

Intel, Oracle and Sensor-Based Computing

Laying the Technology Foundation for Maximum Business Value

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Executive Summary

From aerospace to retail, from hospitals to government agencies, organizations are implementing sensor-based computing and communications initiatives. Their goals reach well beyond industry mandates, to include transforming internal and external business processes based on new sources of information and new ways of using sensor-enabled data to communicate and collaborate more effectively. These organizations are using RFID, wireless networks and mobile information access devices to transform their enterprises. They're tracking assets and monitoring key indicators more efficiently, gaining greater visibility into their operations and making decisions based on real-time information. They're removing supply chain inefficiencies, enhancing safety and reducing operational costs.

But early adopters are finding that attaching RFID tags to their products and reading them as they move through the value chain are just a beginning. Sensor-based computing generates huge streams of real-time data, and much of RFID's business value comes when that data is filtered, proliferated throughout the enterprise and the supply chain, and used to transform decision-making and streamline business processes.

While successful RFID implementation requires solving significant practical challenges on the physics side, it also has dramatic implications for your information architecture and information technology (IT) infrastructure. It is these concerns



that are the focus of this paper. Specifically, successful sensor-based computing and communications initiatives demand:

- A clear and complete vision and plan to improve business processes both within your organization and between business partners to take advantage of the new data sources.
- Robust information architecture to collect, filter, manage and analyze the data, and turn it into valuable, actionable business information.
- Powerful, distributed server infrastructure that scales cost-effectively to support rising demands. Additional processing power is needed at the edge to filter and consolidate tagged data; in the middle tier to run new, enterprise-grade business applications; and on the back end to handle expanded database requirements.
- Wireless networking infrastructure and high-performance PCs and mobile devices to give employees the power to access and act upon the volumes of RFID-fueled business information.

Computing and communications solutions from Intel and Oracle provide a strong foundation for success with RFID and other sensor-based computing initiatives. Oracle® Sensor-Based Services, including Oracle Database 10g, Oracle Application Server 10g, Oracle Enterprise Manager 10g, and Oracle E-Business Suite 11i, provide comprehensive capabilities for capturing, managing, analyzing, access and acting on sensor-enabled data. Platforms based on Intel building blocks offer outstanding performance and a clear roadmap to future technology advances – from Intel XScale® technology-based tag readers and wireless information-access devices based on Intel® Centrino™ mobile technology at the edge of the organization, to massive database and application servers in the data center using Intel Itanium® and/or Intel Xeon™ processor-based servers.

Oracle and Intel work closely together to ensure exceptional performance and compatibility between their products and optimize their solutions to meet end-user requirements. Both companies provide industry-leading services that provide strategic and tactical guidance on how to plan for and implement sensor-based computing.

Whether your business or agency is aggressively deploying RFID solutions or just beginning to test the waters, you can promote your success by identifying ways you can use sensor-based data to

improve business processes within the organization and across your value chain; developing a scalable, distributed information architecture; and deploying solutions based on Oracle and Intel technologies. With those steps taken, you can move forward with the confidence that you've paved the way for your investments in sensor-based computing to deliver maximum business value.

The Business Value of Sensor-Based Computing

A retailer improves inventory management and increases sales. A hospital reduces the substitution of counterfeit medications for the real products. A government agency enhances public health and safety. Transportation and logistics companies improve productivity. Pharmaceutical companies reduce counterfeiting and inventory shrink.

What's the common thread? New business process using sensor-based computing and communications. As the prices of RFID tags and readers fall and wireless networks become pervasive, an increasingly wide swath of private and public organizations are adopting sensor-based computing to more efficiently track the movement of goods and services through their value chain.

- Retailers can collaborate with consumer products (CP) companies who RFID-tag their pallets and cases of products, providing better information on where goods are located and minimizing the lost sales that occur when items are out of stock. Historically, the amplification effect of bad decisions caused by inaccurate information or a complete lack of information about where goods are in the supply chain through the point of sale has been measured in billions of dollars annually, so the value of this new source of data in these sectors is hard to overstate.
- Hospitals can work with pharmaceutical suppliers to track expensive drugs, giving both the assurance that no substitutions or thefts have occurred during packaging and transportation. They can also tag expensive and critical instruments so they can locate them quickly if they needed in an emergency. They can even tag patients and ensure that the right medicine or procedure is applied to the right patient. Given the high cost of medical errors (both in money and in lives), this is another extremely important and beneficial application of technology.

