64-bit mobile computing is here, and to take full advantage of this advance in technology, you need:

- A 64-bit hardware platform
- A 64-bit operating system
- 64-bit applications
- A sufficiently demanding use case

Intel has led evolutions in personal computing from the beginning, so a mature ecosystem already surrounds Intel® processors. This means that optimized 64-bit mobile solutions powered by Intel processors will be ready when you are.

New 64-bit mobile devices are generating a lot of interest. However, it is important to understand what 64-bit computing means—and does not mean—for today’s mobile users. To realize the full potential of 64-bit mobile computing requires a lot of cooperation by a large ecosystem of hardware and software manufacturers.

The appearance of 64-bit mobile devices might seem sudden, but it is hardly surprising. It is the natural next step in the evolution of personal computing technology, which Intel has led from the beginning. Because of that leadership, Intel has long-term relationships with key ecosystem partners. This means that, if 64-bit mobile computing is important to you, optimized solutions powered by Intel® processors will be ready when you are.

This paper maps the 64-bit mobile computing territory so that you can make better choices for your mobile device needs. After reading this paper, you will understand what is required to get the full benefit from 64-bit technology.
64-Bit Mobile Devices Are Here: What Now?

Alice is thinking about upgrading her tablet. She uses it every day as a crossover device between work and her personal life. She gets updates from Facebook friends, receives email messages about quarterly budget reports, and funnels both her work and personal schedules into the tablet’s calendar.

While considering new devices, she hears a lot about 64-bit technology in some of the new mobile devices. She doesn’t know what 64-bit means or how it will help her, but her techie friends and co-workers seem to be excited, so she assumes that 64 bits must be better than whatever she has on her current mobile device.

Alice’s uncertainty is understandable. Recent announcements about 64-bit products, including Intel’s September 2013 launch of its 64-bit Intel Atom processor, have gained a lot of media attention. However, what the new technology really means is often less clear to consumers. If you are feeling pressure to upgrade your mobile computing experience by purchasing a 64-bit device, this paper is for you. It will help you make an informed decision about whether 64-bit devices are a good fit for your unique needs.

The bottom line is simple: to get the full benefit of 64-bit architecture on your mobile device, four conditions are required:

- A 64-bit hardware platform
- A 64-bit operating system
- 64-bit apps
- A use case that would benefit from the previous three conditions

After reading this paper, you will understand 64-bit architecture as well as when and how it might matter to you.

Get the Most from 64 Bits

Imagine for a moment that a car maker announced the availability of a new engine that runs on hydrogen. It is nearly silent, leaves no emissions except water vapor, and lets you drive 50 miles on a single liter.

Would you want one? You would if the marketers have done their jobs. But hold on … there are some things to consider before buying such an engine. Would you have to buy a new car, or would your current car support the new engine? If just one manufacturer is building the engine, can you afford it? Who would install and service it? Where would you buy hydrogen for fuel? You can’t simply choose “H” at the local gas station. In other words, exciting though such an innovative engine may be, you can’t yet realize its full potential. The engine by itself is not yet a solution because the ecosystem isn’t in place that would help you take full advantage of its capabilities.

In similar fashion, 64-bit mobile hardware can best deliver on its potential of greater power and performance when a full ecosystem is in place around it. You need more than just a processor: you also need a 64-bit operating system, apps, BIOS, and drivers that ensure compatibility and consistency across devices and platforms.

Microarchitecture for Everyone

ARM®? x86? What does it all mean?
To learn more about ARM architecture versus x86, or Intel architecture visit http://www.brighthub.com/computing/hardware/articles/107133.aspx
If you want to purchase a 64-bit mobile device, you have two computing designs to choose from—ARM architecture and Intel architecture. It matters because Intel has been a pioneer in 64-bit computing since 2001. It has driven industry innovation in 64-bit servers, workstations, and PCs—a steady march that now culminates in tablets and smart phones. Intel’s long history and leadership in this space mean that it has the expertise and ecosystem partnerships that are needed to help you realize the promise of 64-bit mobile computing.

