

FUNDAMENTALS WHITE PAPER

Nucleus Platform Solutions

EMBEDDED
SYSTEMS
DIVISION

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Graphics®

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Electronic devices are evolving at a breakneck pace as manufacturers strive to differentiate from the crowd with more features, lower power consumption, and a better user experience. Such enhancements might be great for the end user, but they cause major headaches for the software developer who must deliver ever more sophisticated software on top of ever more complex silicon, and still get products out the door on time and within budget. What's needed is a new kind of development platform which empowers electronic devices: flexible enough to be reused across a wide range of products and scalable enough to exploit the unique capabilities of any target silicon.

Introducing Nucleus Platform Solutions from Mentor Graphics...

CHANGING MARKET DYNAMICS FOR ELECTRONIC DEVICES

There is no question that today, electronic devices are becoming more complex with each new product release. Take the MP3 player for example. Is an MP3 player really an MP3 player when it offers web browsing, Wi-Fi connectivity, email, full-screen video playback, and downloadable third-party games? How about the audio system in today's automobile? Is a car stereo truly a car stereo when it can play back pre-recorded digital content from a USB stick, tell the driver the location of the nearest gas station, and act as a wireless hands-free interface for a cell phone?

Products as diverse as cell phones, handheld medical devices, and TV set-top boxes offer a wealth of features that we would never have dreamed possible a few short years ago. Although such products serve very different needs and are used in very different situations, they are converging in terms of the technologies they contain.

Consider the technologies common in these and many other types of electronic device in the market today:

- High-resolution graphical screens displaying sophisticated user interfaces.

- Easy-to-use input mechanisms such as joysticks, keypads, or touch-screens.
- The means to communicate wirelessly with other devices or back-end systems.
- The ability to connect directly to other nearby devices, often via USB.
- Support for fixed and removable data storage such as hard disks and memory cards.

In theory, technical convergence presents an opportunity for device manufacturers to reuse both hardware and software components to achieve economies of scale across a wide range of product types. The reality, however, is that the need to accommodate so many technologies within a single device – often with stringent size and power constraints – greatly increases the complexity of both the hardware and software.

The ever more demanding market

Market forces require device manufacturers to look constantly for new ways to reduce development costs and time to market. Competitive pressure demands that new products be released in less time and at lower cost. The number of new cell phone models introduced every month is now more than the total launched

annually just a few years ago: An extraordinary feat considering the explosion of new features in today's models.

If it were just about getting a product working and out of the door the challenge facing device manufacturers would be hard enough. But to have any chance of success in crowded markets with razor-thin margins, today's products must appeal to the masses. Good looks and out-of-the-box usability are essential. The success of Apple's iPod is a great illustration of how companies can benefit from focusing on such factors.

Some device manufacturers freely admit they spend the majority of their time and budget getting the basics done. There is little scope to focus on making sure that the device's user interface is both easy to use and aesthetically appealing, even though it is this 'final ten percent' which could differentiate them from the competition and ultimately determine whether the product succeeds or fails.

*“Nucleus OS unlocks the full power of the i.MX31
and delivers excellent real-time performance
while keeping resource usage to a minimum.”*

Freescale

What this means for device manufacturers

Hardware issues:

To meet the ever-increasing demands of their customers, silicon vendors are taking great strides to deliver highly integrated processors that are more power efficient, feature rich, smaller, and cheaper. But these benefits come at a price. The techniques employed to achieve such improvements result in more complex silicon and consequently require much higher levels of understanding to make use of it efficiently. In addition, even more complex software is required to take full advantage of all the hardware. Here are a few of the advanced techniques being used in processors today:

- Tightly Coupled Memory (TCM) is an efficient technique for implementing often-used routines and algorithms, with its contents usually defined at compile time. Intelligent use of TCM not only increases performance, but contributes to minimizing power dissipation. Good application profiling is essential in deciding what configuration will achieve maximum benefit while the right compilation tools are needed to accurately place the code and data.
- Multiple processor cores on a device are increasing the processing power

available to the end user. Initial approaches combined an application processor and a DSP for accelerating specific algorithms, but multiple heterogeneous and homogeneous cores are now becoming common and efficient software communication between these is paramount.

