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From "Computer Networks" to the "Computer on Net"

The Convergence of Internet, Broadband, and Telephone Networks in the IEEE 802 Standards

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In the near future, end users, corporations, telecommunications carriers, and vendors will need a way to turn the current network technologies into something much faster, less costly, with more capabilities and integrated services over a shared unique network infrastructure. Nevertheless, if communications networks are always developed based exclusively on technology, there is a danger that they will keep getting more and more complicated.

As stated by E. F. Schumacher in his famous book *Small Is Beautiful* (1973): "Any third-rate engineer or researcher can increase complexity; but it takes a certain flair of real insight to make things simple again." We have to apply the scientific method in order to make things simpler and at the same time more efficient. Nowadays, almost everybody agrees that the future of the networks is based on "everything over IP"; however, we should ask ourselves if this future could rather be based on IEEE Ethernet.

To reduce the "digital divide," the best solution is to seamlessly develop the existing telephone network, because, as Sean Maloney, Executive Vice President of Intel, said in spring 2004, "There isn't the money in the industry to roll out fiber to a billion people's homes." This means that the current 1.25 billion fixed telephone lines all over the world must be reused, with an integrated solution in which emergency call service is supported.

The solution must also support the 3 billion mobile phone subscribers, as well as others that use fiber optics, Wi-Fi/WiMAX, power line communications, or cable modems to access the network. Packet switching is essential for any interactive connectivity, and as the Internet model has demonstrated, complexity should only be found at the extremes of the network, maintaining the core as simple as possible without compromising performance.

The Reference Model: Applying the Concepts of Ethernet and Internet

There are two clear reference models in today's communications networks: Robert M. Metcalfe's Ethernet and Vinton G. Cerf's Internet. Those, along with the experience gained from the traditional telephone network, serve as grounds for the proposal of a new model we call the Universal Ethernet Telecommunications Service (UETS). It is 100 percent in accordance with the IEEE 802, 802.2, and 802.3 standards.

Since its invention by Robert M. Metcalfe in 1973, Ethernet has achieved widespread use. The price-performance ratio, or cost per bit transmitted, is better in Ethernet than in any other technology. Ethernet is also the most mature, flexible, scalable, and robust solution available in the market. In addition, Ethernet has the advantage of being an international IEEE 802.3 standard.

