DENSITY SOLUTIONS WITH TEMUX AND FREEDM-84

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1 INTRODUCTION

PMC-Sierra's new TEMUX and FREEDM-84 chipset is the industry's most integrated standard product chip set designed to satisfy requirements of high density port cards. The chipset is ideal for numerous applications including:

- Routers
- Multi-service Switches
- Multi-service Access Multiplexers
- High density packet port cards
- Packet-based Digital Subscriber Line Access Multiplexers – DSLAMs

Flexibility is not the only advantage of this chipset. Incredible density, coupled with an innovative interconnect architecture, allows designers to develop new port cards that triple the bandwidth - with no increase in board size! The chipset also incorporates enhanced diagnostics to simplify design, implementation and test reducing both development and operating costs.

This paper discusses how and why PMC-Sierra implemented a card level solution to satisfy the unique requirements of these applications. After an overview of the TEMUX and FREEDM-84 devices, we analyze the driving need for density and describe how the features of the TEMUX and FREEDM-84 meet these requirements.

2 TEMUX AND FREEDM-84 ADVANTAGES

2.1 Feature Set Advantages of TEMUX and FREEDM-84

To facilitate the density requirements of packet access port card designs, TEMUX and FREEDM-84 were developed. The TEMUX/FREEDM-84 chip set is optimized for use in full-featured access equipment delivering high speed Internet and frame relay services to end customers. As shown in the following table, its feature set has been carefully crafted to minimize the required board space of SONET, SDH and DS3 access platforms allowing unparalleled density to service the exploding bandwidth requirements of today's architectures.

Table 1 TEMUX/FREEDM-84 Chip Set Features and Benefits

TEMUX/FREEDM-84 Chip Set Feature	Benefit
TEMUX flexibility allows a single design to be used in both T1 and E1 developments, not only for DS3 applications but also for SONET and SDH optical applications.	System hardware and software design is greatly simplified, thereby reducing development costs and speeding time to market.
One FREEDM-84 along with three TEMUXs can handle bandwidth up to 155 Mbit/s, allowing them to process up to 672 HDLC channels that can be assigned up to 84 physical links.	Offers unprecedented density that now allows a channelized OC-12 of 622 Mbit/s to be processed on a single port card in a form factor that previously allowed only a channelized DS3 of 45 Mbit/s to be processed.
Scalable Bandwidth Interconnect bus provides seamless interconnection between TEMUX and FREEDM-84 using only a minimum set of pins.	With less pins to connect, SBI allows greater density by requiring less routing and saves board cost by reducing the number of layers required on the circuit board.
Enhanced diagnostics that include line rate and N*DS0 PRBS error testing and various loopback modes for fault isolation and troubleshooting have been built in the devices	Flexible loopback modes and built-in bit error rate testing capabilities not only reduce or eliminate the need for expensive test equipment, but also allow the flexibility of in-service testing.

2.2 TEMUX and FREEDM-84 Chipset Description

The TEMUX is a high density T1/E1/J1 framer that includes an M13 multiplexer. It can be used in any application requiring high density link termination over T1 channelized DS3. It also includes an integrated VT/TU mapper for T1 and E1 channelized SONET/SDH applications.

The FREEDM-84 Frame Engine and Datalink Manager is a high density device that implements HDLC processing for a maximum of 672 bi-directional channels. It may be configured to support channelised T1/J1/E1 or unchannelised DS-3 traffic on up to 84

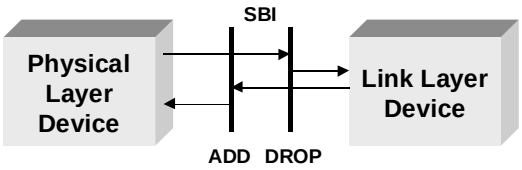
links conveyed via a Scaleable Bandwidth Interconnect (SBI) interface. The SBI interface transports data in three Synchronous Payload Envelopes (SPEs), each of which may be configured independently to carry either 28 T1/J1 links, 21 E1 links or a single DS-3 link. FREEDM-84 is offered in two versions. The FREEDM-84P672 supports the traditional PCI system side interface that the first generation of FREEDMs supported. The FREEDM-84A672 supports newer Any-Phy Packet Interface for architectures that need high bandwidth and low packet latency.

Figure 1 PMC's TEMUX and FREEDM-84 Devices

2.3 Connectivity Advantage with SBI

The Scaleable Bandwidth Interconnect bus, shown in Figure 2, is a proprietary bus developed by PMC-Sierra to inter-connect physical layer devices like the TEMUX with link layer devices like the FREEDM-84. To maintain its flexibility for use with different devices, it was developed to support widely varying channel densities and payload types.

