WINPATH™ ACCESS PACKET PROCESSORS

Network Processor Selection:

Making your Packet Processing Project Successful

Selecting a network processor for access applications requires careful attention to a broad range of considerations. Certainly, the needs of the access network application (DSLAM, cell-site, or MSAP) help determine the technically acceptable options, but many other factors ultimately contribute to the relative success of the program.

To best position your project for success you have to make effective decisions, and knowing the right information to solicit is a necessary first step. Network processor architectures vary widely, vendors focus on different niches and emphasize varying capabilities, and there are many internal program considerations as well. Fortunately, other projects have blazed the path, and you can benefit from their experiences. This paper will guide you through the key selection decisions essential for project success.

Network processor selection is not only a technical decision, but also a business decision.

How do network processors impact the development process?

Network processors are novel and powerful packet processing inventions, providing valuable flexibility compared to hardware-focused ASIC solutions and attaining packet performance far beyond the capabilities of traditional software-centric microprocessor solutions. However, introducing network processor technology into your organization can also impact far more than hardware and software development processes. Some of the more subtle implications to consider include:

- Engineering resource loading. Network processor applications will often increase the software/hardware ratio.
- Existing code base reuse. Determining whether to reuse or replace existing protocol stacks is an important consideration.
- Future product design considerations. Network processor families with a broad range of performance points enable a long-lived technology base.
- Knowledge base investment options. Network processor decisions often involve weighing "make vs. buy" options.
- Program risk mitigation. Introducing new technology into an organization always incurs risks. Network processors can magnify or reduce these risks.
- Development team reputation. Success builds on success, while projects that don't meet expectations are hard to live down. A well done network processor based product can be the "home run" your development team needs.

Realistically assessing organizational impacts promotes project success.

As the nature of each vendor's devices, software and supporting organizations vary widely, so do the impacts each would make upon your business. Before committing to a particular vendor's offering, ascertain the effect each option will have upon your organization, and weigh carefully the corresponding costs, benefits and risks.

How does network processor technology offer competitive advantage?

While the technological facets of network processor selection are important, the first considerations should be business related, as the goal is to increase sales and profits. Solutions that get quickly to market and rapidly bring in revenue are desirable, while those that languish in development and consume resources are not. Before making development decision, it is worthwhile to carefully consider the business aspects of the program, and to appropriately weigh decision criteria.

A good vendor helps reduce existing risks, rather than creating new problems.

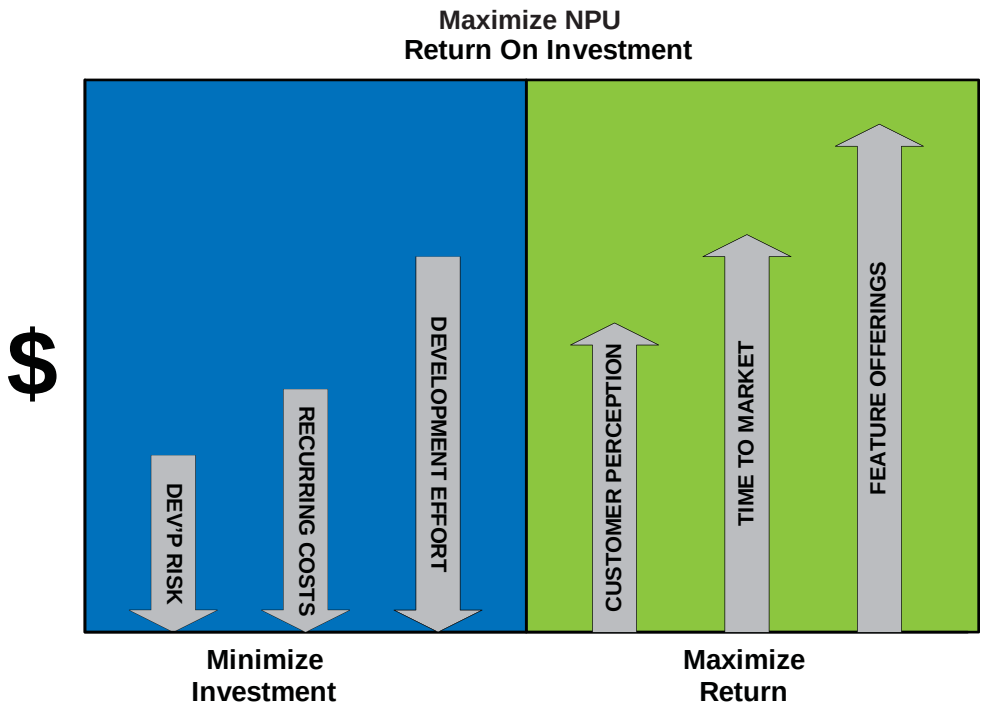
For product success, a company must effectively set customer expectations, and to deliver product meeting those expectations profitably. Meeting expectations requires focusing development resources on the critical customer problems, and ensuring that priorities are aligned and needs are well understood. A high-quality network processor vendor can:

- Help the design team plan and execute the design process
- Provide insight and understanding of common application details and industry expectations
- Aid in crafting efficient and timely solutions
- Effectively share responsibilities and adopt priorities
- Promote sound risk-reduction strategies throughout the lifecycle.

A low-quality vendor:

- Exaggerates capabilities and functionality
- Exacerbates problems by omitting or hiding key details during selection
- Amplifies development task misunderstandings from lack of experience
- Adds development risks to already complex projects
- Creates production delays for undoubtedly stringent schedules.

For most programs, gaining a substantial and rapid return on investment is a primary goal. To maximize ROI, the obvious approach is to minimize investment while maximizing return. For a technology product, minimizing investment generally includes minimizing development effort,



minimizing bill-of-material costs, and effectively managing development risk. Maximizing return includes bringing products to market more quickly, providing high-value feature sets, and maintaining customer confidence by meeting expectations.

Improved predictability through risk management is key to maximizing ROI.

Customer credibility is increasingly important as service providers forego traditional early-phase lab testing and instead wait for deployment-ready solutions before investing in product verification. With compressed deployment schedules even small slips in schedule or modest lapses in functionality can spell disaster for fledgling products as costs balloon and revenues postpone.

How will network processors provide technology leverage?

For any new development project, the immediate technical and resource needs are typically urgent and obvious. However, broader company impacts are of greater long-term consequence, yet are often overlooked. Integration of a network processor often requires significant restructuring of an existing protocol stack in order to properly create the necessary control plane and data plane split that all true network processors require. Depending on the natures of any particular processor and of the existing stack, this

restructuring could range from a modest integration of protocol components to a full stack redesign and coding exercise.

Rarely does a company invest in a significant technology for a single use The ability to flexibly scale performance while reusing software solutions is important, as is the ability to readily add features, interfaces, and protocols broaden scaling points and address new applicaitons. Often, the true return on a technology investment is not realized in the initial project, but on a related effort sometime later, so creating a technology base that is a "safe bet" for reuse is a good idea.

What other factors should be considered?

Technology considerations are perhaps the most visible and obvious aspects of a network processor decision, though it is easy to oversimplify technology concerns. A matrix of check marks may exaggerate feature availability, and fail to provide much context as to what is actually feasible in a reasonable timeframe for a market-ready product. For many network processors, the question shouldn't be "can a protocol be implemented?" but "what effort is required to create an integrated, market-ready solution?" Not only must features be market-ready, but be available simultaneously at run-time and integrated in various combinations to address complex product needs.

There is more to feature coverage than protocol check-boxes.

For a technology-driven company, long-term success depends heavily on being a leader in a rapidly-moving field, and remaining competitive requires effectively creating an intellectual property base. Employee expertise and knowledge is a primary corporate asset, and wisely determining the areas of expertise in which to invest is critical to maintaining a competitive edge and retaining quality employees. When undertaking a network processor project, the investment in intellectual property – whether in software skills, protocol expertise, application understanding, or product architecture – should be understood.

Network processor integration is your key intellectual property investment.

How do I avoid common pitfalls?

Selecting a network processor is a sophisticated analysis project, as the field is rapidly evolving, the vendor offerings vary widely, and the technical research required can be extensive. Programmatic concerns, especially for software development and testing resources, are broad and deep, and again the required analysis can be significant. While it can be tempting to hurry through a pro-forma analysis in order to reach a decision, data-driven

decisions based on technical, programmatic and business analysis will improve the probability of product success.

Making a well-informed selection is important, as a superficial understanding of the options and issues can easily result in common mistakes which will be all too obvious in retrospect:

- Viewing network processor selection as a hardware problem
- Misestimating schedule and effort
- Focusing on data plane tools versus control plane integration
- Evaluating features via check-list versus functionality by application
- Considering interface speeds rather than protocol processing rates

A superficial understanding of options is all too obvious in retrospect.