What Is 64-Bit Computing, Anyway?
At its geeky root, the term 64-bit computing refers to the width of a CPU register, data path, and/or memory address at the microarchitecture level. For everyday users like Alice, the term is a measurement of how much information a computer can handle at a time, and it is best understood against its smaller architectural cousin, 32-bit (see figure 1). The 64-bit architecture can handle twice as much information at a time ($2^{64}$ bits versus $2^{32}$) because the physical and logical elements that control such things are twice as wide as in 32-bit architecture.

With 32-bit architecture, there is a built-in limitation: the CPU can only address up to 4GB of memory. However, 64-bit architecture overcomes this limitation and allows the CPU to address much more memory. In addition, 64-bit architecture provides more space in CPU registers, which means the CPU might have to reach out to RAM less often, thus improving performance. Because a 64-bit system can hold much more information in registers and RAM, which are much faster than disk, the underlying operating system can handle more tasks at once. A user might notice a more responsive device or smoother multitasking. In addition, some applications can run faster on 64-bit architecture.

Users are most likely to notice these performance improvements in the operating system and applications when:

- The software (operating system and applications) are designed for a 64-bit system
- More than 4 GB of RAM are installed on the device
- The software and tasks are demanding enough that they can take advantage of more available memory

What 64 Bits Can Do for You
As you can see, 64-bit computing can deliver more computing power and faster performance with certain tasks and software. It allows servers to handle a lot more transactions or queries simultaneously, which can help improve a web user’s experience. 64-bit workstations enable smoother 3-D modeling or graphics rendering. On PCs, 64 bits can mean performance improvements in complex spreadsheets, financial calculations,
and some games. Even some 32-bit applications running on a 64-bit system could see incremental performance improvement if they require the larger amounts of RAM available to them. On a 32-bit system, the memory available to these applications would be capped at a theoretical maximum of 4 GB. Of course, no application ever gets that full allotment because the operating system reserves some memory for itself. With 64 bits, however, those demanding applications could be allocated much more memory, allowing them to run at full throttle.

Now, as 64-bit computing moves to mobile devices, we could see heavier workloads in the palms of users’ hands and performance improvements in some circumstances for everyday tasks.

It Takes an Ecosystem

Before that exciting potential can be completely realized, however, an ecosystem must rally around it. Fully empowered 64-bit mobile computing is a cooperative solution, and an upgraded device is only the first step. To achieve the full potential of 64-bit functionality, the processor, system designer, operating system, and applications must all work together. In other words, the device must also be supported by a complete ecosystem (see figure 2).

Before Alice can take full advantage of her new 64-bit tablet, she would need a 64-bit operating system. Windows® 8.1 and iOS® 7 are 64-bit operating systems, and Google Android is currently a 32-bit operating system, but work is underway on a 64-bit version. For example, Intel announced in January 2014 that it had completed work on a 64-bit Android kernel for Intel processors. In addition to the operating system, Alice would need more RAM on her device, which could increase the cost. She would then need apps that are written for a 64-bit system and properly coded to take advantage of wider registers and more addressable RAM. And those apps then be given tasks that are demanding enough to benefit from more memory.

The most likely place to find such apps is in the enterprise. Job-related tasks on Alice’s tablet might benefit from 64-bit architecture long before her personal tasks do. Enterprises would need to port custom 32-bit applications to the new architecture, but they currently lack the impetus to do so because 32-bit apps are backward-compatible with 64-bit hardware.

On the other hand, some enterprises have already ported mission-critical applications to 64-bit architecture on laptops and desktops running Windows. These organizations might want to deploy 64-bit mobile devices so they can more easily support 64-bit applications and continue to take advantage of their investment in porting mission-critical software. But if these organizations were to deploy 64-bit mobile devices based on ARM architecture, they would have to rewrite those applications again.