Dr. Metcalfe describes Ethernet as "a communication sys-

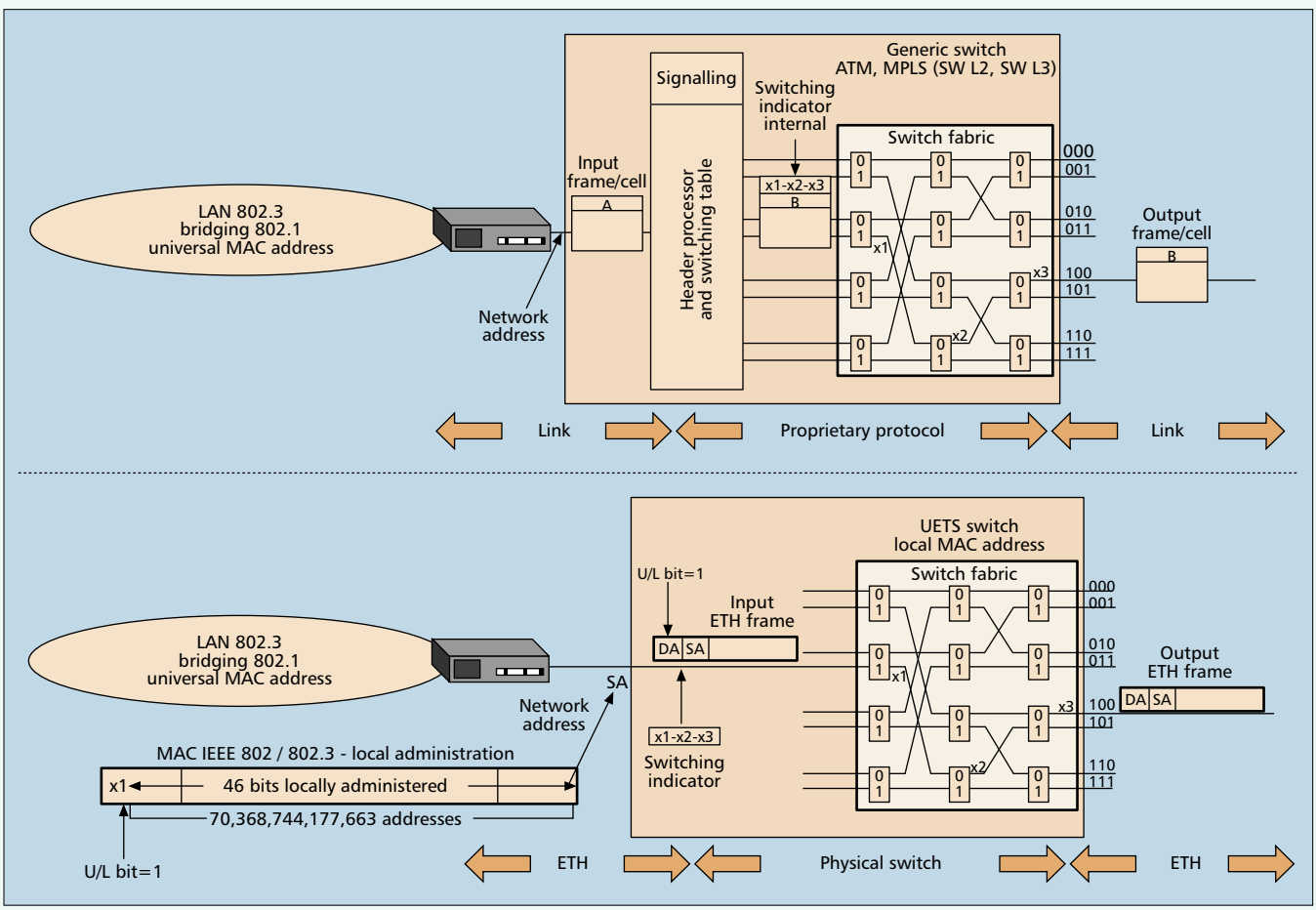

Figure 1. *UETS switch: CUE (central universal Ethernet).*

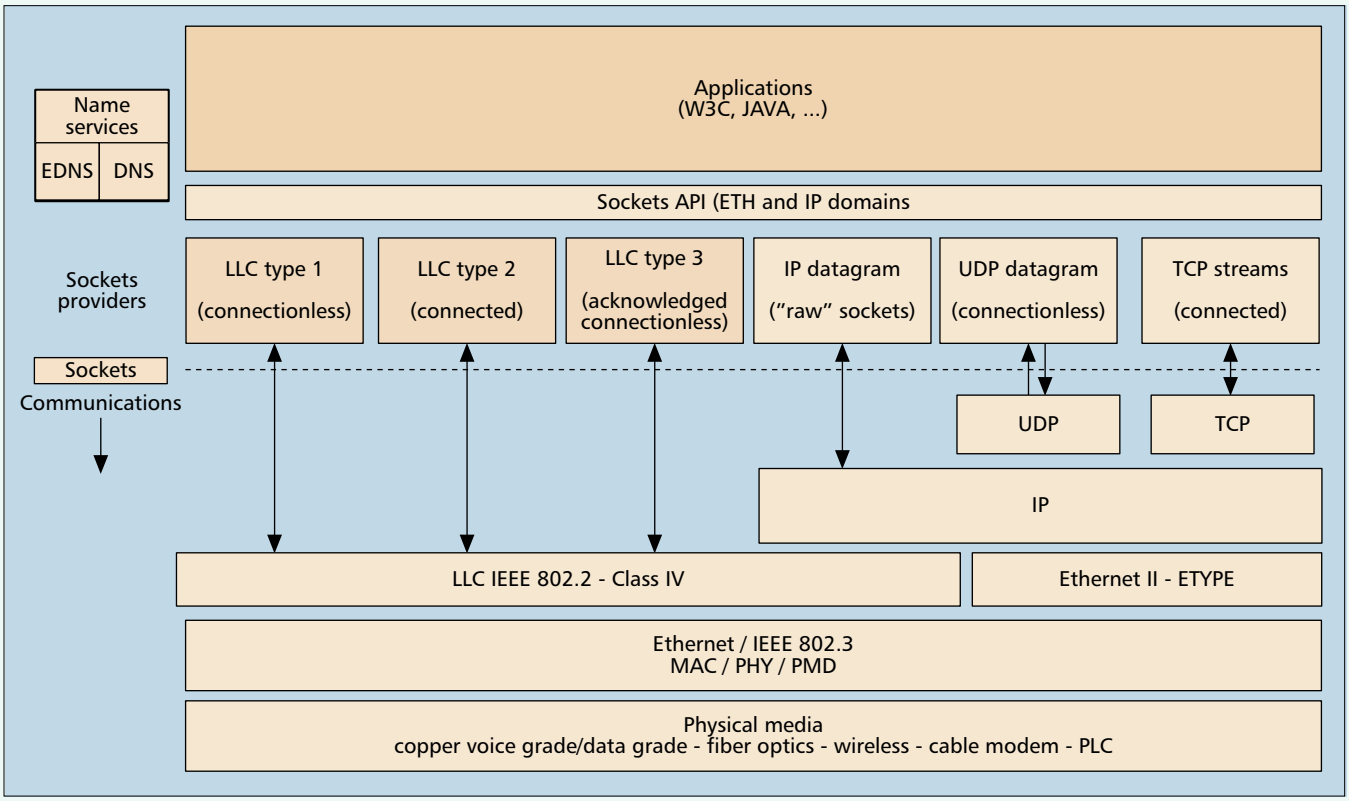

Figure 2. *UETS communications architecture: reference model.*

tem for carrying digital data packets ... to build systems, which can be viewed as ... loosely coupled multiprocessors. An Ethernet's shared communication facility, its Ether, is a ... medium with no central control. Switching of packets to their destinations on the Ether is distributed ... using packet address recognition."