- Government agencies, collaborating with farmers and other food suppliers, can more effectively keep contaminated products off the shelves and trace them to their point of origin. This is becoming critical with animal diseases ranging from Hoof and Mouth to Avian Flu and Creutzfeldt-Jakob (Mad Cow) disease. Agencies can also work to track and contain hazardous waste materials all of which pose significant and otherwise costly threats to health and well being.

Beyond RFID, other wireless, sensor-based technologies give manufacturers more latitude to monitor and control variables such as temperature, moisture and light, leading to improvements in product quality and quantity. Remote sensors can also be used for homeland security purposes, to determine whether a container has been tampered with or opened. Typically, the sensor network data is combined with RFID and other wireless and wired data sources to provide a more comprehensive solution.

With such compelling business value, it's no wonder many companies and agencies are implementing sensor-based computing initiatives. Many are motivated in the short run by industry mandates. Retail leaders are requiring their largest suppliers to RFID-tag pallets and/or cases of products. The US Department of Defense will require RFID compliance by 2005. The US Food and Drug Administration has created guidelines on how pharmaceutical companies can implement RFID to reduce drug counterfeiting. In the aerospace field, archrivals Boeing and Airbus are collaborating on a common specification to enable their thousands of suppliers to RFID-tag aircraft parts. They expect the initiative to improve safety and airworthiness and engender operational efficiencies.

In addition to broad industry initiatives, many companies see sensor-based computing's potential to increase productivity, enhance supply chain visibility, reduce operations costs and minimize theft and fraud. NASA is piloting the use of RFID-enabled smart cards to control building access, and says the technology could eventually be used to enhance the tracking and monitoring of the millions of parts used to build the space shuttle. British Petroleum is pioneering the use of intelligent sensor devices that monitor the status and location of assets ranging from expensive equipment to chemicals in storage drums to workers in remote or dangerous locations.

Radio Frequency Identification (RFID) and autonomic sensor networks promise transformative business value across multiple industry sectors. But fulfilling that promise requires far more than slap and ship compliance. The real payoff comes from turning sensor-generated data into actionable information and using it to transform business processes. This effort will profoundly impact your computing infrastructure and information architecture. See how solutions from Oracle Corporation, running on Intel® processor-based platforms, can maximize your RFID success.

Sensor-based computing promises value both immediately and over the longer term:

- **Immediately.** Unlike bar codes, RFID tags don't require a human to manually align the reader and take a reading, one item at a time. RFID tags can be read in multiples, without requiring line of sight or human intervention, and at a distance of around 3 meters. RFID can therefore provide immediate efficiencies and cost savings in checkout, inventory control and loss prevention, and free employees to concentrate on higher value activities.
- **Mid-range.** RFID offers more sophisticated track and trace capabilities to any company or agency involved in producing, moving or selling goods. Need to recall a product, see where a shipment went astray, enhance product freshness? RFID provides visibility into the movement and velocity of goods through a supply chain, enhancing asset tracking and management, product recall, product origin tracking and more. Retailers and suppliers can collaborate to reduce out of stock items, increasing profits for both. Manufacturers can reduce the loss of high-value items by using RFID to pinpoint where thefts are occurring. Hospitals can maximize the use of expensive medical equipment by tracking its location anywhere in the facility. Logistics and transportation companies can determine cargo locations, reduce theft and loss and maximize their assets while reducing labor costs.
- **Ultimately.** In the long run, RFID is an enabling technology for retailers and CPG manufacturers to transform their

current supply chain into demand-driven product fulfillment systems that link consumer behavior back into inventory planning, logistics and even product design.

It all sounds promising – and it is. But turning promise into sustainable competitive advantage requires much more than a slap and ship conformance to mandates. To achieve the business value of sensor-based computing, companies and agencies must look beyond tags and readers. They must determine where and how they will use sensor-based data to generate value, and create an information architecture that can integrate that data into the organization and the value chain. Those that stop at simple compliance have incurred significant cost with little payback. Even worse, they’ll suffer an enormous opportunity cost as competitors convert the promise of RFID into transformative reality.

