CISCO'S TECHNOLOGY VISION FOR THE EVOLUTION OF NETWORKING

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The Impact to Cisco

By designing all our equipment to a baseline of standards and architecture, we will be able to lower the cost to develop and manufacture our products since we will not have to reinvent the wheel—so to speak—for each new router or switch. Such an approach will further encourage the leveraging of knowledge and components across Cisco® product groups while promoting more consistent manufacturing and testing.

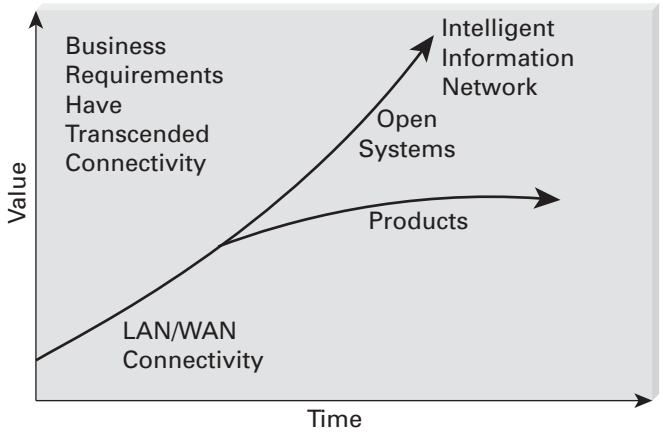
Also, by standardizing on a foundational infrastructure, our component equipment will share more common hardware and software, and we will benefit from economies of scale. We will need fewer manufacturing partners to produce greater volumes of the same or similar components used throughout the network. And, by standardizing component design, we will be able to perform more extensive and rigorous testing on fewer component types. In future phases, our holistic system approach to networks will generate new markets and revenues while providing a consistent framework for integration with partners, helping bring new services to the network.

The future of networking stands at the proverbial fork in the road of what we at Cisco Systems® refer to as "the great trade-off." On one hand, we can continue to focus on building individual networking products, each exemplary yet specialized in its features and functions. Or we can concentrate on building equipment which, above all else, contributes to creating a unified networking system.

On one side of the trade-off is the incremental value customers gain from individual networking products that are optimized for one portion of the network or one service. However, this approach creates increased operational, management, and end-user complexity as disparate products are added to the network.

On the other side of the trade-off are the ease-of-use, integration, and consistent functionality of a unified network system. However, building components of a network system where each serves an integrated role in the network requires far greater design vision and coordination. We must develop each part in coordination with other parts, to fit together like pieces of a puzzle.

Figure 1
We Are at an Inflection Point



Despite the technical challenges of creating a holistic network system, our customers will benefit from seamless access to critical information, which will aid business agility and more informed decision-making. From a technology standpoint, this translates into faster deployment of new, more powerful applications and services that improve productivity and lower the total cost of network ownership. In addition, this system-based approach not only requires ongoing product innovation, but innovation within the context of a systems

framework. As we continue this drive to a systems-based approach, our technology strategy has not changed. We are committed to building intelligent services, increased performance and an evolutionary infrastructure that our customers can continue to utilize throughout the lifetime of their network.

Networked intelligence is difficult to define in a deterministic equation. It must include multiple parameters that, when combined, exhibit specific network capabilities across the entire system. Those parameters must also delicately balance innovation and integration. Integration cannot supersede innovation.

At its heart, a system is an assemblage or combination of elements that form a complex or unitary whole that has emergent properties not possessed by the individual elements. In other words, a unified networking system is greater than the sum of its parts. Each product in a network needs to provide outstanding performance, but these products must serve as integrated components within a unified system.

To date, the networking industry has chosen the other fork in the road. It has focused on solving customer problems one at a time, with individual products specifically designed on a case-by-case basis. As a result, networking equipment manufacturers have developed components that tend to increase management complexities and fail to offer investment protection for existing infrastructure. With each individual product having its own management and feature design, the operation, management, maintenance, and optimization of networks has become more complex, challenging, and expensive. It is this burden created by point products that inspires us to build integrated network system components rather than simply high performance parts.

Systems: The Natural Evolution Toward Efficiency

The evolution to a system-based approach is a logical development for many technologies and industries. Innovation at the component level invariably moves to innovation at the system level as complexity increases; technological sophistication improves, and performance requirements expand. Historically, innovation within the context of a larger system has marked the emergence of far more efficient business and production models. For example, the development of the assembly line created dramatic improvements in the speed, quality, and costs of automobile production. Thanks to the intrinsic benefits of this carefully orchestrated system of manufacturing, cars became available to the masses.

