1394 Automotive network enables powerful, cost-efficient in-vehicle networks for infotainment, navigation, cameras

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In the race to develop the most appealing infotainment solutions, car makers can now take advantage of standard 1394 bus technology. Under the names FireWire (Apple), i.Link (Sony) and Lynx (Texas Instruments), 1394 has proven useful for carrying infotainment data in a variety of applications. It now promises to provide the same high performance in automobiles with a version known as the 1394 Automotive network.

The bandwidth requirements for an automotive network become clear with a glance at the list of devices that will connect to the network (Figure 1):

PCs and other devices interfacing with Web pages and e-mail available via cellular and Wi-Fi networks
These devices need a significant amount of network bandwidth, with throughput requirements likely to grow continuously into the future. The traffic must be handled properly to provide good quality-of-service. The technology used in this network has both hardware and software consequences.

**Introduction to 1394 Automotive technology**

The 1394 standard covers two types of data communication: isochronous and asynchronous. Isochronous data (video and audio) is guaranteed for timeliness but not for delivery. The very nature of such data makes it useless if it arrives late, but some of the data can be discarded without causing major problems. The 1394 spec has periodic 125-s time slots allocated to send isochronous data. On the other hand, asynchronous data is guaranteed for delivery, but not for timeliness. This class of data must reach its destination, but the specific timing is not critical. A node resends data if a delivery attempt fails. **Figure 2** shows the 1394 protocol stack, consisting of Transaction, Link and Physical Layers. In a 1394 controller IC, the Transaction Layer is implemented in software, the Link Layer is implemented in software or hardware and the Physical Layer is done in hardware.
1394 Automotive comparison with competing technologies
The easiest way to get a perspective on the capabilities of 1394 Automotive is to compare it with alternative technologies. MOST150 (the highest-speed version of MOST) and Gigabit Ethernet have significant disadvantages compared to 1394, as the following overview underscores. These disadvantages involve both the networking standards and the IC implementations available on the market. MOST150 disadvantages Lack of integrated DTCP
Content protection is a must in automotive digital multimedia networks, and Digital Transmission Content Protection (DTCP) is the leading technology to implement this function. Because MOST150 products lack this feature, MOST networks require additional devices to implement content protection (Figure 3).
This lack of content protection increases both the hardware cost and overhead of the additional software support required. Moreover, even with the use of an external DTCP device, the multimedia content in a MOST150 system is protected only over the network and not on the storage media (HDD, etc.). By contrast, 1394 Automotive ICs have built-in DTCP. This approach minimizes both hardware and software cost and ensures complete data protection. **Low bus speed** MOST150 networks are only capable of speeds up to 150 Mbps, a fraction of the 800-Mbps bus speeds available from today’s 1394 Automotive devices. Future 1394 devices are expected to double this speed. **Requirement for external data compression**

To compensate for low bus speed, MOST150 networks can bring data throughput up to a level that compares with that of 1394 Automotive by using data compression. This strategy requires external codecs to compress and decompress multimedia data, thereby creating two problems. First, the typical devices required for multimedia compression and decompression (such as for MPEG2-TS)
add a significant latency — possibly as high as 400ms. As a result, the driver will see a noticeable delay in the perimeter camera video. The compression/decompression latency will also cause extensive delays when users fast-forward a DVD (Figure 4).

The second problem resulting from the use of external codecs is cost. Along with codecs, the implementation requires external frame memory to buffer video. In fact, a MOST150 implementation may require as many as eight silicon devices. Since 1394 Automotive networks offer much higher bus speeds, compression may not be necessary at all. If anticipated bandwidth requirements are extreme, however, implementations can achieve both low latency and low cost by taking advantage of codecs built into Fujitsu 1394 Automotive devices. We maintain that these built-in codecs keep latency to just 4 ms, and the implementation can be accomplished with only two chips. A 1394-based solution

Figure 5 compares the number of devices required for 1394 Automotive and MOST150.