The Internet is based on the concept of catenet, a "confederation of cooperating nets," as Vinton Cerf describes it in IEN 48. With Robert Kahn, Cerf developed in 1973 TCP, "to interconnect these networks in such a way... that would allow many such networks to interwork and the computers on each of them to interwork." Kahn and Cerf describe the communications between processes: "Within each host, we assume that there exist processes which must communicate with processes in their own or other hosts."

Kahn and Cerf introduce "the notion of ports in order to permit a process to distinguish between multiple message streams," and define what they call a uniform addressing scheme. They stress simplicity by stating "both economic and technical considerations lead us to prefer that the interface be as simple and reliable as possible." The intelligence resides outside of the network, in the hosts connected to many physical networks that form a unique logical IP network.

The Universal Ethernet Telecommunications Service

The network model has changed since the approval of the IEEE 802.3ah EFM standard for Ethernet-based access to telecommunications networks. The UETS extends today's local computer networks to a metropolitan or even planetary scale, and builds on the concept of Ethernet.

The key of the system, as described in Fig. 1, is to utilize physical switching techniques, like those used in asynchronous transfer mode (ATM), with the local (U/L bit = 1) MAC address of the Ethernet frames as network addressing. This mechanism makes it possible to switch to more than 70 trillion addresses in each local Ethernet domain — enough to build a planetary network.

This opens the world to a new approach to the digital revolution, radically simplifying the operation of switching devices. It is 100 percent compliant with IEEE 802, 802.2, and 802.3 standards, has the power of ATM switches, and is cost effective and not complex. UETS network nodes can be built using the switch fabrics of current 802.1 bridges, layer 3 switches, IP routers, or ATM switches. Using the <port id> as a switching indicator in the local medium access control (MAC) address, this eliminates the internal tables.

The core of that network can use multiprotocol label switching (MPLS) techniques. With Ethernet encapsulation, which is per se multiprotocol, and the local MAC address as an end-to-end label, this particular mode of operation can be called Ethernet label switching (ELS).

Internet Applications over IEEE 802.2 LLC/802.3 Ethernet

This new paradigm of a global network, or Inthernet as we call it, is based on the idea of developing the Internet model in a way that would drastically reduce the TCP/IP processing overhead. It reduces the open system interconnection (OSI) layers so that instead of layers 3 (IP) and 4 (TCP), only layer 2 (ETH/LLC) would be used for multiprotocol transport, multiplexing, flow control, error detection, source/destination port identification, and so on.

The TCP/IP Internet is composed of a logical network (IP) over multiple physical networks (ETH, FRL, ATM, SONET/SDH). In the new UETS-based Inthernet the logical and physical networks coincide. Actually, TCP/IP hosts do not

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use logical IP addresses in Ethernet domains, but physical MAC addresses, obtained by means of the Address Resolution Protocol (ARP).

Ethernet also offers seamless interoperability and adaptation to changing requirements. Ethernet and IP share a set of characteristics that are of fundamental importance. Both operate in connectionless mode, and both are packet-based technologies designed for computer communications, providing statistical multiplexing needed to share network resources. However, the services provided by IP over the Internet are the same as those provided by Ethernet over just one network.

Figure 2 describes the ability to provide the same services using a layer 2 hardware-based operation device, breaking the limits of hosts collapsed by very-high-speed TCP/IP connections (see "TCP Onloading for Data Center Servers," *Computer*, November 2004, pp. 48–58). The logical link control (LLC) is better than TCP/UDP for offering end-to-end services, because it is optimized to hardware operation, and also has reduced overhead and tighter loop control.

Conclusions

This new approach can be considered the evolution from computer networks to computer on net. It keeps the original idea and "spirit" of Ethernet and Internet, extending the system of loosely coupled multiprocessors worldwide. According to George Gilder, "When the network is as fast as the computer's internal links, the machine becomes a special purpose appliance across the Internet."

The new architecture and simplification of the service, along with voice over packets (VoP), make the convergence of Internet, broadband, and telephone networks possible. It works like the traditional telephone network, but using IEEE 802.2/802.3 frames that support the higher OSI layers. Therefore, it maintains backward compatibility for Internet applications, using either TCP/IP or LLC/ETH protocols.

The new model solves the IP insecurity problems, because it is impossible to spoof addresses within the Ethernet domain. Telecommunications carriers have the additional advantage that the new architecture can use a similar addressing schema as the international telephone network, thus drastically reducing the use of domain name services.

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