I-TDM: Supporting TDM voice in the age of MicroTCA and AdvancedTCA

By Robbie Dhillon, Ian MacMillan, and Amir Zmora

The ecosystem that is growing around the I-TDM standard now includes both hardware- and software-based implementations. As with any new standard, initial implementation work involves identifying areas where the standard needs enhancement. The authors outline the role PICMG SFP.1 – also known as Internal Time Division Multiplexed circuit switching – plays in converting voice and media packets for transport and storage.

Demand for voice and video over IP along with the adoption of IMS architecture for next-generation networks are driving the trend towards network components based on standard form factors. Many telecom equipment manufacturers who have traditionally designed proprietary platforms internally are now seeking off-the-shelf components based on standard telecom grade, high capacity form factors. As a result, the market is adopting MicroTCA and AdvancedTCA platforms, with large deployment numbers predicted for 2007 onward.

A number of key IMS architecture elements handle voice and media traffic. In order to interconnect with voice and media traffic from TDM networks, the IMS architecture provides platforms that interface with these TDM networks and support voice, media, and signaling.

MicroTCA and AdvancedTCA are packet-based, causing IMS systems to transmit TDM via I-TDM running over packet transport, such as GbE. There is now a growing ecosystem around the I-TDM standard with the availability of both hardware and software-based implementations.

IMS voice and media platforms

There are a number of IMS platforms that interface with TDM voice and media.

Media gateways

IMS and other NGN networks require a media gateway, which typically translates voice and video traffic from TDM to IP networks, to connect between the following networks:

- Broadband wireline IP network, mainly using SIP but also using legacy H.323 equipment
- Broadband wireless IP network (Wi-Fi and WiMAX), typically using SIP
- 3G real-time conversational voice and video, using 3G-324M currently and SIP in the future
- Voice PSTN network
  - Access media gateways that have TDM telephone lines or TDM trunk interfaces
  - Border media gateways that interconnect TDM networks to IMS networks. For example, connecting a TDM wireline network to an IMS-based wireless network
  - Mobile video media gateways that translate voice and video bidirectional and streaming traffic between IP (typically SIP) networks and mobile 3G-324M networks. The 3G-324M network has a fixed limited bandwidth of 64 Kb and screen size is typically limited to QCIF resolution, so the gateway must perform two key tasks:
    - **a.** Transcoding: Voice to NB-AMC and video to H.263 or MPEG-4
    - **b.** Modification: Changing the frame rate, typically to 10 FPS and the resolution to QCIF
- Video over PSTN using H.324 is deployed in countries where broadband penetration is limited

In the case of video over PSTN, deployed in Italy and the UK, the H.324 streams are sent using modem connectivity over PSTN lines. As in 3G-324M control, voice and video are multiplexed and sent over the network. Connecting this communication with other networks such as broadband SIP requires gateway functionality similar to that used by the mobile video media gateway.

Media resource functions

Media resource functions perform IMS network media services, such as voice mail and recorded announcements. Many MRFs are designed to support both IP and TDM interfaces, although implementing an MRF with IP support only is possible.

Wireless radio network controllers/ base stations

Wireless radio network controllers manage and connect with wireless base stations. While the base stations will migrate to IP transport over time, many existing base stations use TDM transport to connect with the RNC. Base stations performing IP transport can use I-TDM to transport voice internally to the base station.

Conferencing servers

Similar to MRFs, many conferencing servers are designed to support both IP and TDM interfaces.

I-TDM allows these IMS platforms to be implemented using MicroTCA or AdvancedTCA by taking the TDM voice and media and converting them into packets for transport and storage within the platform.

I-TDM building blocks

The IMS platforms we have described incorporate two types of building blocks that must support I-TDM:

- I/O interfaces, which provide the physical interface to TDM networks
- Digital signal processors, which transform the TDM media for storage and transport in IMS networks

I/O interfaces

In MicroTCA and AdvancedTCA platforms, I/O interfaces are typically implemented as Advanced Mezzanine Cards (AdvancedMCs). The AdvancedMCs take the TDM interfaces and convert the TDM voice to I-TDM for transport over the backplane of the MicroTCA and AdvancedTCA platforms.