Implementation Challenges

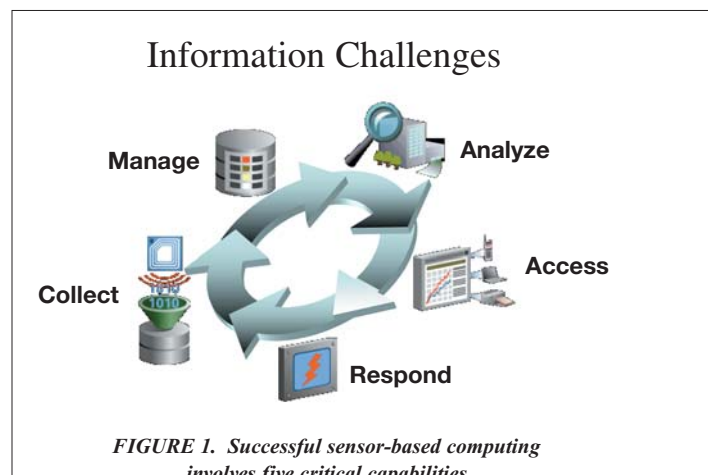
While many companies are analyzing the physics of RFID and determining where to place tags and readers, information architecture is also critical to maximizing the return on sensor-based computing investments. Sensor-based computing generates massive quantities of data; to realize a sustainable competitive advantage from sensor-based computing, you’ll need to turn that data into operational intelligence and use it to transform the enterprise, agency, or value chain. Database integrity is key – so much so that retailers and manufacturers can create new value with existing bar codes just by cleaning up existing data sources and creating a “single version of the truth” for databases that affect or are affected by product information. Indeed, if database integrity is not in place – if you can’t handle the amount and velocity of data you have now – the mountain of data generated by sensor-based computing will only make matters worse.

As Figure 1 shows, successful sensor-based computing involves five critical capabilities:

- **Capture information.** Sensor-based information must be captured from a wide array of hardware platforms, including readers, sensors, light stacks and more. This can create a huge development overhead to integrate applications with these different hardware paradigms. Once captured, data must be consolidated and filtered.

- **Manage information.** Sensor-based computing creates an explosion of data and events. The challenge comes in creating a consistent “picture” of RFID data that is scalable, reliable, and secure on a common flexible infrastructure. The new information architecture must integrate with existing information sources, applications and business processes, and facilitate the development of new, value-generating applications and business processes.
- **Analyze information.** Data and events must be analyzed in near real-time to provide the business intelligence and business activity monitoring for continuous process improvement.
- **Access information.** Incoming data needs to be made available throughout the supply network to trigger critical business processes. This includes providing the information internally to all relevant enterprise resource planning (ERP) applications and externally to trading partners and customers.
- **Act on information and events.** A sensor-based computing solution should allow for organizations to manage by exception and respond to events triggered from their supply chain. Employees must be empowered to access, interpret and act on information when and where they need it.

Sensor-based computing raises the demands on information architecture along virtually every axis. Database infrastructure must be powerful and scalable, to manage the massive amounts of data and the increasing number of applications making use of the data. Hardware and software solutions must be secure, standards-based and interoperable, to enable sharing of critical information across departmental and corporate boundaries. Computing platforms must be flexible and distributed, because data will be coming into the enterprise or agency from many



Oracle and Intel: Comprehensive Solutions for Sensor-Based Computing

| Tasks | Oracle Software Solutions | Intel® Architecture-Based Platforms |
|-------------------------------|---|---|
| Capture data | Oracle® Application Server 10g | Readers based on Intel XScale® technology Edge servers based on the Intel® Xeon™ processor |
| Manage data | Oracle Database 10g | Servers based on the Intel Xeon processor family |
| Analyze data | Oracle Business Intelligence Oracle E-Business Suite | Application servers based on the Intel Xeon processor family; Database servers based on the Intel Itanium® 2 processor and Intel Xeon processor MP |
| Access information | Oracle Application Server Portal Oracle Wireless | Handheld devices based on Intel XScale technology Notebook PCs based on Intel Centrino™ mobile technology Desktop PCs based on the Intel Pentium® 4 processor |
| Act on information and events | Oracle Application Server 10g | Handheld devices based on Intel XScale technology Notebook PCs based on Intel Centrino mobile technology Desktop PCs based on the Intel Pentium 4 processor |

different points and must be filtered and consolidated at the point of origin to avoid flooding the network and databases. Both software and hardware infrastructure must provide the utmost scalability and flexibility, both because of the large quantities of data and because new uses are bound to arise that weren't planned for initially. And, as with any significant IT investment, enterprises and agencies must architect to reduce risk, make effective use of existing information assets, reduce the time and expense of deployment and accelerate time to value.

