intel Leap ahead™

# Deliver WiMAX Faster

Enabling fast design-in, small form factors, and energy-efficient performance with an integrated WiMAX chipset solution

Intel® WiMAX Connection 2400
Baseband Chip

Intel® WiMAX Connection 2300R
Triple-Band Radio

Intel® WiMAX Connection 2320R
Dual-Band Radio System-in-Package

intel WiMAX TECHNOLOGY

## A Wave of Opportunity for Device Manufacturers

WiMAX is poised to change the face of mobile computing, with multi-megabit-per-second mobile broadband Internet access,[1] complementing Wi-Fi* with low-cost connections to the Internet far beyond the reach of the nearest hotspot. Service providers have begun building out WiMAX networks worldwide, including plans by U.S.-based Sprint and Clearwire to cover tens of millions of subscribers by the end of 2008.

The potential demand for hardware to support this transition is dramatic. Over the next several years, global WiMAX deployments will fuel the purchase of hundreds of millions of interface cards, integrated PC components, and other WiMAX devices. Adding to this momentum, users will drive demand for newly connected consumer electronics equipment, ranging from handhelds and ultra-mobile PCs to media players and smartphones.

High integration in the Intel® WiMAX Connection 2400 baseband chip (left) and Intel® WiMAX Connection 2320R dual-band radio system-in-package (right) supports very small form factors.

As an early driver of WiMAX technology for the past several years, Intel is leading this new generation of mobility with the Intel® WiMAX Connection 2400 baseband chip and the Intel® 2300R series radio solutions which, when combined, deliver a complete WiMAX connectivity solution for notebooks and other devices. Intel WiMAX silicon solutions support very small form factors while minimizing design overhead and power consumption, as well as improving performance.

For more information about Intel® WiMAX products, go to **www.intel.com/go/wimax**

# WiMAX Silicon Solutions from Intel

The high-performance, power-efficient Intel 2400 integrated (MAC + PHY) baseband chip integrates with Intel radio silicon to provide a complete certifiable WiMAX solution that OEMs can use to significantly decrease the time and expense required to integrate WiMAX functionality into devices.

Radio functionality can be implemented using the Intel WiMAX Connection 2300R triple-band radio chip, affording designers the ability to choose their own radio front-ends, power amplifiers, and other components for a custom solution. OEMs may also choose to use the Intel® WiMAX Connection 2320R dual-band radio system-in-package (SIP) that includes those components in a pre-integrated configuration.

Building upon the same base WiMAX silicon, Intel plans to introduce integrated Wi-Fi / WiMAX modules for notebooks with Intel® Centrino® processor technology in 2008. These platforms would deliver both WiMAX and Wi-Fi access, including Intel® Next-Gen Wireless N, for up to 2x greater range and up to 8x better performance than previous 802.11 standards.[2] Intel's commitment to driving high volumes of WiMAX connectivity in the notebook yields benefits to OEMs designing mobile devices built upon the same base silicon in terms of economies of scale—which reduces costs—and comprehensive software testing. Ongoing certification by the WiMAX Forum* of Intel notebook modules built upon the same base silicon and software should also accelerate the OEM's device-level certification, for faster time to market.

## Optimized, Flexible Form Factor

Optimized for small form factors, the Intel WiMAX Connection 2400 baseband chip also provides low power consumption for cool operation, making it well suited to portable consumer electronics devices where battery life is key to user satisfaction and heat dissipation is at a premium. The small size also makes these solutions suitable for multi-mode devices, where WiMAX is one of several connectivity options.

Further helping to accommodate a broad range of small devices, nearly the entire WiMAX protocol stack resides on the chip. That enables WiMAX functionality to take up less host processor power, leaving headroom to support a wider range of applications. Intel provides an OS-agnostic driver architecture, simplifying porting.

