

A Guide to High-Speed Embedded Processors

Fifth Edition

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Authors: Joseph Byrne and Linley Gwennap

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Looking for a Fast Processor?

The number of markets for high-speed processors continues to grow. In networking alone, these speedy chips are needed for complex functions such as intrusion detection and other security functions, storage management, router control plane, and networking services. Consumer devices such as set-top boxes, HDTV receivers, and automobile navigation systems also need high-performance CPUs, as do high-speed printers, thin clients, kiosks, industrial control, medical imaging, and a host of other devices.

These applications share a need for speed but also the flexibility that a general-purpose processor provides. These chips use standard instruction sets such as MIPS, PowerPC, ARM, and x86, allowing programmers to use a wide variety of operating systems and development tools. System designers prefer a chip that integrates easily into their designs.

These applications have diverse requirements for performance, power dissipation, peripheral integration, and price. As a result, several vendors are selling dozens of different processors into the embedded market. In fact, we had to exclude processors below 400MHz or so, a speed range that is easily achievable by synthesizable cores today. This report focuses on companies developing their own CPUs to deliver extra performance to the customers that need it most.

Get the Facts Quickly

"A Guide to High-Speed Embedded Processors" provides an in-depth look at these products and vendors. This completely revised report from The Linley Group provides extensive coverage of high-end embedded processors with 230+ pages of information on AppliedMicro, AMD, Broadcom, Cavium, Freescale, IBM, Intel, Marvell, NetLogic/RMI, Tiler, Uvicom, and Via Technologies.

The report focuses on general-purpose RISC and x86 processors at speeds of 400MHz and above, excluding specialized architectures (e.g. DSP, NPU). This report covers most PowerQuicc and P-series chips from Freescale; the PowerPC 405 and 460 processors from AppliedMicro plus the company's new 1.5GHz APM83290 processor; Intel's embedded Atom and Nehalem-based processors; the entire Oction family from Cavium plus the company's new ARM-based Econa CNS3xxx processors; NetLogic/RMI's XLR, XLS, and XLP; Marvell's Discovery and Kirkwood processors; Tiler's TilePro many-core chips, and other RISC and x86 processors.

This handy guide, packed with valuable information, brings you up-to-date on the newest developments in this important market and gives you the analysis you need to help choose a supplier or partner in this field. In addition to networking, the report discusses processors that can be used in high-end consumer applications and printers. It also provides market share and market size data for the embedded segments covered.

"A Guide to High-Speed Embedded Processors" begins with tutorials on the key technologies implemented by these products, background on the embedded market, and a discussion of the newest technology and market trends. Following these introductory chapters, the report delivers thorough coverage of all announced products in this area. For each of these vendors, the report examines the performance, feature set, and architecture of each product, highlighting its strengths and weaknesses in a consistent, easy-to-compare fashion. The report concludes with our own comparisons of these products and conclusions about which will fare best.

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Analysts [Joseph Byrne](#) and [Linley Gwennap](#) bring their extensive experience in the processor market to deliver the technical and strategic information you need to make informed business decisions. As the leading vendor of technology analysis for networking silicon, The Linley Group has the expertise to deliver the technical and strategic information you need to make informed business decisions.

Whether you are looking for the most effective solution for your application, a vendor to partner with, or a rising company to invest in, this report will cut your research time and save you money. Get the inside scoop on this market segment. Order "A Guide to High-Speed Embedded Processors" today.

This report is written for:

- Engineers who are designing embedded systems that require high-performance processors
- Marketing and engineering staff at companies that sell chips that connect to or interact with high-speed embedded processors
- Technology professionals who wish an introduction to embedded processors
- Financial analysts who desire a detailed analysis and comparison of embedded-processor vendors and their chances of success
- Press and public-relations professionals who need to get up to speed on this technology

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The following excerpt is from "[*A Guide to High-Speed Embedded Processors, Fifth Edition.*](#)" This PDF contains the complete table of contents, list of figures, list of tables, preface, and executive summary. The full report may be purchased from The Linley Group.

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Fifth Edition

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By Joseph Byrne and Linley Gwennap



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About the Authors

Joseph Byrne



Joseph Byrne is a senior analyst at The Linley Group. With more than 15 years of industry experience, he is one of the industry's leading analysts covering the semiconductor market. He has published numerous reports analyzing various segments of the industry and is the coauthor of *A Guide to CPU Cores and Processor IP* and *A Guide to Mobile Processors*. Joe has spoken at several investor forums and industry conferences, including Network System Design Conference, Communication Design Conference, Gartner Semiconductor Conference, Selby Venture Partners' LP Conference, and the BusinessWeek IT Symposium at Comdex. He has frequently been quoted in both technical and business publications, including *EE Times*, *Unstrung*, *Electronic Business*, the *San Jose Mercury News*, NewsFactor Network, and the wire services.