Meeting the Challenges with Intel and Oracle

Industry leaders Oracle and Intel provide robust solutions that meet the above requirements and enable companies and agencies to derive maximum value from their investments in sensor-based services. Oracle Sensor-Based Services offer a robust and comprehensive set of capabilities to handle all five elements of the sensor-based computing solution. Based on Oracle Database 10g, Oracle Application Server 10g, Oracle Enterprise Manager 10g, and Oracle E-Business Suite 11i, Oracle Sensor-Based Services enable companies to quickly and easily integrate sensor-based information into their enterprise systems.

Intel provides high-performance, standards-based building blocks for all aspects of sensor-based computing infrastructure:

- Tag readers and wireless information-access devices at the edge of the organization.

- Scalable application servers driving new RFID-powered business applications.
- Powerful database servers that meet the rigorous demands on RFID-swollen databases.
- High-performance PCs and notebooks that help empower employees to fully utilize the new applications and data sources.

Oracle and Intel: Comprehensive Solutions for Sensor-Based Computing

Individually, Oracle and Intel bring outstanding solutions to the marketplace. They also work closely together in a synergistic relationship that results in more powerful, competitive solutions to customer needs. Because of the collaborative efforts of these two industry leaders, organizations that deploy Oracle solutions on Intel architecture enjoy exceptional performance, compatibility and cost-effectiveness, along with the ability to deploy industrial-strength technology rapidly and at a fraction of the cost of non-standards-based platforms.

Few companies have all the expertise in house for successful sensor-based computing deployments. Both Intel and Oracle offer industry-leading services that can provide strategic and tactical guidance on how to plan for and implement sensor-based computing. Experts from Oracle Consulting and Intel Solution Services can evaluate an organization's readiness for sensor-based

computing, identify potential business value, offer advice on industry best practices and help architect flexible solutions that accelerate time-to-value and deliver superior business results.

Intel and Oracle also provide industry leadership in removing roadblocks to robust, interoperable sensor-based computing solutions. Both companies collaborate with international standards bodies and with other industry leaders to remove industry roadblocks and pave the way for robust, standards-based solutions that promote flexibility, interoperability and rapid deployment.

Oracle Sensor-Based Services: Capturing Value from Sensor Data

Built on more than 25 years of development in data sensor-based computing transactions, Oracle Sensor-Based Services delivers a comprehensive set of capabilities to turn sensor data into actionable operational intelligence and turn the promise of sensor-based solutions into sustainable competitive advantage:

- **Capture information.** Oracle Application Server 10g enables out-of-the-box integration and device management for sensor readers. Data can be captured and filtered appropriately before being passed to a common data store, where it is analyzed and made available to all business applications.
- **Manage information.** Oracle Database 10g ensures that the vast amounts of sensor data are effectively stored and managed. Its advanced event management capabilities allow users to transform, distribute, query and audit specific events occurring in the system.
- **Analyze information.** Oracle Business Intelligence is a comprehensive platform that enables timely, informed decision-making for rapid responses to changing business requirements. Oracle's embedded location (spatial), network and trend modeling, and analysis tools provide organizations with powerful route optimization and predictive capabilities. Embedded analytics allow organizations to identify, model, and apply statistical inference to trends within their operational environment, to better anticipate and plan for environmental or business practice changes. Time stamping and version control capabilities allow managers to analyze operational history for more informed decision-making. Oracle Business Intelligence encompasses robust solutions for information access, collaboration, corporate performance management,

data analysis and data warehousing, as well as application development tools to facilitate customizing the suite to meet unique enterprise requirements.

- **Access information.** Oracle Application Server Portal and Wireless provide decision makers with up-to-the-minute business intelligence from online and from mobile devices. Employees, partners and customers can collaborate in real time in a unified workplace.
- **Act on information and events.** Oracle Application Server 10g integrates systems together to streamline and automate business processes and provides model-based, event tools for business process management and activity monitoring, enabling enterprises and government organizations to manage by exception, respond to events and collaborate in real time to reduce risk and maximize opportunities.

Oracle also offers flexible deployment options depending on where organizations are in the adoption cycle. An EPC Compliance Enabler includes a pre-built compliance application coupled with the services needed for rapid deployment and compliance with recent mandates from Wal-Mart and others. An RFID pilot kit facilitates prototype testing and pilots by including drivers for leading RFID readers, as well as reporting capabilities and advanced business intelligence tools.