Unified systems, given their multiple components, take time to emerge. While our existing architecture supports a unified system approach, we have room for improvement. What we do know is that the lack of a system-level approach creates technology islands and the need for additional components that either integrate subsystems or duplicate functionality. In systems, there is an interdependency of variables that maintain functional relations through time. A fully cooperating system provides for command and control (who does what and when); information interchange (data sources and sinks); collaboration and partitioning (location of handoffs); and conflict resolution (process for addressing operational problems). Since a system must be flexible, stable and predictable (maintains security and integrity); a higher-level deterministic architecture that accommodates a number of different lower level designs is optimal. This allows us to create a number of different designs from a common architecture, and it helps us to be both consistent and flexible enough to address customer needs.

Despite the incredible strides networking has taken over the past 30 years—from local area networks, to wide area networks, and now to integrated data, voice, and video communications—networks still suffer from a lack of baselines and a standard architecture for building an efficient, flexible, and integrated system of easily interchangeable components. Such baselines and architecture are imperative for creating networks with seamlessly embedded resources and applications.

The challenge that is before us is to develop and build open, standards-based systems that offer obvious advantages to customers, such as unified management, improved performance, and consistent intelligent services. Our technology excellence, engineering resources, and breadth of products place us in a unique position to build these systems that offer benefits to our customers. We call our evolutionary vision the Intelligent Information Network. As we evolve the Intelligent Information Network, it will grow to encompass the dynamic networking of resources and the virtualization of applications and services. Cisco is committed to making this happen through continued system-level innovation over the next three to five years.

Building the Foundation for the Intelligent Information Network

Today, we are building the foundation and establishing the architecture for development of the Intelligent Information Network, one more closely tied to, aware of, and responsive to the needs of the applications, resources, and devices connected to the network. At the core of this foundation are the key principles of Cisco's technology strategy: intelligent services, increased performance and an evolutionary infrastructure. The architectural baselines we are implementing across the full range of our networking equipment comprise the first tier of that intelligent foundation. The baselines which we are innovating on today include IPv6, high availability, quality-of-service (QoS), multicasting, security, and management. Each one extends through all Cisco routing, switching, and optical network operations, as well as supporting the extended network into storage, wireless, and IP communications. With such architectural baselines, we can better assure the fast, efficient, and dependable delivery of any form of communication over the converged IP network.

Another pillar to the foundation of the Intelligent Information Network is increasing performance through our silicon and software expertise, the engines that run all of Cisco's routers, switches, firewalls, and other networking equipment. We are now creating processing power and ASIC coding as sophisticated as the most advance chip makers, including Intel, IBM, and others. We can also tap the Cisco IOS® software and processing improvements made on our most advanced routers and switches, and migrate it to all of our equipment, helping raise the entire performance of the network, not just a few nodes.

As with our software and silicon innovation, the breadth of products Cisco is developing for the Intelligent Information Network must also have common, modular platforms with common management and feature sets. By architecting our products this way, we are encouraging the evolution of the Intelligent Information Network by offering investment protection to network operators. Our modular chassis frees our customers from the agonizing conundrum of expensive "forklift" upgrades to next-generation technology. They only need to add a card, a blade, or software to take the next step in networking. And as part of our system-level approach, we are developing our products not only with data in mind but also with integrated support for voice, security, content networking, and other basic services of the Intelligent Information Network.

Network services are the final pillar of the Intelligent Information Network foundation. We are implementing an array of support functions common throughout the infrastructure, ones needed by most any application, whether that's a wireless point-of-sale device, an IP telephone, or a corporate database. These functions include network-embedded services such as security, storage, voice and wireless, as well as packet layer services, such as routing, content awareness, encryption, and traffic shaping.