- Complex internal bus structures and efficient DMA controllers offload work from the main processor, allowing it to make full use of the available memory bandwidth.
- Hardware acceleration (e.g. graphics and multimedia) allows intensive computations to be offloaded from the main processor.

While such techniques might offer significant performance advantages, they do little to reduce development overheads. In fact, they place a greater burden on the software engineer who must ensure that the new features are fully supported before any benefit can be gained.

Software issues:

Today's sophisticated electronic devices require significant amounts of software. The sheer breadth and complexity of the software means that it is now rare for a device manufacturer to attempt to build everything from scratch; instead they rely

on a full-featured Operating System (OS) to provide a consistent set of core services on top of their chosen silicon.

Selecting the right OS is important for a number of reasons. The variety of services offered can have a significant impact on the time and effort required for integration. The demands that the OS places on the underlying hardware (e.g. the amount of memory required and the frequency of the processor to implement the application) can seriously impact production costs by raising the per-unit bill of materials. The responsiveness and predictability of the OS are also key concerns in real-time applications such as voice communication or critical data monitoring applications.

To address both the hardware and software issues, there is a need for a standardized and reusable platform technology that offers a solid, performance-based foundation upon which multiple end products can be built.

When board support packages no longer suffice

Silicon vendors usually offer a Board Support Package (BSP) for their evaluation boards. This typically provides just enough driver and sample code necessary for the software engineer to begin developing the software to run on that specific processor. But not all BSPs are created equal.

Processors are now so sophisticated that it takes significant effort – even for the silicon vendor – to create the software necessary to exploit all of the latent capabilities built into the silicon. In extreme cases, a feature may go completely unsupported by a BSP; the reason being that a new revision of the BSP could be implemented to address this omission if and when a customer requests it at a later date. Of course, the reality is that if a customer needs something for a specific project they probably won't have time to wait for the silicon vendor to catch up. And to the busy software engineer, a processor's advanced capabilities may as well not be there unless they can be used with minimal (or no) additional effort.

Even if a customer's engineers had the time and expertise to attempt to "fill in the gaps" of a BSP there is no guarantee that every feature of a particular target processor would be efficiently exploited. Depending on the choice of OS and development tools, some features of the silicon may not even be available. For example, to exploit the – potentially substantial – performance advantages of TCM, it is necessary for the developer to have fine-grained control over how the code is linked in order to mandate which functions should be executed from TCM. Linux, for one, does not provide such control.

Some processor-specific features such as hardware accelerators, may be supported

in a BSP via an implementation of an open standard Application Programming Interface (API) if one exists. However, the presence of such an API does not necessarily translate into immediate value for a device manufacturer. For example, a 3D graphics accelerator may be supported via the industry standard OpenGL/ES API (see www.khronos.org), but this is a very low level API. This means that a great deal of software development work is required to do anything useful at the application level (to add special effects like smooth scrolling, zooming, twisting, and fading) to make the device's user interface more appealing. Most device manufacturers have neither the time nor the expertise to create such specialized software, and thus, the 3D accelerator in many processors ends up going largely unused or performing well below its full capacity.

A more holistic approach is required

Today's full-featured OS provides a common foundation for development of multiple electronic devices, enabling manufacturers to focus more effort on the specific application software unique to each product. Even so, it's not uncommon for manufacturers to claim that software integration accounts for over 50 percent of their total product development cost. This overhead is extremely high and limits the amount of attention that can be paid to

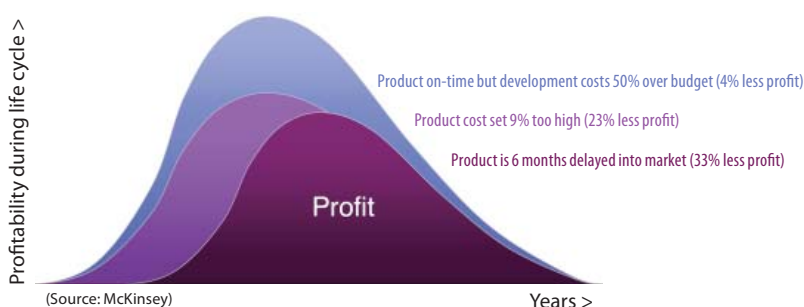
product differentiation – not least through iterative refinement of the user interface – to achieve the high levels of usability and aesthetic appeal that today's market demands.