Other Oracle offerings are being enhanced to accommodate RFID and other sensor-based services. Oracle E-Business Suite will enable enterprises to transform and automate their business processes by taking advantage of sensor-based information. The latest version of Oracle Warehouse Management includes RFID capabilities to improve inventory control and extend supply chain visibility.

Maximizing Value: Powerful Platforms for Sensor-Based Computing

To maximize sensor computing's business value, organizations need to build their current computing infrastructure along multiple dimensions simultaneously. Figure 2 illustrates a distributed architecture for RFID implementation, and shows three critical steps to meet the infrastructure demands of sensor-based computing:

1. Put servers where tags are read, to provide intelligent data flow and event management, identify exceptions and make sensor data immediately available for business services and global synchronization. This is the lower left area of the block diagram.
2. Introduce wireless devices and networking intelligence to filter the incoming data and send/respond to real-time events.
3. Deploy translation and integration services systems that prepare data for movement to internal and external data pools and to external registries for synchronization with business partners (the center portion of the diagram).
4. Create a consolidated business services layer that can enable rapid decision-making based on sensor-enabled data as it flows into the enterprise (the center left portion of the diagram). This approach avoids stovepipes and maximizes reuse and cost-effectiveness.

Networks and storage capacity should likewise be deployed with an eye to performance, scalability and interoperability. Companies will also need powerful desktop PCs, notebooks and handheld devices, so employees can access, interpret and act upon data when and where they need it. High-performance PCs – both desktop systems and notebooks for mobile users – are crucial in enabling employees to turn the data into actionable, executable information.

Intel processor-based systems offer an outstanding foundation for sensor-based computing infrastructure.

Powered by Intel’s extensive R&D investment and the economic advantages of volume manufacturing, Intel architecture-based platforms provide robust, cost-effective infrastructure at every stage of deployment. Enterprises and government organizations can expand their existing infrastructure with end-to-end Intel architecture-based solutions that include:

- Intelligent, cost-effective RFID readers based on Intel XScale technology.
- Distributed edge servers and blade servers based on the Intel Xeon processor, for use where data is aggregated and filtered and critical events are triggered.

- Scalable application servers based on the Intel Xeon processor MP to support new, sensor data-enabled business services.
- Massive database servers based on the Intel Itanium 2 and Intel Xeon processor with Intel Extended Memory 64 Technology¹ (Intel EM64T) to house the filtered data.
- High-performance desktops powered by the Intel Pentium 4 processor for manipulating complex data sets and communicating results.
- Wireless notebooks with Intel Centrino mobile technology⁺ and wireless handheld devices based on Intel XScale technology for convenient access to data when and where it’s needed.

All offer open standards-based support for a broad range of software, solutions and services, with a price/performance curve well beyond that of any RISC architectures. Intel architecture-based solutions enable organizations to create infrastructure that is:

- **Powerful.** From lightweight handheld devices and readers to the largest servers, Intel processor-based systems are powered by high-performance building blocks. Intel invests billions of dollars annually in research and development, providing an aggressive roadmap to continuing performance increases.
- **Scalable.** Intel processor-based servers offer a choice of scalability methods, including scaling out by adding more servers, or scaling up to larger configurations and more powerful processors.