How much of a network processor design project is software?

For any network processor project, software is the key concern. Given that a key value of network processors is their programmability, it should be little surprise that software work typically forms the bulk of the development effort. Depending on the particular network processor and the vendor focus, software development can carry a range of meanings.

Network processors are really software projects in disguise.

For some NPUs, customers must program the data plane micro-engines and host processor completely by themselves, armed with only the barest of tools. For others, the tools are more capable and support common languages (though typically with proprietary extensions), but the protocol slate is still clean and the effort remains a full design and development task.

Still others leverage third-party software offerings, in a manner akin to DSP algorithm solutions from a few years ago, and the effort becomes one of 3-way integration and 3-party problem management. In these cases the real problems surface only in integration, when time is short, and it is important to note that software companies can make money by creating a need for doing more work. Some NPU companies outsource the development even for "internal" products, hiding the 3-way relationship while still incurring the inevitable problems and delays.

The best code is code that doesn't need to be written at all.

Some vendors offer example code, typically providing snippets of functionality in standalone applets. Though an application code base is valuable, a select few vendors offer fully tested and integrated data plane or control plane software as part of the solution, as the effort to create reliable and complete protocol offerings is high. For any network processor, be sure to investigate the following software topics:

- What protocols are available, and exactly where and by whom was each protocol developed?
- Who makes any necessary software modifications and enhancements? Who owns them when completed?
- What tools and environments are available for the control plane and data plane?
- How was software integration accomplished? What system configurations were tested and by whom?
- How complete is the provided code?
- What protocols are available simultaneously, and what run-time restrictions are there to instantiating multiple protocols at once?
- What operating systems are supported?
- Are full turn-key application solutions available?
- What first-line technical support is available, and what expertise do they have?
- What expert developer support is available? What people wrote the code, and where are they now?

What is unique about access network processors?

The hardware capabilities of a network processor are as important, if not as effort-intensive, as the software aspects described above. Network processor capabilities vary in their capabilities, performance, and interfaces. Often the internal architecture of a processor is optimized to best address specific applications, yielding a subset of network processors with unique capabilities and interfaces specifically targeting the access network. Since today's access network consists of a mixture of technologies, access network processors must support a broader variety of encapsulation and interworking capabilities than core network processors, and support sufficient flexibility to support the ever-changing needs of the networks and subscribers. Important questions to ask a prospective access network processor vendor:

An access network processor is significantly different than a core network processor.

- What applications are targeted by the vendor, and with which specific devices?
- What interfaces are supported on-chip for ATM, TDM, and Ethernet? What interworking features are available with each interface?
- What is the internal architecture of the part, and the design history behind the solution?
- Is the device fully programmable, or merely configurable?
- What are the control processor options?
- What is the estimated performance, and how is processing budgeted?
- What is the required memory architecture for various applications and rates?

Access network processor products tend to have common characteristics driven simply by the location within the network. Typically, access network products handle ATM, Ethernet, and TDM protocols and span the range from T1 rates (1.5Mbps or less) to OC-12 (622Mbps) or gigabit Ethernet (1Gbps). Most also offer some degree of protocol encapsulation and interworking capabilities to meet the needs of the particular application, and operations may range from layer 1 and 2 protocol bridging up through layer 3 routing or even higher protocol manipulations.

Interface and performance scalability are very important access network processor attributes.

Often the intended network location of a product determines the type and number of supported interfaces. With products targeting customer premise, outside plant, and various service provider office installations, a matching range of code-compatible processors with corresponding physical interfaces helps keep circuit card real-estate and costs in line for each application. Often the protocol complexity of a solution is determined by the underlying networks and the functionality expected by the network operator, so having a range of processor performance grades and memory complements is important as well.

Aren't all network processors essentially the same?

Current network processors target core and access infrastructure segments, but the architectures and capabilities required to address each segment are unique. Access network applications were historically the realm of communications processor solutions, rich in interface flexibility but with low data rates. Core network applications were the primary focus of many early network processor efforts, with high performance but with limited interfaces. Recent access network solutions have evolved from both historical groups as access rates have climbed yet the importance of interface flexibility remains.

Access network processor architectures are heavily influenced by their roots.