Before joining The Linley Group, Joe served as a principal analyst for semiconductors at Gartner Research. In this role, he was responsible for tracking technology trends and market size, preparing market forecasts, and assessing the competitive landscape. His expertise also includes evaluating business and strategic plans, advising startups and major IC suppliers on marketing and positioning strategies, and providing insight to VCs and investment banks to support investment decisions.

Joe led Gartner's coverage of networking semiconductors in the era of the telecom boom and bust. Thereafter, he led Gartner's coverage of computing semiconductors, including microprocessors, system-logic chip sets, and graphics processors. Through both eras, he led coverage of wireless LAN chip sets. Joe also authored Gartner's seminal report on digital-camera technology, and he covered embedded microprocessors in the late 1990s. Before serving as an analyst, Joe held consulting positions with Gartner, Deloitte Consulting, and smaller firms in the U.S. and Europe.

He began his career as a microprocessor designer for SMOS Systems, where he honed his technical skills as a principal engineer. He earned a bachelor of science degree in electrical engineering and computer science from Duke University and an MBA from the University of Michigan.

Linley Gwennap



Founder and principal analyst of The Linley Group, Linley Gwennap is one of the most respected analysts in the microprocessor industry. He has followed the industry for more than 15 years. A prolific writer, Linley has published hundreds of articles in a variety of publications including *EE Times*, *Upside Magazine*, *Electronic Business*, *Nikkei Electronics*, and the *San Jose Mercury News*. His work has also been translated into Japanese and German for international publications.

He has written several book-length reports, including *A Guide to Wireless Handset Processors* and *A Guide to Mobile Processors*.

Linley also provides high-level consulting to the microprocessor industry on subjects such as product positioning, strategic analysis, and competitive assessment. He has assisted companies such as Agere, Applied Materials, Hewlett-Packard, IBM, Intel, and Motorola, as well as several smaller companies and investment firms.

Linley's expertise, a rare combination of deep technical understanding and business savvy, is frequently sought by the technical and business press. He is often quoted in *The Wall Street Journal*, *Electronic News*, *Business Week*, the CNet web site, and other leading technology and business publications. He has also appeared on CNNfn, CNBC, Fox News, Tech TV, and National Public Radio. In 1997, Linley was profiled in *Worth* magazine as the analyst who "decodes Intel for the rest of us."

He founded The Linley Group in 1999 to provide technology and market analysis to a broad group of clients. Since then, the firm has established itself as the leading vendor of technology analysis of the networking-silicon industry.

Before founding his company, Linley served as publisher and editorial director of MicroDesign Resources' *Microprocessor Report*, leading the top independent technology-analysis team in the microprocessor industry. Under his leadership, the publication won the Computer Press Award for best industry newsletter four times in six years. He joined MDR in 1992 as its first full-time analyst.

Before joining MDR, Linley spent eight years working on RISC systems at Hewlett-Packard. As a design engineer, he developed test and initialization firmware for HP's PA-RISC servers, gaining a deep understanding of the operation of large multiprocessor servers. He later worked on PA-RISC processor design.

Linley then served as program manager for HP's Model 810 and 815 Unix systems, successfully driving those projects to market. He began seriously analyzing the microprocessor industry while serving as product marketing manager for HP's PA-7x00 family of RISC processors.

He graduated *cum laude* from Yale University with a bachelor of science degree in electrical engineering. While at Yale, Linley also studied at the graduate School of Organization and Management. As a student, he served as vice president of the Yale Political Union and chairman of the university's Independent Party.

About the Publisher

The Linley Group

The Linley Group is the leading vendor of technology analysis on networking, communications, mobile and wireless semiconductors, providing a unique combination of technical expertise and market knowledge. We help clients understand the market for these devices, their product requirements, the choices available, and which ones are best for a particular application.

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For clients desiring off-the-shelf assistance, we offer standard reports on specific topics. These in-depth reports provide an overview of a particular market segment, including market size and share, key trends, and expected developments. The reports then analyze all available products, highlighting their strengths and weaknesses. Readers find our reports particularly useful when they are selecting a vendor or partner.

Our reports are written by our own expert analysts. Technical accuracy is very high, as each vendor provides information about its products and reviews our presentation of those products. We add our analysis and insight, comparing and contrasting the various offerings and indicating the applications for which they are best suited. To ensure that our opinions are objective and unbiased, The Linley Group does not accept stock or retainers from the companies we cover. Our reports are used by more than 200 companies, including leading equipment makers, chip makers, software vendors, and investment firms.