But suppose for a moment, device manufacturers had available to them an operating system that supports the rapid creation, customization, and testing of world-class user interfaces, so that less effort has to be expended on that all-important differentiation. Does that not solve the problem? Not entirely, because if that OS runs on top of a traditional BSP, chances are its performance will be less than optimal and the full value of the target silicon will not be realized.

The answer requires a holistic approach; treating software and hardware as a unified, tightly integrated platform.

INTRODUCING NUCLEUS PLATFORM SOLUTIONS

Device manufacturers need an OS that offers the range of services necessary to meet the needs of today's electronic devices. It must also be possible to fine tune this OS at the point at which it meets the underlying hardware, so that system



The Importance of On-Time Development

A McKinsey report found the most disruptive force to profitability of a device was being late to market. As consumer goods life cycles are ever shortening (some measured in months rather than years), even a small delay can have significant impact upon profit.

developers can make any modifications necessary to accommodate the idiosyncrasies and capabilities of whatever target silicon the OS is deployed on. And tools must be provided to enable the effectiveness of any such modifications to be measured and iteratively optimized to ensure the best possible performance.

Nucleus Platform Solutions from Mentor Graphics encapsulate exactly these attributes.

Nucleus Platform Solutions are designed to help electronic device manufacturers minimize the time, effort, and cost required to get great-looking products to market.

Each Nucleus Platform Solution consists of a pre-validated application running on top of a fine-tuned version of Nucleus OS, which has been optimized to get the best out of the underlying hardware. When investigating whether a Nucleus Platform Solution is best for you, it's important to consider:

■ **Proven Reliability:** At the heart of every Nucleus Platform Solution is Nucleus OS, which has been designed into thousands of products and shipped in billions of devices worldwide. Nucleus OS delivers the flexibility and functionality of a heavyweight OS but with the performance, size, and determinism of an RTOS.

■ **High Performance:** From its inception, Nucleus OS was designed exclusively for real-time performance. It was conceived from the ground up for resource-constrained devices (frequency and memory) and for environments where squeezing out every cycle per watt was essential. This is just one of the reasons why Nucleus powers the communications processor in the vast majority of cell phones in use today.

■ **Low Resource Demands:** Nucleus OS is both highly modular and scalable. All components utilize a fine-grain structure so that only required modules are included within the final application to minimize memory footprint. Customers delivering real world applications using Nucleus OS have reported as much as 75 percent savings in terms of memory requirements compared to embedded Linux.

■ **Rapid Differentiation:** Nucleus OS incorporates an advanced menu-driven 3D graphical user interface engine, which enables the rapid and radical modification of a device's GUI – without requiring the underlying software to be changed. Design and user testing can be performed in a drag-and-drop visual environment while the device's software is still being written, thus enabling a greater emphasis to be

placed on differentiation throughout the product development lifecycle.

■ **Silicon Optimization:** Nucleus Platform Solutions are designed to maximize whatever silicon is being targeted. For example, if graphics hardware acceleration is available, the 3D graphical user interface engine in Nucleus OS can exploit it to deliver even more compelling results while simultaneously reducing power consumption by offloading as much work as possible from the main processor.

■ **Comprehensive Toolchain:** To develop sophisticated electronic devices effectively, a powerful set of embedded tools is essential. Mentor's EDGE Developer Suite delivers the means to design, code, compile, simulate, debug, and optimize a device's application software, all from within one integrated development environment.

■ **On-Host Simulation:** Each Nucleus Platform Solution is complemented by a 'virtual platform solution' running within the EDGE Developer Suite's SimTest tool. This offers a host-based simulation environment in which applications can be developed, debugged, tested, and customized even in the absence of target hardware.

BitRouter Leverages the Small Footprint of Nucleus OS

When a major U.S. cable company asked BitRouter Corp. of San Diego, California, to build a Digital Transport Adapter (DTA), the company started its development on Linux. But after discovering its Linux-based software footprint required 4Mb of embedded memory to perform – too big and way too costly, given the razor-thin margins involved – BitRouter turned to Mentor Graphics. The company quickly ported its software and discovered that the Nucleus OS version did the same job in only 1Mb: one quarter of the memory Linux required.



