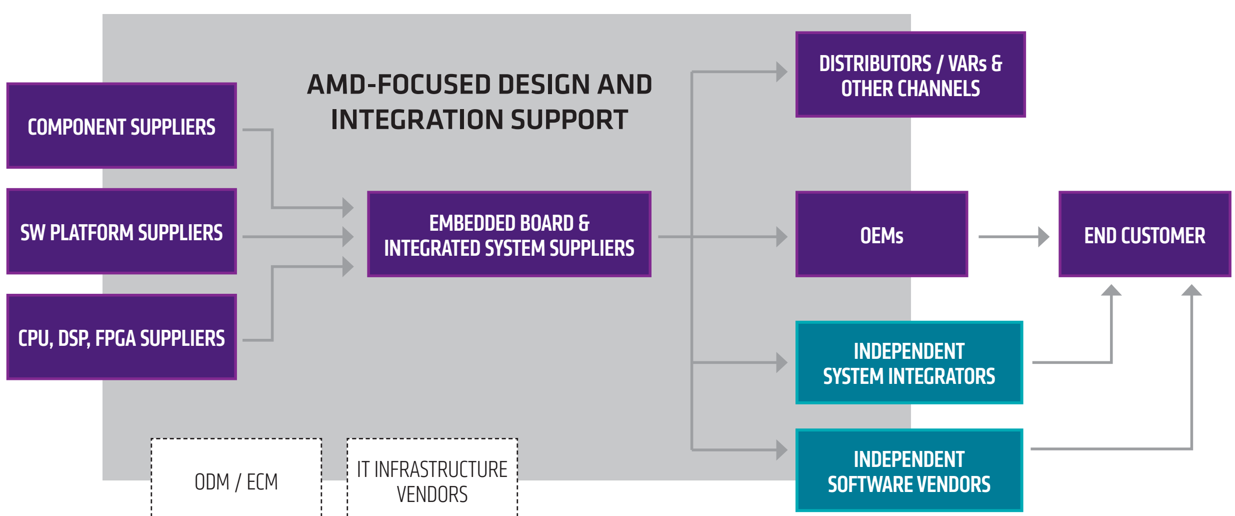

Figure 6: Embedded Market Multi-level Value Chain

- Ensuring long term availability of our embedded products by working with our global foundry partners to fabricate our products in mature, high volume, and cost-optimized processes. AMD has a planned 7 years availability for embedded products on our roadmap and works with customers and development partners to ensure that the entire ecosystem including boards, SW, systems, and platforms also support extended availability.
- Driving up performance while driving down power consumption through innovative architectures, high levels of integration, and leveraging cost-effective process technologies optimized for high performance and low power such as Silicon On Insulator (SOI).

SUMMARY

Standard commercially available PC platforms are a tempting alternative to embedded platforms in high performance, high-volume embedded applications. The embedded technology landscape is changing dramatically and today's high performance, low power embedded platforms, like those being enabled by AMD, offer low risk, and superior TCO for long-lifecycle applications.

www.amd.com/embedded

References

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