Our reports cover Ethernet chips, network processors, communications processors, embedded processors, security processors, and high-speed interconnect as well as processors and connectivity chips for mobile and wireless devices. Additional titles are in development. We offer our reports in paper and PDF formats. Multiple paper copies and multi-user PDF licenses are available at significant discounts.

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The Linley Group offers customized consulting services for clients that need help with a specific issue. The Linley Group has served a variety of

clients, including Altera, AppliedMicro, AMD, ARC, Bay Microsystems, Brocade, Cavium, Cortina, Cypress, Exar/Hifn, EZchip, Fulcrum, Freescale/Motorola, Gennum, HP, IBM, IDT, Intel, LSI/Agere, Marvell, Mindspeed, MIPS, NetLogic, Raytheon, Sony, Symantec, Transmeta, Wintegra, Xelerated, Xilinx, Crosslink Capital, Piper Jaffray, and Ziff Brothers Investments. Typical consulting projects include the following:

- Helping established semiconductor vendors with competitive analysis, messaging, and positioning for upcoming product launches
- Working with young companies to improve their product definition to best differentiate themselves from potential future competitors
- Assisting equipment vendors to identify the core silicon most appropriate for their application
- Providing valuable insights and technical due diligence to investment firms evaluating whether to invest in a semiconductor company

Our analysts start with a deep understanding of the key technologies in these markets, ignoring the hype and finding the features that make a difference. But we also understand that market success is based on business strategy as much as on technical excellence, and our recommendations are always steeped in the realities of the marketplace. We understand the dynamics of startups and established corporations alike and can shape our message to apply to the client's situation.

Events

The Linley Group presents focused seminars and conferences that analyze products and design strategies in a particular technology segment, providing information that engineers can immediately use to improve their designs. These one- and two-day events feature in-depth technical presentations from our own analysts as well as leading technologists from the industry. Thousands of people have already attended.

Please check our web site for a list of upcoming dates, topics, and locations. The web site also offers the proceedings (slides) from past events free of charge.

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Preface

What This Report Covers

This report covers high-performance RISC and x86 processors for embedded systems, either without integrated peripherals (standalone processors) or with integration of only generic system logic, such as memory controllers, PCI interfaces, and Ethernet interfaces. We focus on processors operating at 400MHz and above.

These general-purpose processors are used in many different embedded applications, including networking and communications equipment, networked storage, security appliances, PBXs, kiosks, point-of-sale (POS) terminals, thin clients, high-end printers, set-top boxes, digital video recorders (DVRs), car-navigation systems, industrial control, military, and medical imaging.

This report does not cover processors used only in PC or server applications. It does not cover high-performance application-specific processors that integrate special-purpose hardware for data-plane, video, or similar applications.

Who Should Read This Report

This report is designed to meet the needs of a variety of readers:

- Engineers who are designing embedded systems that require high-performance processors
- Marketing and engineering staff at companies that sell chips that connect to or interact with high-speed embedded processors
- Technology professionals who wish an introduction to embedded processors
- Financial analysts who desire a detailed analysis and comparison of embedded-processor vendors and their chances of success
- Press and public-relations professionals who need to get up to speed on this technology

As described below, the report is structured to allow some readers to skip certain sections, as needed. For example, experienced design engineers

may wish to focus on the vendor and comparison chapters; financial analysts may instead focus on the tutorial, introduction, comparison, and conclusions chapters.

Organization of the Report

The first four chapters offer tutorial and background material. Chapter 1 provides a tutorial on processor design, including CPU microarchitecture, memory, and I/O interfaces. Chapter 2 provides background on the types of embedded systems that use high-speed processors. Chapter 3 gives general information on the x86, MIPS, PowerPC, and ARM instruction sets. Chapter 4 discusses the common features of high-speed embedded processors and how to measure their performance.

Chapter 5 presents market data such as market size, vendor share, and forecasted revenue as well as our take on current technology trends.

Chapters 6 through 12 cover the top vendors of high-speed embedded processors—AppliedMicro, Cavium, Freescale, Intel, Marvell, NetLogic (formerly RMI), and Tiler—and their current products. For each vendor, the report provides a company overview, an overview of applicable products, microarchitecture details, system-design information, a road-map of future products, strategic analysis, and overall conclusions.

Chapter 13 briefly covers several other high-speed processor vendors, including AMD, Broadcom, IBM, LSI, PMC-Sierra, Ubicom, and Via.

Chapter 14 groups the available products into several categories and presents detailed technical comparisons within each group.

Chapter 15 concludes the report with our analysis of market trends and presents our take on which vendors will win in each segment.