## Broad Device Vision

Intel envisions WiMAX devices encompassing many types of applications, such as IP-based TV and other entertainment services, transactional e-Commerce, and business productivity on the go. The high degree of integration in Intel WiMAX chipsets supports rapid and robust integration of low-cost, high-throughput WiMAX connectivity into a wide range of power-efficient mobile devices:

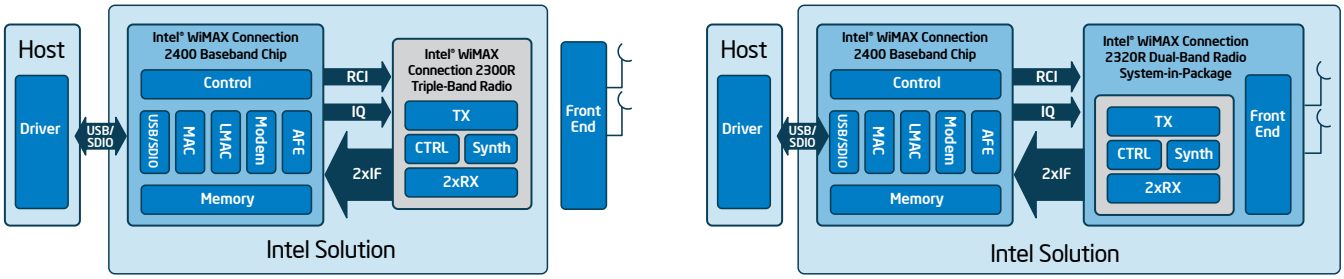
- **Computing and communications devices**, such as notebooks, handheld and ultra-mobile PCs, Internet tablets, infotainment devices, VoIP handsets, and smartphones
- **Add-on cards**, including USB 2.0, Express Cards, and SDIO cards, as well as fixed customer premises equipment
- **Consumer electronics devices**, like automobile navigation devices, digital video and still cameras, set-top boxes, media players, and mobile gaming devices

### FEATURES AND BENEFITS

| Chipset Features | Benefits |
|---|---|
| Highly integrated solution | ▪ Shortens design-in and speeds time to market<br>▪ Enables very small form-factor devices<br>▪ Minimizes radio design requirements |
| Low power architecture and advanced power-save features | ▪ Supports longer battery life<br>▪ Helps to address heat dissipation concerns |
| Embedded protocol stack (only minor software in host) and OS-agnostic driver architecture | ▪ Lowers host CPU and code requirements<br>▪ Simplifies driver porting to various OSs<br>▪ Decreases system power requirements |
| Integrated memory | ▪ Decreases size (including height requirements)<br>▪ Lowers cost and simplifies design/debugging<br>▪ Helps to further decrease system power |
| Integrated multi-band radio (2.3-2.69 GHz and 3.3-3.6 GHz) | ▪ Enables worldwide roaming capability<br>▪ Increases market opportunity across frequencies |
| Compatible with Intel® Centrino® processor technology WiMAX profile | ▪ Ensures compatibility with notebooks<br>▪ High volume simplifies and accelerates device certification |
| Low host CPU utilization | ▪ Zero MIPS in idle mode |

**Nokia Nseries Internet Tablets**

Among the early products anticipated to be powered by Intel WiMAX chipsets will be the Nokia N800 series* Internet Tablets, expected to ship in 2008. Running open-source Linux*, a Mozilla*-based browser, and an array of popular applications, the device will deliver full-featured Internet access through Sprint's Xohm* WiMAX network.




OEMs may choose to integrate the Intel WiMAX Connection 2400 baseband chip with either a stand-alone radio chip (left) or the SIP radio module (right).

## Innovation through Integration

All of the components of the Intel WiMAX chipsets are designed from the ground up to work together, helping to produce optimal results.

Intel's unparalleled wireless design expertise has led to the development over several years of the Intel WiMAX Connection 2320R dual-band radio SIP module—a highly refined combination of radio silicon, front-end module and power amplifier along with other components in a single, very small SIP. Designed specifically to work together with the Intel WiMAX Connection 2400 baseband chip, these components relieve OEMs from a significant level of design complexity, which helps to reduce costs and speeds time to market. OEMs also have the flexibility to perform specific radio customizations or optimizations using the standalone Intel WiMAX Connection 2300R triple-band radio chip.

The Intel WiMAX Connection. 2400 baseband chip's integrated internal memory significantly reduces solution size compared to competing solutions. With no external memory requirements, device board space is used more efficiently—enabling the OEM to further reduce the area of the device (in the x-y plane), or the height of the device (in the z-plane.) When OEMs choose Intel's integrated radio module solution, board footprint is further reduced by means of the radio front end's integration into the SIP solution.