Figure 2. Benefits achieved with 64-bits are the result of a cooperative ecosystem.
64-Bit Doesn’t Mean Twice the Performance of 32-Bit

Contrary to what some users might expect, a 64-bit device does not mean two times faster performance. In fact, most users will notice little, if any, difference in the everyday applications they use on their mobile devices. This is because most mobile applications running today are written for 32-bit systems and do not require the processing power or memory volume provided by 64-bit design. Think of email and social media apps, Internet browsers, or video and music players running on your tablet. Application developers have little reason to rewrite them for 64-bit systems because they work perfectly well in 32 bits, can run on 64-bit systems, and do none of the heavy lifting that would benefit from a 64-bit architecture. In other words, you currently do not need 64 bits to update your Facebook status, send email messages, or watch today’s online video clips.

Certain applications with demanding workloads might see more immediate benefit from 64-bit design. For example, data-intensive or computationally demanding applications—such as 3-D modeling, graphics and video rendering, or high-speed financial calculations—perform intense number crunching on very large data sets and might benefit from 64 bits. Users in verticals such as manufacturing, oil and gas exploration, or film production could benefit from a 64-bit mobile device if they were to run these applications on the smaller form factor.

Hardware Leadership: It’s More Than Bit Count

While it is gaining a lot of press attention, 64-bit mobile computing is not a surprise. It is simply the latest transitional step in the evolution of microprocessor technology. Intel has driven these transitions from the beginning, with the development of the first microprocessor in 1971, the 4004, as seen in figure 3.

While not a complete history of the microprocessor, the timeline in figure 3 emphasizes Intel leadership in transitions that have led to 64-bit mobile computing. Note that in its first 15 years
A Map to 64-Bit Mobile Computing
Top facts you need to know

(with Intel leadership), the microprocessor evolved from 4-bit architecture to 32 bits, an eight-fold increase. Equally striking are the achievements of the last decade. Not only did data handling capacity double again from 32 bits to 64 bits, but that processing power became more accessible to users, expanding steadily from the server to the PC and now to the mobile device.

This evolution does not merely reflect capacity growth. Intel has also packed many other innovations into its processors—technologies embedded into the silicon that deliver additional capabilities and performance benefits to users. These innovations include:

- Changes in the manufacturing process that allow smaller, more compact devices that consume less power
- New instructions that accelerate processing, allowing users and applications to do more in less time
- Changes in microarchitecture design that support more efficient energy use and data movement

The Intel® 64-bit processors based on Bay Trail microarchitecture, which Intel announced in the fall of 2013, bring a long history of Intel expertise and leadership to mobile architecture. The high-powered technology that first debuted for servers with Intel® Itanium® processors in 2001 now fits in your pocket on devices powered by Intel® Atom™ processors or Intel® Core™ processors.

Get More Than Just the Engine
Let’s return for a moment to our hydrogen-powered engine. When you finally are able to fully harness its potential, it will be because many people and businesses have worked together to make it possible. The engine manufacturer will have shared information with car makers and fuel suppliers. It will have helped train mechanics to service the engines and shared specs with regulatory bodies.

In the same way, every computing advance that brings benefits to users—such as faster performance and thinner, lighter devices—emerges from the joint efforts of a cooperative ecosystem. Intel leadership has helped drive the innovations in computing that you use every day in your digital life, and it is also at the forefront of the transition to 64-bit mobile computing. For example, Intel was the first to complete work on a 64-bit Android kernel for smart phones. More than 1,000 Intel engineers are currently working to optimize the Android user experience on mobile devices powered by Intel hardware. As a result of this work, 64-bit Android code and processors that run it will be in the hands of OEMs when Google releases a 64-bit version.