Acknowledgments

The authors wish to thank the numerous people at AMD, AppliedMicro, Broadcom, Cavium, Freescale, IBM, Intel, LSI, Marvell, NetLogic, Tiler, Ubicom, and Via who supplied information on their products and reviewed sections of the report. These reviewers helped ensure the highest possible technical accuracy.

Thanks go to our ever-vigilant copy editor, Jeff Clark, for keeping our grammar straight, and to Eileen Schmidt, who assisted with production.

Executive Summary

Embedded designers who require maximum CPU performance turn to high-speed embedded processors. For ease of programming, these processors use general-purpose instruction sets such as MIPS, PowerPC, ARM, or x86. Although these instruction sets are interchangeable in theory, in practice the instruction set and the application are strongly correlated. Consumer electronics—including broadband gateways, HDTVs, and set-top boxes—mainly uses MIPS or ARM. PowerPC is the top choice for networking equipment such as routers, security, storage, communications infrastructure, and cellular base stations.

Many other applications borrow from the PC platform to quickly build complex systems that may involve networking, storage, graphics, and I/O. These systems include interactive kiosks, point-of-sale (POS) terminals, PBXs, industrial control, storage servers, and media servers.

Some applications, such as packet processing and multimedia, can easily be divided into many small pieces. These applications work well on multicore processors, which include 4 to 64 CPUs on a single chip. This approach, which improves performance per watt, is now offered by Cavium, Freescale, NetLogic (through its recent acquisition of RMI), and others. The majority of application software, however, does not yet scale well with so many CPUs. These applications work best with one or two CPUs. Most embedded-processor vendors now offer products with up to two CPUs per chip.

We estimate the total revenue from general-purpose embedded processors was \$3.3 billion in 2008, including devices such as communication and RAID processors but excluding specialized devices such as PlayStation 3's Cell processor and application-specific standard products (ASSPs). This revenue rose 2.4% over that of the preceding year, and we expect a five-year compound annual growth rate of 2.8% from 2008 through 2013 as the market begins its recovery in 2009.

Intel generates the most revenue from general-purpose embedded processors. Simply by offering its standard PC and server processors, Intel can generate hundreds of millions of dollars from a variety of PC-like embedded applications as well as from security and storage designs. For most networking and communications applications, however, the company's standard processors are too power hungry, and its new Atom

products lack key features. The company is developing new chips to address many of these issues.

As in the PC market, AMD and Via Technologies compete against Intel in PC-like embedded applications. AMD has been gaining share using embedded versions of its PC and server processors. Via has struggled to establish its Nano processor against Atom, but its C7 processor remains a popular embedded choice owing to its very low price.

Supported by AppliedMicro, Freescale, IBM, and soon LSI, PowerPC comprises more than half the embedded RISC market and is particularly popular for communications and networking. Freescale, the PowerPC leader, offers a broad range of products. The company's QorIQ P4080 is a strong eight-CPU processor that will open new opportunities for the company. Other QorIQ processors refresh Freescale's lineup and will enable the company to protect its market share. Formerly called AMCC, AppliedMicro has new management and is building a processor development team to refresh the company's aging product line. The company recently sampled its first dual-CPU processor.

MIPS processor vendors include Broadcom, Cavium, and NetLogic. Cavium has quickly built a broad processor lineup ranging from 1 to 16 CPUs on a chip. These Octeon processors are well suited to security and other networking applications, particularly at the high end. NetLogic offers a similar lineup under its XLR and XLS brands. Its new XLP design incorporates high-speed CPUs supporting features such as simultaneous multithreading (SMT) and speculative execution. Broadcom combines a licensed CPU from MIPS with its own technology to address cost-sensitive systems.

Marvell developed its own ARM CPU for single- and dual-CPU products. Operating at up to 1.2GHz, these processors are very power efficient and offer excellent price/performance for consumer and SMB applications. Ubicom targets low-cost designs with a unique multithreaded architecture. Tilera developed a new mesh interconnect that supports up to 64 CPUs on a single chip, delivering industry-leading performance.

Although the embedded-processor market will top \$3.7 billion in 2013, a number of vendors have decided to exit the market or revamp their strategies. IBM is deemphasizing its standard-product business to concentrate on technology development and licensing. Broadcom offers single-, dual-, and quad-core MIPS processors using a custom CPU, but it has wound down development of these products. PMC-Sierra's custom-processor operation has declined; instead, the company now offers application-specific products, such as PON chips, that integrate CPU technology.

The faltering of various suppliers, the emergence of multicore and many-core processors, and transitions in end-market technologies, such as the emergence of LTE, are forcing customers to reevaluate their suppliers. This report analyzes the products, capabilities, and strategies of each vendor to determine which products are best suited to each embedded application and which vendors are most likely to succeed in this dynamic environment.