

Evolution of the Virtual Interface Architecture



The recent introduction of the VIA standard for cluster or system-area networks has opened the market for commercial user-level network interfaces. The authors examine how design decisions in prototype interfaces have helped shape this industry standard.

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To provide a faster path between applications and the network, most researchers have advocated removing the operating system kernel and its centralized networking stack from the critical path and creating a user-level network interface. With these interfaces, designers can tailor the communication layers each process uses to the demands of that process. Consequently, applications can send and receive network packets without operating system intervention, which greatly decreases communication latency and increases network throughput.

Unfortunately, the diversity of approaches and lack of consensus has stalled progress in refining research results into products—a prerequisite to the widespread adoption of these interfaces. Recently, however, Intel, Microsoft, and Compaq have introduced the "Virtual Interface Architecture," an emerging standard for cluster or system-area networks. Products based on the VIA have already surfaced, notably GigaNet's GNN1000 network interface (<http://www.giganet.com>). As more products appear, research into application-level issues can proceed and the technology of user-level network interfaces should mature.

Several prototypes—among them Cornell University's U-Net²—have heavily influenced the VIA. In this article, we describe the architectural issues and design trade-offs at the core of these prototype designs, including

- How to provide applications with direct access to the network interface hardware, yet retain sufficient protection to ensure that applications can't interfere with each other.
- How to design an efficient, yet versatile programming interface. Applications must be able to access the network interface and still control buffering, scheduling, and addressing. The programming interface, on the other hand, must

accommodate a wide variety of hardware implementations.

- How to manage resources, in particular memory. Applications must consider the costs of DMA transfers that map a virtual address to a physical one. At the same time, implementation-specific details must be hidden from the application, and the operating system must ultimately control all resource allocation.
- How to manage fair access to the network without a kernel path which, in traditional protocol stacks, acts as a central point of control and scheduling.

PERFORMANCE FACTORS

Network performance is traditionally described by the bandwidth achieved when an infinite stream is transmitted. However, an increasing number of applications are more sensitive to the network's round-trip time, or communication latency, and the bandwidth when sending many small messages.

Low communication latency

Communication latency is due mainly to processing overhead—the time the processor spends handling messages at the sending and receiving ends. This may include managing the buffers, copying the message, computing checksums, handling flow control and interrupts, and controlling network interfaces.

As Figure 1 shows, the round-trip times for a remote procedure call with a user-level network interface can actually be lower than for a local RPC under Windows NT. The remote call uses Microsoft's distributed component object model (DCOM) with the VIA, on the GNN1000 interface. The local call uses Microsoft's component object model (COM). The figure also shows the round-trip latency of raw messages over the VIA, which we used as a baseline in estimating the DCOM protocol overhead.

Virtual Interface Architecture

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Table of Contents Virtual Interface Architecture

1. Understanding the eBook Virtual Interface Architecture
 - The Rise of Digital Reading Virtual Interface Architecture
 - Advantages of eBooks Over Traditional Books
2. Identifying Virtual Interface Architecture
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in a Virtual Interface Architecture
 - User-Friendly Interface
4. Exploring eBook Recommendations from Virtual Interface Architecture
 - Personalized Recommendations
 - Virtual Interface Architecture User Reviews and Ratings
 - Virtual Interface Architecture and Bestseller Lists
5. Accessing Virtual Interface Architecture Free and Paid eBooks
 - Virtual Interface Architecture Public Domain eBooks
 - Virtual Interface Architecture eBook Subscription Services
 - Virtual Interface Architecture Budget-Friendly Options

6. Navigating Virtual Interface Architecture eBook Formats
 - ePub, PDF, MOBI, and More
 - Virtual Interface Architecture Compatibility with Devices
 - Virtual Interface Architecture Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Virtual Interface Architecture
 - Highlighting and Note-Taking Virtual Interface Architecture
 - Interactive Elements Virtual Interface Architecture
8. Staying Engaged with Virtual Interface Architecture
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Virtual Interface Architecture
9. Balancing eBooks and Physical Books Virtual Interface Architecture
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Virtual Interface Architecture
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Virtual Interface Architecture
 - Setting Reading Goals Virtual Interface Architecture
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Virtual Interface Architecture
 - Fact-Checking eBook Content of Virtual Interface Architecture
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
 - Integration of Multimedia Elements

- Interactive and Gamified eBooks

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