### SPECIFICATIONS

| | |
|---|---|
| Chipset Components | Intel® WiMAX Connection 2400 baseband chip (10 mm x 10 mm)<br>Intel® WiMAX Connection 2320R dual-band radio SIP (11 mm x 11 mm) |
| Throughput | Max sustainable average: 10 Mbps DL/4 Mbps UL<br>Typical: 6 Mbps DL/2 Mbps UL<br>Peak: 20 Mbps DL/5 Mbps UL |
| Power | WiMAX idle: < 5 mW<br>Standby: < 3 mW<br>Power down: < 100 µW |
| Supported Bands | 2.3-2.4 GHz<br>2.5-2.69 GHz<br>3.3-3.6 GHz |
| Supported Bandwidths | 5, 7, 8.75, 10 MHz<br>(WiMAX Forum defined) |
| Board Space | Module: < 400 $mm^2$, single sided<br>Chipset: < 220 $mm^2$ |
| Host Interface | USB 2.0<br>SDIO (1 bit, 4 bits, SPI) |
| Host Operating System | Windows XP*, Windows Vista*, Linux*<br>OS-agnostic driver architecture, APIs, and source code for easy porting to other OSs |

## Integrated Dual-Band Radio Solution

The Intel WiMAX 2320R dual-band radio SIP solution supports the 2.3-2.69 GHz and 3.3-3.6 GHz bands to enable worldwide roaming on WiMAX networks. Together with providing a very small physical footprint, this integration effectively enables OEMs to design a single device that can accommodate multiple geographies.

In addition to the radio itself, the Intel WiMAX 2320R dual-band radio SIP includes the radio front-end components, such as low noise amplifier, power amplifiers, transmit and receive switches, filters, and signal converters. Software support accommodates the 2.5 GHz band today, timed with the first major mobile WiMAX deployments in the U.S., and software support for other bands is being added as worldwide build-out of WiMAX networks continues.

If an OEM desires greater flexibility to customize or optimize its radio solution, Intel also offers the Intel WiMAX Connection 2400 baseband chip in combination with the Intel WiMAX Connection 2300R triple-band radio chip, which does not include the front end components.

## Optimized Design-In

The Intel WiMAX 2320R radio module is highly optimized to facilitate rapid device design, testing, and certification, and it compares very favorably with historical radio solutions that typically would have required several hundred external components to emulate the solution's capabilities. Because its internal complexity is isolated from the larger board design, device manufacturers are able to make smaller, simpler system boards. Reference design boards and a technology evaluation kit are available for fast prototyping, including APIs that allow for rapid integration into end-user devices.

Because all of the RF-critical parts are included in the chipset, certification of the solution is simplified, reducing OEM testing time and costs, as well as reducing time to market.

## Design Features Boost Performance

The design of the Intel WiMAX Connection 2400 baseband chip creates significant performance advantages without additional effort on the OEM's part. The high degree of integration affords very fast loads at runtime. For example, an embedded protocol stack runs on an internal application processor, and integrated internal memory reduces latency, for better performance plus overall system cost savings relative to solutions that require external memory.

The Intel WiMAX Connection 2400 baseband chip efficiently utilizes bandwidth through strict compliance with the IEEE 802.16e-2005 standard. Support for channel-aware resource scheduling over frequency and time improves spectral efficiency.

Mobile WiMAX optimizes the data rates associated with asymmetric data flows using time-division duplexing (TDD). By differentiating between the bandwidth allocations for upload and download traffic, it is typically possible to more efficiently use the available throughput to increase the download data rate. Orthogonal Frequency Division Multiple Access (OFDMA) effectively limits inter-cell interference by adaptively assigning sub-carriers to various users on an as-needed basis, which decreases error rate and increases spectral efficiency.

## Advanced Antenna Technologies Enhance Throughput

Intel WiMAX silicon solutions support Multiple Input/Multiple Output (MIMO), which is incorporated in the IEEE 802.16e-2005 standard. MIMO technology provides significant increases in throughput and range, relative to SISO (Single Input/Single Output) systems using the same bandwidth and transmission power.