Software
Because a small number of companies control MOST technology, software expertise for this multimedia bus resides in a small number of companies. Consequently, MOST systems have higher
software development costs and limited software control by the system integrator. **Gigabit Ethernet disadvantages**

**Lack of integrated DTCP**

As with MOST, Ethernet controllers lack an integrated DTCP function. The extra components for external DTCP increase cost and compromise data protection in storage devices. **Possible external codec**

Although Gigabit Ethernet has much higher bandwidth than MOST150, ever-increasing bandwidth needs (for high-definition video, for example) may eventually force the use of data compression. A lack of integrated codecs in Ethernet controllers will require the use of external components, thus increasing the number of chips required and cost. **No inherent Quality of Service (QoS)**

Ethernet standards do not include provisions for QoS. To achieve a level of QoS equivalent to that in 1394 Automotive, Ethernet needs additional software overhead, memory buffers, and time-stamp circuits. These additions are necessary to ensure reliable video and audio data communication. **Cost of discrete PHY and LINK devices**

Most Ethernet Media Access Controllers require an external PHY chip. Even though these chips are not expensive, the overall system cost is still higher than that of 1394 Automotive. **Cost of high CPU demand**

Because Ethernet has no inherent multimedia capability, an external CPU has to provide a great deal of assistance. Specifically, the CPU must intercept and parse data packets from the network and route them to the appropriate devices for converting the data into audio and video. That processing increases CPU requirements considerably for providing multimedia support over Ethernet. **Software cost**

Just as Ethernet demands considerable CPU support for handling multimedia content, the network standard requires a lot of software to implement those functions reliably. An abundance of Ethernet software is available, but acquiring usage rights can increase licensing costs significantly.

**MB88395: Key features**

The latest 1394 Automotive serial bus controller from Fujitsu, the MB88395, complies with IEEE Standard 1394b-2008. The chip integrates PHY and LINK layers into a single-chip solution and has two ports for 1394 cable connection. Its also incorporates the DTCP protocol. The chip achieves bus speeds up to 800 Mbps. This bandwidth makes it easy to handle the high level of bus traffic from high-definition Blu-ray video, GPS navigation data and additional perimeter cameras. As shown in **Figure 6**, the device has an MPU/DMA or serial interface for host control. Like older 1394 controllers, the new chip’s hardware acceleration of all functions allows use of a low-MIPS MCU as a host processor to control the device. Two internal channels are available for both isochronous and asynchronous data. The isochronous channels are shown in the bottom half of Figure 6.

Built into the MB88395, Fujitsu's original SmartCODEC for video data compression eliminates the need for external compression chips (MPEG2, H.264, etc.) at sender and receiver ends, thus we claim significant cost savings. The SmartCODEC implementation supports a higher compression rate than the previous version — 1/4 compared with the previous 1/3. Together, we maintain that the chip's higher bus speed and higher compression rates expand the possibilities for a feature-rich and

![Fig. 6: MB88395 1394 automotive controller (click on image to enlarge).](image-url)
enhanced infotainment experience for the driver and passengers. For backward compatibility, the new codec also supports the 1/3 compression of the previous-generation SmartCODEC. **Figure 7** shows the block diagram of the SmartCODEC. This functional block uses the Predictive Coding Adjacent Pixel Correlation technique for video compression.

**Conclusion**

We argue that the 1394 Automotive standard has the bandwidth, flexibility, cost effectiveness and technological features to satisfy requirements for infotainment networking today and into the future. Fujitsu's MB88395 controller attempts to embody all the advantages that 1394 brings to the automotive world, as well as providing a wealth of additional functionality that simplifies system integration while minimizing costs. *About the author: Waqar Saleem has worked with Fujitsu Microelectronics for eight years. He is responsible for providing applications engineering support to automotive Tier 1's and OEMs in the Americas.*