Over the course of Intel’s long-term leadership in the microprocessor industry, it has developed relationships with critical ecosystem players. This means that, when innovations such as a 64-bit processor for mobile devices are announced, a mature ecosystem has already been engaged to create solutions for it. The relationships that power the ecosystem include the following:

<table>
<thead>
<tr>
<th>Operating systems</th>
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<tbody>
<tr>
<td><strong>Windows</strong></td>
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<tr>
<td>Intel engineers have worked closely with Microsoft since 2004 to ensure exceptional performance for 32-bit and 64-bit versions of Microsoft software on Intel platforms. 64-bit mobile devices are now available powered by Intel processors and Windows 8.1.</td>
</tr>
</tbody>
</table>

| **Linux**         |
| 64-bit Linux from industry leaders Red Hat and Novell is fully supported on 64-bit Intel processors. |

| **Google™ Android™** |
| Intel’s announcement that work is complete on its 64-bit Android kernel paves the way for developers to create 64-bit apps. It also allows device makers to bring 64-bit Android, in addition to their own user interfaces, to their devices. |

<table>
<thead>
<tr>
<th>Software vendors</th>
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<tbody>
<tr>
<td><strong>Microsoft</strong></td>
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<tr>
<td>Intel worked with Microsoft to optimize Skype™ and Lync® for 64-bit Intel hardware.</td>
</tr>
</tbody>
</table>

| **VMware and Citrix** |
| Mobile virtual desktop solutions from these virtualization leaders are optimized for 64-bit Intel hardware. |

<table>
<thead>
<tr>
<th>Hardware manufacturers</th>
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<tbody>
<tr>
<td><strong>Dell, Lenovo, HP, and other top manufacturers</strong></td>
</tr>
<tr>
<td>Intel works closely with top OEMs to optimize devices for Intel processors. The 64-bit Intel processors based on Bay Trail architecture are now in the hands of these and other manufacturers.</td>
</tr>
</tbody>
</table>
These relationships and leadership matter because 64-bit mobile computing is a cooperative solution. Users can take advantage of this technological advance only to the extent that a mature ecosystem is in place to develop operating systems and apps for a processor architecture that can handle more information at once. Intel has cultivated that ecosystem around its processors for close to five decades.

Intel 64-Bit Mobile Computing: There When You Need It

64-bit computing is an exciting development in mobile technology, but users should make an informed decision before jumping on the bandwagon. To realize the full potential of a 64-bit platform, a mature ecosystem is required—one that can develop operating systems and apps that are written to take advantage of more memory. ARM architecture lacks that critical ecosystem support. For example, Windows 8 and Android do not yet run on devices powered by 64-bit ARM hardware.

Intel has driven transitions and advances in microprocessor technology since the 1970s and has built a robust ecosystem that creates solutions optimized to run on Intel architecture. If you decide that 64-bit mobile computing is important to you, then mature solutions powered by 64-bit Intel processors are ready to help.
### Quick Facts and Resources for Developers

<table>
<thead>
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<th>Current 64-bit mobile operating systems</th>
<th>Windows® 8, iOS® 7 (Google™ Android™ development in progress)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current 64-bit Intel processor families</td>
<td>Intel® Xeon®, Intel® Core™ i3, Intel® Core™ i5, Intel® Core™ i7, Intel® Atom™</td>
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<tr>
<td>Intel development tools</td>
<td>Intel® C++ compiler Intel® XDK cross-platform development kit Intel® Integrated Performance Primitives (Intel® IPP) library Free cross-platform gaming engine Intel® Threading Building Blocks (Intel® TBB), and much more</td>
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<tr>
<td>Education resources</td>
<td>Papers, videos, documentation, code samples, debugging, how-to articles, Intel Inside® device lists, and more</td>
</tr>
</tbody>
</table>

If you develop solutions for 64-bit architecture, Intel has resources to help simplify and accelerate your development cycles. Intel also supports a large, active developer community where you can bounce ideas off colleagues and contribute to the ongoing conversation.

Learn more and download tools at the Intel Developer Zone for Android:  

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1 This does not mean that all four gigabytes are available to applications. Some of the memory is reserved for the operating system.
2 “Intel finishes work on 64-bit Android 4.4 for x86 smartphones.” http://www.pcworld.com/article/2086380/intel-finishes-work-on-64bit-android-44-for-x86-smartphones.html
3 In fact, Intel CEO Brian Krzanich predicts that 64-bit Android tablets will be available in the spring of 2014. http://www.androidauthority.com/64-bit-intel-bay-trail-tablet-337056/