Bundling signal channels with the voice bearer channels enables AdvancedMC interface cards to add significant value to the MicroTCA/AdvancedTCA platform by providing intelligent protocol offload and acceleration. The AdvancedMC processor and protocol software must be sophisticated enough to handle the TDM network's large number of different protocols.

The typical standard TDM interfaces include T1/E1/J1 and OC-3/STM-1 or OC-12/STM-4.

The Interphase iSPAN 3639 AdvancedMC Multiprotocol T1/E1/J1 Intelligent Communications Controller, available in quad or octal configurations, (Figure 1) is an example of an intelligent protocol offload/acceleration AdvancedMC. This card handles both:

- Signaling protocols such as SS7 and ISDN with an onboard processor
- I-TDM for up to 256 DS-0 flows with an onboard FPGA

Figure 1

Wireless networks introduce an additional complication by using subrate DS-0 TDM voice. AdvancedMCs that can provide subrate TDM voice interfaces address this issue and have enhanced the I-TDM protocol to transport the subrate voice. For example the Interphase iSPAN 3632 Quad-Port Channelized OC-3/STM-1 Interface Processor (Figure 2) provides up to 8,032 I-TDM flows.

Figure 2

Digital signal processors

A digital signal processor farm is an essential component in media processing-intensive applications such as media gateways and media servers. The DSP farm handles all media processing functionalities that enable convergence of IP (wireline and wireless), PSTN, and mobile networks. This board must perform not only simple transcoding of voice and video, but also:

- Voice event detection and generation, DTMF detection, CNG, VAD, and ECAN
- Video frame rate and resolution change, text overlay, alpha blending, cropping, picture-in-picture
- Media server tasks such as streaming, recording, and conferencing of voice and video
- Fax and modem processing

In MicroTCA/AdvancedTCA platforms, the media processing capabilities are usually implemented on AdvancedMC cards populated with DSPs. The SurfRider AdvancedMC from Surf Communication Solutions (Figure 3) for example can support the convergence of PSTN, IP, and wireless networks, and must interface to the IP and TDM worlds by supporting I-TDM. I-TDM enables the passing of the TDM traffic over the AdvancedMC card's packet-based interfaces. Dedicated mechanisms on the AdvancedMC cards convert the incoming I-TDM packets to TDM traffic, and vice versa.

An AdvancedMC DSP board for media processing functions must support:

- A flexible number of channels, I-TDM flows, and different mixes of 1 ms and 125 µs flows
- A variety of external interfaces: Some customers may require the TDM to be moved over Ethernet packets; others may require different packetization support (such as SRIO, InfiniBand)
- The ability to dynamically and simultaneously run all media types to allow moving from 100 percent voice to 100 percent video, and any mix in between
- Separation between media and control functions and utilizes DSPs with a direct IP network interface to avoid aggregation on the host processor, which typically creates bottlenecks in the system and increases media delay, reducing quality
- External memory per DSP on board, enabling easy addition of features without concerns about code and data size
- A DSP software framework that enables:
  - Adding user-defined and proprietary algorithms to the DSP
  - Support for predictive scheduling, allowing tasks such as DMA of relevant data to be sequenced automatically while a previous task is being processed
  - Support for real-time processing with guaranteed quality of service and latency

Figure 3

I-TDM standard brief

The legacy solution for carrying TDM on the backplane has been the H.110 bus, with 32 TDM data highways at 8 MHz. Carrying TDM over a serial packet bus reduces pin count, increases reliability, and allows the prospect of a single fabric for carrying all chassis traffic. The advent of MicroTCA and AdvancedTCA has increased the urgency of the problem, because unlike CompactPCI, there is no defined TDM highway backplane in AdvancedTCA/AdvancedMC.

PICMG chose a layered, fabric-agnostic approach to standardize a TDM-over-packet protocol. The lower layer specification, SFP.0, defines essential fabric services, such as detection of misrouted or dropped packets, multiplexing, and end-to-end fabric integrity check. PICMG deliberately chose a lightweight protocol to run directly on top of the Layer 2 packet. For example (Figure 4), SFP.0 runs directly over MPLS over Ethernet, without requiring a bulky IP or TCP/UDP layer.