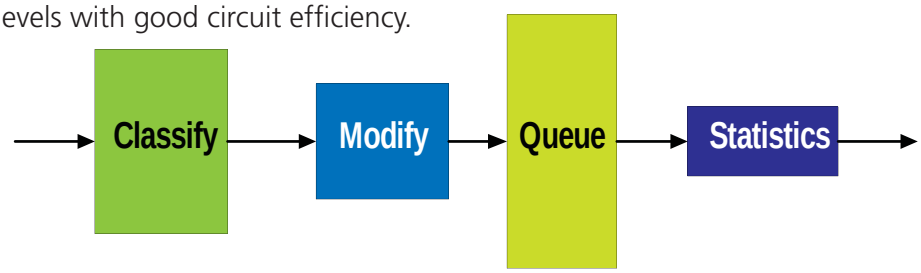
While core network applications traditionally focused upon processing a few simple protocols very quickly and efficiently, access applications typically involve complex operations on multiple protocols with widely varying rates. Often the access network processing mix changes over time as protocols evolve and network applications change, so protocol flexibility and processor headroom are important considerations. Understanding the relationship between the network processor architecture and the target protocols is critical.

Typical latest-generation network processors have one of two architectures, either a heterogeneous pipeline or a homogeneous parallel configuration, with strengths and weaknesses pertaining to each. While heterogeneous processors can heavily optimize performance for particular applications, the resulting architecture may be incapable of effectively addressing a complex and shifting protocol mix. A more general homogeneous processor architecture may be less optimally efficient for any specific application but can readily adapt to differing needs and changing applications.

While many processor architectures exist, parallel and pipeline approaches are the primary options

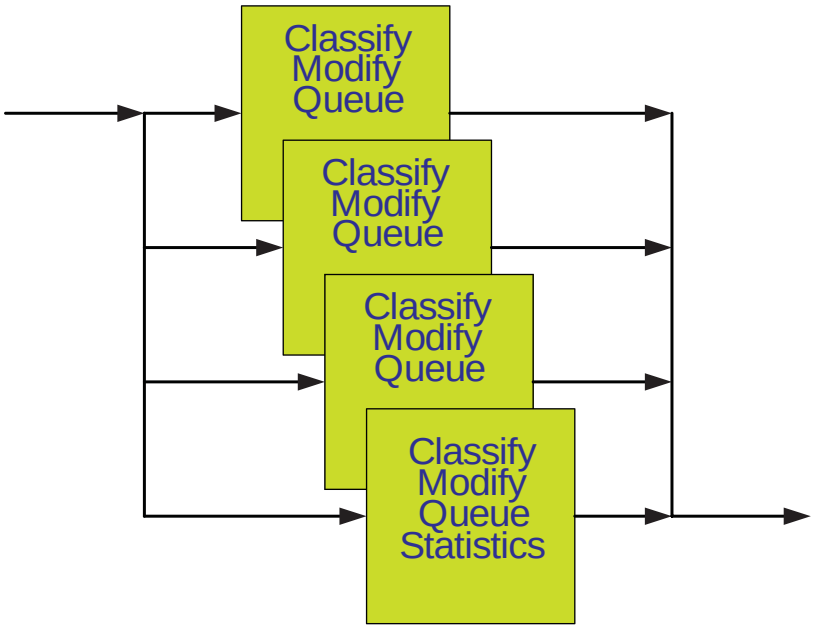
Pipeline processors:

A pipeline processor typically chains several unique processing elements, each specialized for specific protocol processing tasks, to form a single integrated processor. Each processor is optimized for performing particular processing steps, and thereby the combination reaches high performance levels with good circuit efficiency.



While such an arrangement is superb for high-performance simple forwarding activities, it is less suited for complex interworking tasks, and certain tasks may require complex multiple loops through the device. Also, since each of the pipeline processors has a unique implementation, multiple unique programming approaches and toolsets may be required to program it. It is important to note that a complex hardware solution can result in arcane software designs as well.

Heterogeneous pipeline processors provide high performance but offer limited flexibility.



Parallel Processors:

A parallel processor typically consists of multiple identical and fairly generic protocol processors that share the various processing tasks. While the precise nature of the processing cores and the architecture of the scheduler may vary, the significant point is that overall scalability of the solution is largely determined by the number of, and clock speed of, the processing cores. Since the processor cores are feature-generalized and homogeneous, the programming model for the processor is straightforward.

Homogeneous parallel processors offer great flexibility and high performance.

It is important to note that the parallel hardware architecture imposes few restrictions on the software, so the software can be architected based largely on other goals.

What do processor offerings say about a vendor's design philosophy?