MIMO uses multiple antennas at both the base station and subscriber unit to enable data to travel along different independent paths. MIMO configurations on the Intel WiMAX chipsets are 1x2, which refers to one Tx (transmit) and two Rx (receive) antenna chains.

On downlink, a base station configured with two Tx antennas transmits to the client device's two Rx antennas, enabling what is referred to as 2x2 downlink MIMO. On the uplink, 802.16e-2005 supports a feature called "collaborative MIMO." Under this scheme, a base station with two Rx antennas can simultaneously receive signals from two clients, each of which has one Tx antenna, enabling what is referred to as 2x2 collaborative uplink MIMO. With these configurations, clients can support sustained throughput of up to 10 Mbps on downlink and up to 4 Mbps on uplink.

## Intel's WiMAX Investment Helps Ensure Reliability

Intel's strategic WiMAX vision helps to support the success of device manufacturers. As a founding member of the WiMAX Forum, Intel provides ongoing leadership and influence as part of its ongoing commitment to the advancement of WiMAX. Intel has also committed extensive resources, both to accelerate WiMAX deployments and to address regulatory considerations worldwide.

Intel continues to dedicate substantial capital and strategic investments to its long-term WiMAX vision. Intel silicon solutions will continue to be at the forefront of innovation to ensure that OEM products are leading edge.

Intel WiMAX chipsets deliver very high performance at low cost using easily integrated solutions based on a minimal number of components. The solution helps simplify the design cycle for device manufacturers, including manufacturing efforts that span multiple form factors. These factors help OEMs to achieve cost control and rapid time to market, furthering their competitive advantage.

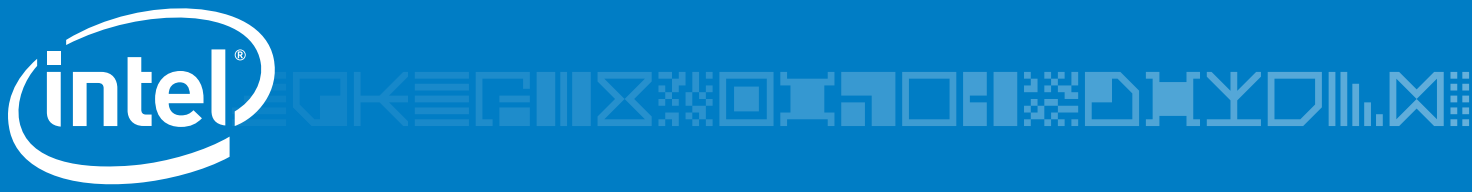
## Enablement for the Future of Mobile Broadband

Intel provides a highly integrated WiMAX solution optimized for small form factors and fast design-in, while yielding high performance and low power consumption. Fully IEEE 802.16e-2005 compliant, Intel® WiMAX chipsets enable OEMs to integrate WiMAX functionality into a wide variety of devices at low cost, while enabling fast time to market. Intel's ongoing leadership in the WiMAX ecosystem, including an ongoing leadership role in the WiMAX Forum, helps to ensure high interoperability with equipment and service networks worldwide. OEMs can pass these advantages on to their customers, helping to achieve success in the expanded wireless future.

## Take the Next Step

To learn more about WiMAX opportunities, contact your Intel representative.

For more information about Intel® WiMAX products, go to **www.intel.com/go/wimax**.



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All plans, features, and dates are preliminary and subject to change without notice.

[1] The service level provided to an individual WiMAX subscriber is solely determined by the service provider and is independent of the actual throughput supported by devices incorporating Intel WiMAX silicon solutions.

[2] Up to 8x better performance and 2x greater range enabled by products with Intel® Next-Gen Wireless N technology in a 3x3 MIMO network configuration. Actual results may vary based on your specific hardware, access point connection, site conditions, and software configurations. See **www.intel.com/performance/mobile/wireless/index.htm** for more information. Requires Intel® Next-Gen Wireless N technology and connection to a Wi-Fi CERTIFIED 802.11n draft 2.0 access point. Check with your PC and access point manufacturer for details.

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