The next protocol layer, SFP.1, also known as I-TDM, provides TDM-centric header services. I-TDM multiplexes several TDM channels together into one packet,

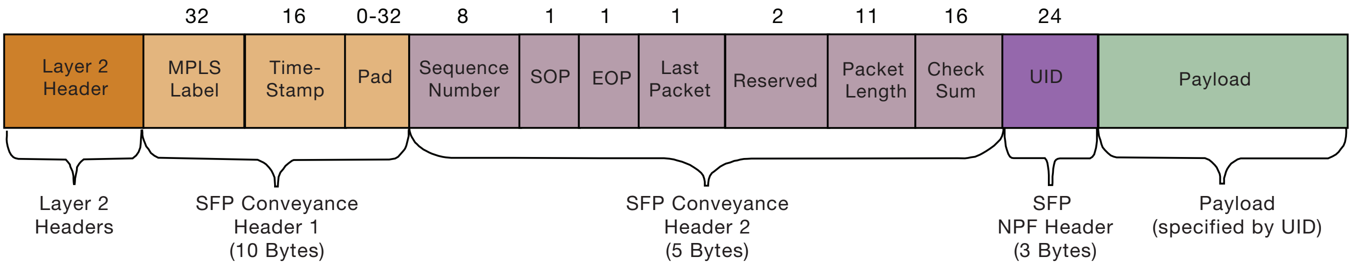

Figure 4

as opposed to waiting several frame times to accumulate enough data for a given TDM channel. This step maintains fabric efficiency, because most fabrics (and network hardware such as switches and endpoints) become increasingly inefficient with small packet sizes. Figure 5 shows an I-TDM 125 µs mode payload format. I-TDM payload format choices are:

- A packet emission interval of 125 µs provides the lowest possible latency, and is recommended for hardware implementation
- Packet emission interval of 1 ms, which creates higher latency, but is easier to handle in host media processing and other software-centric approaches

Unlike WAN-centric TDM over packet standards such as PWE3/TDMoIP, I-TDM is intended as an in-chassis protocol. Therefore, there is no support for timing recovery, which greatly simplifies the implementation.

The I-TDM standard primarily benefits designers as a chassis-optimized, fabric-neutral technology supported by multiple vendors. It is possible to transport TDM over packet in multiple nonstandard ways, and point solutions have been implemented in the industry. Widespread adoption of I-TDM as the TDM transport backplane technology will allow system vendors to use interoperable vendor parts and concentrate on end functionality over plumbing.

I-TDM enabling technologies

Early implementation of the I-TDM standards has included software-only implementations using dedicated network processors and reprogrammable FPGAs (Altera and Xilinx). Both approaches have the flexibility to accommodate the changes and extensions inherent in a newly introduced standard.

The NP-based approach is ideal for supporting a mix of 1 ms and low density 125 µs modes of operation. The FPGA-based method scales better to higher density 125 µs implementations.

A software implementation of 125 µs I-TDM in Wintegra's WinPath NP family (Figure 6) supports densities of up to