Each network processor derives its nature from the focus and philosophy of its creators, and the differing corporate philosophies are evident in their corresponding devices. While specific device features and performance may change with each processor generation, the general design philosophy is unlikely to change rapidly, so a potential customer is wise to understand such differences. The processor philosophy of each vendor follows their market focus as well, depending on the priorities and needs that each foresees for their business.

A company's new devices may inherit features and capabilities of existing early-generation devices, and such inheritance may bring value (from shared software and fielded protocol experience) or it may carry limitations (such as suboptimal design approaches and patchwork software support). Some companies see NPUs as hardware-centric products with software as a customer responsibility, while others see NPUs as software-centric products with vendor-integrated turnkey software as a key aspect of the solution.

Device features can change rapidly, but design philosophies rarely change at all.

How do network processor software approaches differ?

The device architecture impacts the software architecture, and since the bulk of a network processor design effort will typically be software, understanding a vendor's software approach and customer software development responsibilities. A pipeline NPU model requires each supported protocol to be carefully designed with the characteristics and performance limitations of each pipeline processor in mind. If the application requires multiple protocols to be simultaneously available, which is often the case for access application, then the resource needs of ALL expected protocols and the performance load that each protocol places on each processing component must be accurately understood. The resulting protocol software design can be artificially complicated by the need to balance performance across computational elements, as well as carefully consider processing element code and memory space, utilization of shared memory, and efficiently using shared accelerators and memory interfaces..

A parallel architecture provides greater protocol design flexibility, but requires some method, such as fine-grain multi-threading, to interleave the various protocol processing tasks upon the available processor cores. The effectiveness or such balancing and the degree of transparency to the developer will vary between vendors, and will significantly affect the software complexity.

Availability of application-specific protocol bundles, preferably with protocols that can be selected "cafeteria style" to address particular needs, can greatly affect project complexity and scope as well. A vendor's corporate approach to addressing specific porting and integration needs such as OS and BSP hosting, protocol development and integration, and application-software testing should be carefully researched and fully understood.

What is Wintegra's Approach?

Wintegra provides a family of access network processors sharing a common homogeneous parallel architecture with an broad and robust suite of integrated software protocols. The Wintegra WinPath processors were specifically designed from the outset to address access applications. In many ways, the WinPath solution inherits the interface strengths of earlier communications processors, while addressing the performance and protocol software limitations of the earlier devices.

Wintegra offers Winpath processors and integrated software focused solely on access network applications.

The Wintegra offering is a family of closely related WinPath processors, each having some range of ATM, Ethernet, and TDM interfaces, multiple homogeneous WinGine parallel coprocessors, and an optional integrated MIPS host processor. A companion processor (FPGA core) is available to provide greater ranges of TDM interfaces for large-scale applications, but low-scale TDM applications can use on-chip interfaces.

As with most other network processors, the WinPath devices include multiple banks of memory and sophisticated memory managers. Unlike some other vendor offerings, the WinPath processors are architected to flexibly allocate storage between any memory bank, and thereby the range of populated memories and corresponding sizes can be tailored independently to meet the performance and storage needs of the application.

Since the WinPath coprocessors are identical, any code can run on any processor, with a sophisticated hardware context switching engine (which is invisible to the programmer) determining the task switches. The number of processors determines the overall performance, and the homogeneous architectures scales readily and balances task loads effectively with no "weakest link" design concerns.

The goal is not simply to expedite protocol code development, but to eliminate the need.

Wintegra's solution focus, for both processors and protocols, is to reduce customer development and integration efforts, and to generally eliminate customer development of low-layer protocols. Whereas some vendors require the customer to not only implement the control and data plane software but also develop internal expertise for each required protocol, Wintegra encapsulates their existing protocol engineering expertise in their software and silicon. Wintegra's goal is for the customer engineers to focus on application needs and high-level differentiating feature development using languages and tools they already know. Where warranted, Wintegra

will modify protocol code to address peculiar customer needs, and has fully supported data-plane development tools for those few customers (historically less than 10%) who wish to develop custom protocols themselves.

Control plane integration is the most important aspect of network processor software development

With pre-developed, pre-tested, and pre-integrated protocol components and clearly documented control APIs, the advantages are numerous:

- Wintegra engineers spend their time on behind-the-scenes protocol details and tool familiarization, while customer engineers work on visible high-level features.
- With pre-integrated protocol components, pre-ported BSPs, and available control plane applications, most customer engineers aren't even involved in tight real-time software.
- The most valuable customer technical experts – those with an understanding of the applications, protocols, processors, and tools – are not consumed with low-level development tasks, and can instead focus on high-level customer-related values.
- Time, effort, and expense required to verify protocol compliance with industry standards is already take care of, so customer testing can focus on black-box system features versus low-level protocol details.