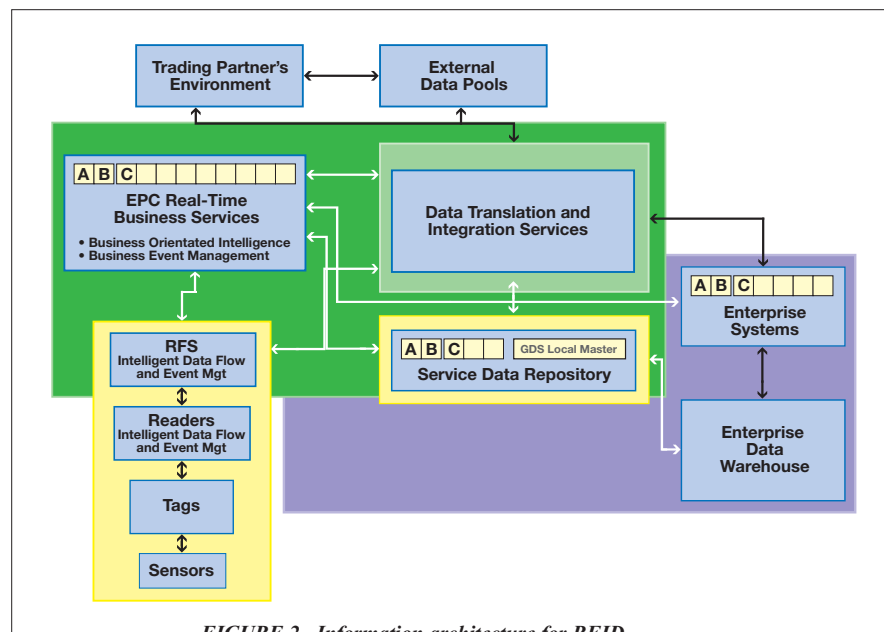


FIGURE 2. Information architecture for RFID.

- **Flexible.** Systems based on Intel building blocks are supported by a wide range of applications, development tools and operating systems.
- **Consistent.** The ability to create end-to-end solutions based on a single architecture helps reduce environmental complexity, which in turn lowers total cost of ownership by reducing training, development and deployment costs.
- **Secure.** Intel processors support many industry-standard and third-party security standards, enhancing the security of the enterprise.
- **Open.** A standards-based architecture enables systems based on Intel architecture to be easily and affordably interfaced with existing infrastructure, helping agencies and companies make the most of their existing investments and shorten deployment times.
- **Cost-effective.** Intel architecture-based systems are typically more affordable than traditional proprietary RISC architectures. Capital cost savings are generally compounded by reductions in the cost of deploying, managing and maintaining the systems.

Maximize Your Return on Investment with Intel and Oracle

Sensor-based computing enables companies and agencies to more accurately track assets and monitor key indicators. It can provide greater visibility into their operations and allow decisions to be based on real-time information. It can transform retail supply chains into consumer-driven demand networks, and improve efficiencies and business processes in industries ranging from healthcare to defense.

Sensor-based computing solutions from Intel and Oracle provide outstanding business value. Oracle's industry-leading database and business application solutions run superbly on high-performance, reliable and cost-effective clusters based on the Intel Xeon

processor and servers based on the Intel Itanium 2 processor and Intel Xeon processor MP. The combination of Oracle and Intel technologies and services produces some of the most powerful, flexible solutions available for sensor-based computing.

Take advantage of sensor-based computing's transformative business potential – and of the work Oracle and Intel have done to ensure robust, compatible, high-performance solutions. Work with Intel and Oracle to map out a strategy for sensor-based computing success, and make Oracle Sensor-Based Services and Intel processor-based servers, PCs, handhelds and readers a cornerstone of your sensor-based computing infrastructure. Then, move forward with confidence as you convert the promise of sensor-based computing to a reality. Oracle and Intel offer the following recommendations for success:

- Learn about RFID and sensor network technologies.
- Benchmark your current supply chain and inventory management systems. Look for areas of inefficiency where there are gaps in digital information.
- Develop a roadmap to improved business value using RFID and sensor networks with the appropriate information architecture.
- Start one or more pilots to test the capability and evaluate the business benefits for your specific enterprise environment. Apply what you learn, and create a spiral of success. Identify and resolve issues and opportunities with both the physics of RFID and the business value of sensor-enabled information. Both are critical to achieving maximum business value from sensor-based computing.

FOR MORE INFORMATION

Please contact your local Intel & Oracle representatives or visit our websites:

www.intel.com/business/bss/technologies/rfid/index.htm
www.oracle.com/technologies/rfid/index.html

¹ Intel Extended Memory 64 Technology (Intel® EM64T) requires a computer system with a processor, chipset, BIOS, OS, device drivers, and applications enabled for Intel EM64T. Processor will not operate (including 32-bit operation) without an Intel EM64T-enabled BIOS. Performance will vary depending on your hardware and software configurations. Intel EM64T-enabled OS, BIOS, device drivers, and applications may not be available. Check with your vendor for more information.

* Wireless connectivity and some features may require you to purchase additional software, services or external hardware. Availability of public wireless LAN access points is limited, wireless functionality may vary by country and some hotspots may not support Linux-based Intel Centrino mobile technology systems. System performance measured by MobileMark* 2002. System performance, battery life, wireless performance and functionality will vary depending on your specific operating system, hardware and software configurations. See http://www.intel.com/products/centrino/more_info for more information. *Other names and brands may be claimed as the property of their respective owners.

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