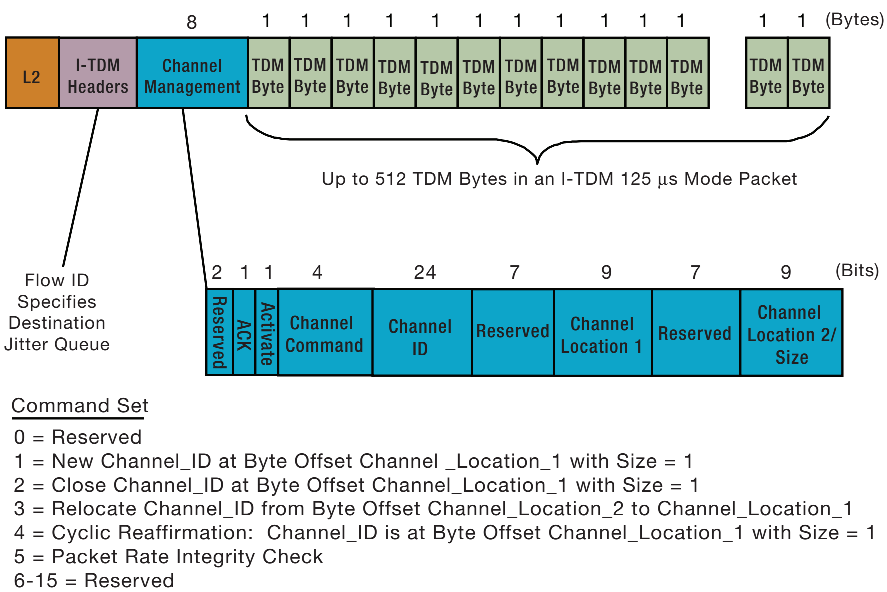

Figure 5

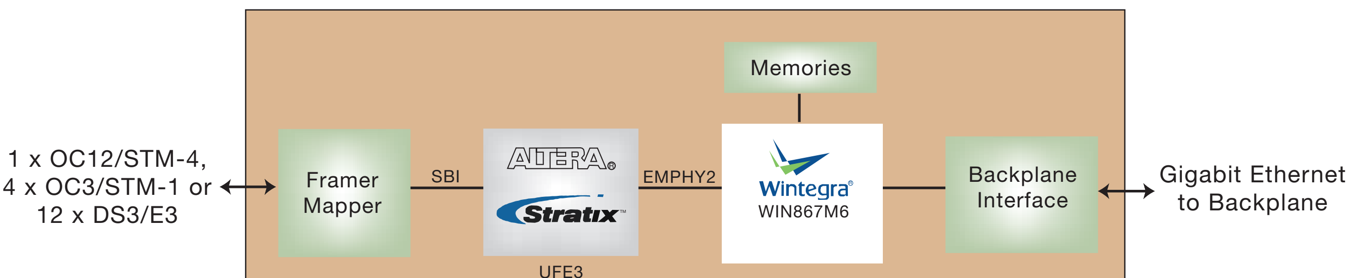

Figure 6

28 T1/21 E1s (672 DS0s) with DS0 granularity per I-TDM channel and up to 84 T1/63 E1 with 8xDS0 granularity per I-TDM channel. Wintegra also supports higher densities of up to OC-12 (8K channels) by using an I-TDM load in its UFE FPGA.

Figure 7 shows Accolade Technology's FPGA-based ASTDM solution. The ASTDM features dual GbE interfaces to the fabric switch side, a TDM bus (signaling termination, DSP resources, or SONET framers), and a CPU interface. This architecture uses dedicated state machines to manage both 1 ms and 125 µs modes of operation while directing command and control packets to the CPU interface. It can support densities of four T1/E1s to OC-12.