The Evolution of the Intelligent Information Network

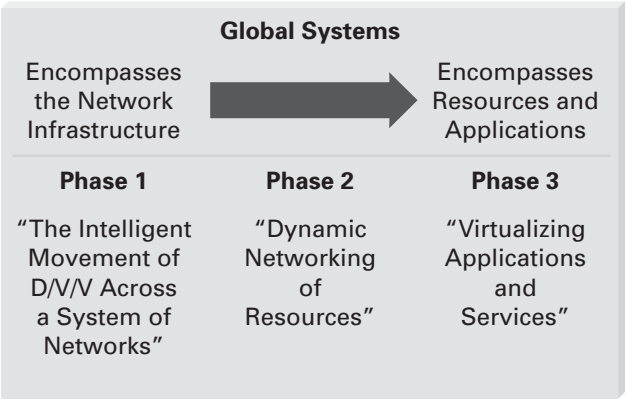
Building a solid foundation of baseline architecture and capabilities is just the start to the creation of the Intelligent Information Network. The increasingly complex tasks of the Intelligent Information Network will require more sophisticated functions, such as better content awareness, seamless encryption and filtering, greater quality-of-

service, and more adroit traffic shaping. To meet these demands our technology must support such features as network-wide security, end-to-end performance controls, service-level resiliency, and system-wide management visibility. We must question not just if a design will help create good routers, switches, or software, but also if it will create a better component to the Intelligent Information Network—if it fits into the system as a whole.

Such system-level support is as crucial to networks as modern technologies are to the American road system. Just as today's road system works more efficiently because of intelligent stop lights, traffic monitoring cameras, on-ramp flow controls, and vehicle-based GPS mapping systems, so too will anyone needing to communicate benefit from coupling the capabilities of the Intelligent Information Network with well-built fiber optic connections. Simply building wider roads or faster connections does not address the growing demands on these systems. They must be smarter as well.

We view the evolution of the Intelligent Information Network in three phases. We are currently in "phase one": the convergence of data, voice, and video across a system of networks. Over the next three to five years, we aim to develop the network through two additional phases. Each phase will build off each other and overlap, with the phases advancing more rapidly in certain networking areas, while taking more time in other parts of the network.

Figure 2
Cisco's 3–5 Year Technology Vision—The Intelligent Information Network



Phase one is already showing the traits of a system-level engineering approach. We are moving from a piecemeal security approach to network-wide security policies, from route-specific performance to endpoint-to-endpoint performance, from route-level resiliency to service-level resiliency, and from box-level management to system-wide management. As a result, phase one is bringing to customers lower total cost of ownership (TCO), better network management and performance, more cost-effective scalability, and the seamless enablement of advanced technologies such as wireless, storage, IP voice, and security.

As we complete phase one, the evolution of the Intelligent Information Network moves to phase two: dynamic resource utilization. This refers to a more efficient and flexible use of the resources connected by the network. Many of these resources revolve around the data center, including processing power, memory, and storage. Phase two brings lower operating costs through more flexible and efficient asset utilization. Rather than having specific resources hardwired to support various applications and services, these applications and services can draw on a pool of resources and tap into just what they need. This will enable what is often referred to as "on-demand" computing.

The Intelligent Information Network will manage the distribution of these resources dynamically, relying on message-level communications and policies. Such on-demand resource computing will require us to closely integrate advanced technologies such as storage, security, and wireless seamlessly to the current IP infrastructure. Phase two will also require silicon and software advancements, in addition to advances in adaptive network technology.

Phase three of the evolution of the Intelligent Information Network will virtualize applications and services. This phase aims to make it even easier for businesses and consumers to use the resources connected by the Intelligent Information Network. In phase three, our goal is to tie the network and applications more closely together, so that the network can automatically provide the resources and services any application might need. Such functions will help the network understand the intent of the application and therefore better serve the application's needs. This will allow users to access the applications and information they want, when they want it, and how they want it.

Such capabilities will require better communications between the network and the application, requiring message-level inspection. To do this, phase three will require powerful application programming interfaces (APIs) to let applications communicate with the network about what resources and services they require. This is often referred to as application-oriented networking.

The implementation of phase three rests in the cohesive and comprehensive systems-level architecture Cisco is now establishing. Application-oriented networking will also require extensive partnerships with application developers, as well as a move towards a more distributed approach to currently centralized functions, such as file systems.

While many steps remain in the evolution of the Intelligent Information Network, the work towards that future has begun at Cisco. The foundation of product-wide technologies we are implementing today is helping build the Intelligent Information Network of tomorrow, one that offers end-to-end functionality and centralized, unified control for efficient application usage and information delivery. The most important part of that evolution is the shift from creating network components to developing a network system, one with common integrated resources, features, and functionality for optimized communications and management. With such a comprehensive infrastructure in place, the Intelligent Information Network can create the opportunity for greater business agility and the rapid deployment of new business services and applications.

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KO/LW5939 03/04