Few product companies desire to create a cadre of low-level protocol software engineers.

How broadly does WinPath scale?

The WinPath family of access processors includes a broad range of processor variants, each targeted to specific applications, performance points, or interface needs. The WinPath processors all share the same code base, and are broadly footprint compatible. Wintegra's traditional WinPath1 processors are available with 1, 2, or 4 cores, while the new WinPath2 processors offer 2, 4, or 6 cores. Both have processor and interface options as well, though the WinPath2 offers higher core performance and additional interface options. With broad scalability not only can any initial software investment be readily leveraged in future projects, but over time the dual pressures of feature creep and cost containment can be addressed by creating updated BOM variants of a single design.

Scalability should span projects, applications, and price/performance points.

What Distinguishes Wintegra as a Vendor?

As the leading access network processor vendor according to The Linley Group, the foremost authority on network processors, Wintegra has provided components and protocols to a very broad range of access equipment vendors. Like most hardware component vendors, Wintegra enjoys success when customer products ship in volume. But unlike most

third-party software vendors, Wintegra only enjoys success when the customer product reaches production. Wintegra has a closely vested interest in having software that is reliable and easy to integrate. Unlike most other network processor vendors, Wintegra shoulders the bulk of the protocol software development effort, significantly reducing the scope of customer development.

Wintegra uses proven fabrication processes and leading foundries, ensuring availability of product and low process yield risks.

What Distinguishes Wintegra as a Partner?

As a partner, Wintegra is unparalleled in the access space. The Wintegra business model is based upon being a solid solutions partner, with Wintegra adding value in hardware and software at the lower protocol layers, for both existing and emerging applications.

Wintegra is more than just a vendor; they are a technology development partner as well.

With a focused hardware and software engineering staff dedicated to delivering market-ready solutions for access network products, Wintegra has a depth of protocol and application understanding that cannot be easily matched, even by much larger companies. Since Wintegra isn't just a component supplier, but a solutions partner from early concept to full production, the Wintegra staff is continually involved in emerging, current, and legacy protocols. With engineers active in protocol standards bodies, involved with pre-ratification interops, and even pre-standards customer solutions, Wintegra is often shipping second or third generation solutions before competitors ship their first.

By looking forward to emerging technologies, including standards body involvement, attending industry interop events, and providing early technology demonstrations with other industry pioneers, Wintegra provides multiple values to its customers. Wintegra gains expertise that quickly results in hardened, market-ready functionality, and the customer gains reliability and protocol leverage, thereby bringing products more quickly to market.

What Values Does Wintegra Offer?

As the leading access network processor vendor, Wintegra has a successful history of helping customers rapidly and efficiently achieve design success with minimal risk. WinPath processors variants provide a wide range of common-footprint performance points and interface capability options,

yet all parts share the same code base. Better still, field-ready data plane and control plane software packages mean that the customer spends less time architecting and developing low-level protocol stacks and spends more time creating differentiating features. Best of all, Wintegra components and software contain the accumulated wisdom of many engineering man-years spent developing solutions for real-world applications, resulting in higher performance and lower risks for customer projects. Wintegra is a not just a component supplier, but a technology partner ready to help make your project a timely, capable, efficient, and cost-effective success.

Wintegra products bring recurring value to the design process.

What Wintegra Development Resources Are Available?

Wintegra offers a range of resources to assist those commencing design programs.

- Performance estimation of your desired configuration to an accuracy of a few percent.
- Multiple development system configurations, with a range of interface and host processor options, with schematics and BOMs
- Production code and pre-ported BSPs for common configurations
- Expert design review and development support services

Summary

Selection of a network processor and integration into an organization's technology base is a complex task that warrants careful attention, but a clear comprehension of the issues and risks will enable sound decisions and promote program success. Understanding not only the architectural and feature differences between the various network processors, but also the corporate philosophy, historical focus, and support offerings from each vendor is important as well.

Wintegra processors, software, resources, and expertise are ready to help you bring your products efficiently and profitably to market.

Contact your Wintegra sales representative or visit www.wintegra.com for further information and assistance.

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