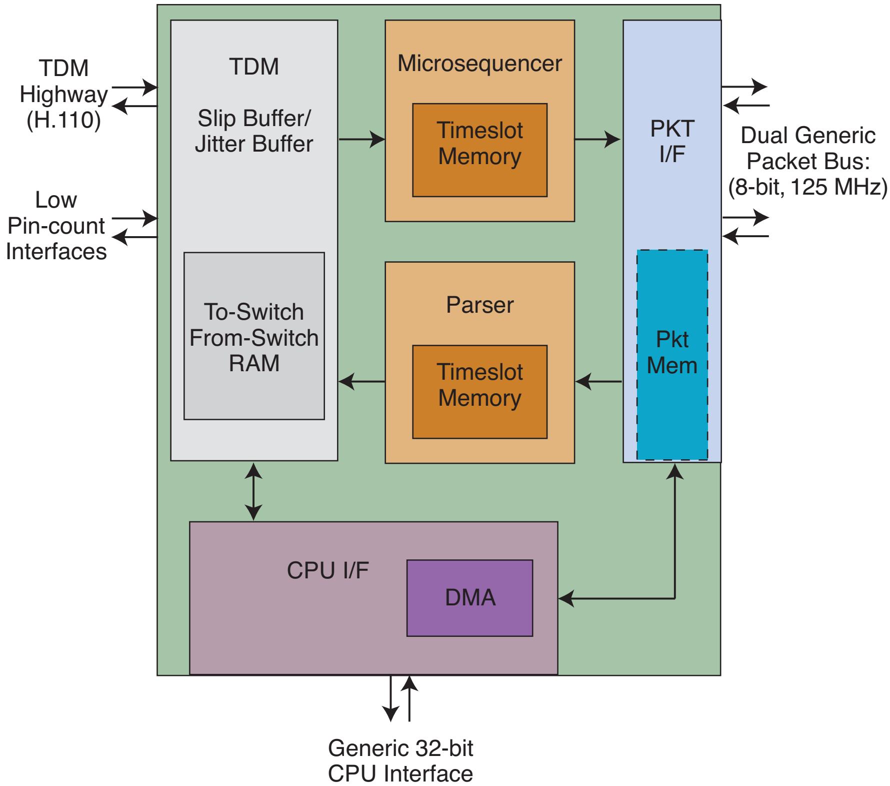

Figure 7

State of the I-TDM ecosystem

The current I-TDM ecosystem includes manufacturers of enabling technologies and board level products. Suppliers of IP cores for FPGAs and software implementation on network processors that have announced I-TDM solutions include Accolade Technology and Wintegra Inc.

Suppliers of TDM, signaling interfaces, and media server/DSP blades that have announced AdvancedTCA/AdvancedMC board level solutions with I-TDM functionality include Interphase Corporation and Surf Communications, among others.

TDM interface vendors and DSP vendors are testing I-TDM interoperability. Accolade Technology is introducing an I-TDM reference test platform based on its ASTDM implementation of the I-TDM standard on a Xilinx-based development platform. This menu-driven I-TDM reference test platform supports call setup and I-TDM traffic generation and termination.

Future enhancements to standard

The current I-TDM standard is sufficiently mature for product implementation. However, for optimal functionality and interoperability, additional issues should be considered.

Explicit support for subrate channels

The most common channel format is a complete DS0, equivalent to a 64 Kbps data rate. However wireless networks widely use subrate channels (fractional DS0, such as 32 Kbps, 16 Kbps, 8 Kbps). Currently, the I-TDM standard cannot specify channel ID or carry out 125 µs mode channel management commands like New, Change, Relocate, or Cyclic Reaffirmation on a sub-DS0 granularity. While it is still possible to transport sub-DS0 channels by some private understanding between the two peers, a standardized scheme promotes interoperability and possibly reduces wasted bandwidth.

Redundancy and protection switching support

While specific redundancy schemes at the chassis level are not precluded by the I-TDM standard, they are not explicitly supported.

Modifications or extensions to the 125 µs channel management command scheme

I-TDM's 125 µs channel management in-band nature is a strong architectural benefit. However, improvements in some modes of operation may be desirable.

Summary

Platforms designed around MicroTCA and AdvancedTCA are rapidly coming to the market. I-TDM provides a key technology to enable IMS next-generation network platforms based on MicroTCA and AdvancedTCA to successfully leverage the significant investment in legacy TDM voice and media networks, while at the same time being able to provide the advanced services and flexibility inherent in the MicroTCA/AdvancedTCA architectures.

A growing number of critical IMS I/O and DSP building blocks are incorporating I-TDM solutions.

Since the standards and the building blocks for these solutions are currently in the initial stages of market penetration, innovative and flexible implementations will pave the way for additional capabilities in the near future. As with any new technology, the I-TDM standards will likely continue to evolve based on implementation experience in voice and media transport within MicroTCA and AdvancedTCA platforms. I-TDM clearly

I-TDM ECOSYSTEM GLOSSARY

BSC	Base Station Controller
CNG	Comfort Noise Generation
DMA	Dynamic Memory Allocation
DSP	Digital Signal Processor
DTMF	Dual Tone Multi-Frequency
ECAN	Echo Cancellation
FPGA	Field Programmable Gate Array
GbE	Gigabit Ethernet
GGSN	Gateway GPRS Serving/Support Node
IMS	IP Multimedia Subsystems
IP	Internet Protocol
I-TDM	Internal Time Division Multiplexed
MRF	Media Resource Function
NP	Network Processor
PSTN	Public Switched Telephone Network
PWE3/TDMoIP	Pseudo Wire Emulation Edge to Edge/Time Division Multiplexed traffic over IP
QCIF	Quarter Common Intermediate Format
RNC	Radio Network Controller
SIP	Session Initiation Protocol
SONET	Synchronous Optical Networking
SRIO	Serial RapidIO
TCP/UDP	Transmission Control Protocol/User Datagram Protocol
TDM	Time Division Multiplexed
TEM	Telecom Equipment Manufacturer
VAD	Voice Activity Detection
VoIP	Voice over Internet Protocol

offers the benefits of a cost-effective, standards-based solution for offering new services while protecting investments in today's infrastructure.

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