“The Nucleus OS platform with its small footprint and rich multimedia capabilities leverages the high-bandwidth architecture and the robust set of peripherals on our AT91SAM9 ARM9-based microcontroller family, offering a very competitive cost/performance combination.”

Atmel

Real world Nucleus Platform Solution examples

Nucleus Platform Solutions offer a consistent development environment across a range of processors. For example:

The Atmel AT91SAM9RL64

■ A cost-sensitive ARM 9-based device designed to serve as a ‘smart control panel’ – an intelligent touch-screen user interface – to be added to all manner of devices, from desktop printers and point of sale terminals to high-end white goods such as domestic washing machines. The Nucleus Platform Solution utilizes the limited resources of the silicon to deliver a high-end user experience – including animated 3D graphics, rendered without any hardware assistance – that would normally be associated with much more powerful hardware.

The Freescale i.MX31 PDK

■ Built upon an ARM1136 core with numerous hardware accelerators. The Nucleus Platform Solution for this target exploits the i.MX31’s 3D graphics accelerator via the industry standard OpenGL/ES API to deliver incredibly compelling user experiences with minimal hit on the main processor. This makes the solution ideal for portable applications where both aesthetics and battery usage are primary concerns.

Both of these Nucleus Platform Solutions include a demonstration ‘media browser’ application, which allows navigation of content (via touch-screen or keypad) held on removable mass storage devices such as USB sticks or SD memory cards. This application can be readily modified and extended to launch any number and type of context-sensitive file viewers.

The media browser application code is, of course, identical across the 9RL64 and i.MX31, and all other Nucleus Platform Solutions, since all board-specific optimizations and peripheral support is handled at operating system level.

What is required is a flexible, extensible software platform which can scale to get the best out of any target hardware while simultaneously delivering a comprehensive range of system services that meet the needs of a wide range of product types.

Nucleus Platform Solutions – founded on the world’s most widely deployed commercial real-time operating system – offer the answer.

CONCLUSION

Electronic device manufacturers are under pressure to deliver more products, with more features, more frequently. With each successive product release, more sophisticated software is required. This represents a formidable challenge to device manufacturers.

Software developers do not have the time nor often the expertise to focus on unlocking the full power of today’s complex silicon, when what they need to be doing is concentrating on that ‘final ten percent’ – delivering a great user experience – which will differentiate their product from the crowd.

MENTOR GRAPHICS EMBEDDED SYSTEMS DIVISION TECHNOLOGY PORTFOLIO

Nucleus OS

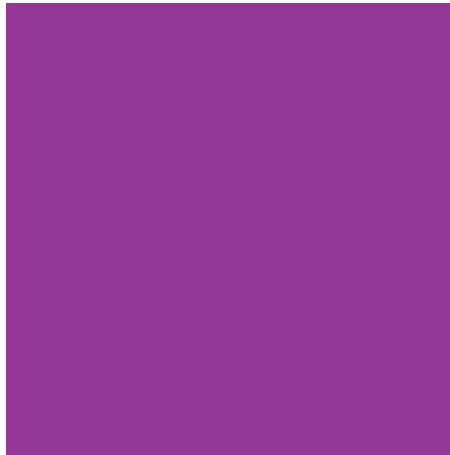
Nucleus OS includes all of the core operating system services demanded by today's electronic devices, including real-time kernel, networking & connectivity, user interface, multimedia, storage & database, and USB. Combining a high degree of flexibility with industry leading real-time performance, Nucleus OS has shipped in billions of products and empowers some of the most sophisticated electronic devices in use today, from brain scanners to cell phones.

EDGE Developer Suite

The EDGE Developer Suite offers an end-to-end suite of Eclipse-based tools for embedded software developers, covering the entire workflow from code creation and simulation through to testing and optimization on the target device. Specific tools include: IDE compiler, debugger, profiler, simulator, UI designer, and debug probe.

Nucleus Platform Solutions

Nucleus Platform Solutions are designed to help electronic device manufacturers minimize the time, effort, and cost required to bring great-looking products to market. Each Nucleus Platform Solution consists of a pre-validated application running on top of a fine-tuned version of Nucleus OS which has been optimized to get the best out of the underlying target hardware. A complementary on-host simulation solution enables applications to be developed, debugged, tested, and customized even in the absence of specific target hardware.



For additional information please visit www.mentor.com/embedded.

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