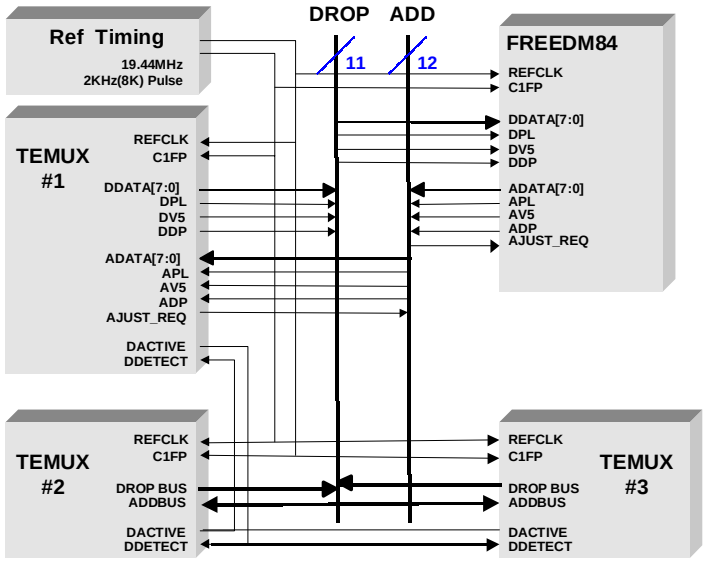
Figure 2 SBI connectivity between Physical Layer Device and Link Layer Device



Based on well understood telecom structures, SBI provides the dense interconnect needed for today's edge equipment. Its flexible clocking and mapping is a technology enabler for multiservice platforms for frame relay, ATM and circuit emulation services.

The main advantage of the SBI bus is illustrated in Figure 3. If clock and data interconnections were to be used, TEMUX would require four system-side interconnects for each T1, for a total of 112. Using the SBI bus reduces the required number of interconnections on each TEMUX device by a factor of 4 to only 27. It can be easily seen that clock and data interconnection to FREEDM-84 is not even viable as it would require 336 interconnections to the three TEMUXs instead of only the 27 that are required when using SBI.

Figure 3 SBI interconnect between TEMUX and FREEDM-84



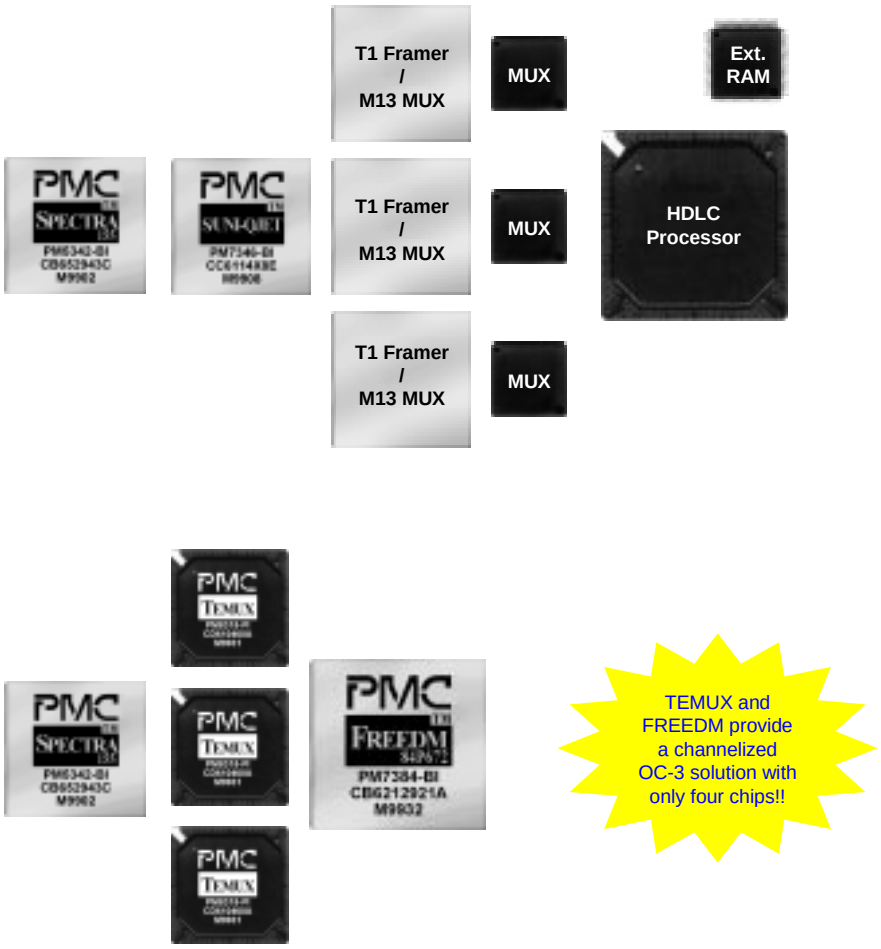
2.4 Density Advantage with TEMUX and FREEDM-84

High density HDLC solutions primarily use multiple DS3s for data transmission across the Wide Area Network (WAN). As more and more bandwidth is required and the number of DS3s per port card increases, the allowable board size and form factor remains constant. More circuitry has to be packed in smaller and smaller areas. Form factors of boards that previously implemented single DS3 interfaces can now fit six and

twelve DS3s. Existing HDLC are being replaced by the more dense TEMUX/FREEDM-84 chipset.

Figure 4 illustrates the space savings offered with TEMUX and FREEDM. A typical HDLC port card would require 21 separate chips to terminate three DS3s. TEMUX and FREEDM-84 can terminate this same number of DS3s in only seven chips, using less than a third of the board space. This new chipset even allows HDLC processing right down to three DS3s sharing up to 672 channels. Coupled with the additional functionality and flexibility TEMUX and FREEDM-84 offer, per channel port costs are significantly reduced.

Figure 4 Typical space savings with TEMUX and FREEDM



Along with size, power consumption also becomes more and more of a major issue. The use of 2.5 volt power supplies for both TEMUX and FREEDM-84 reduces the power consumption in half, significantly minimizing thermal restrictions of these newer port card designs. It is this combination of the density savings of a reduced chip count, savings in interconnects the SBI allows and the power saving of the new lower voltages that all combine to allow the port card densities to go up by a factor of three or more.

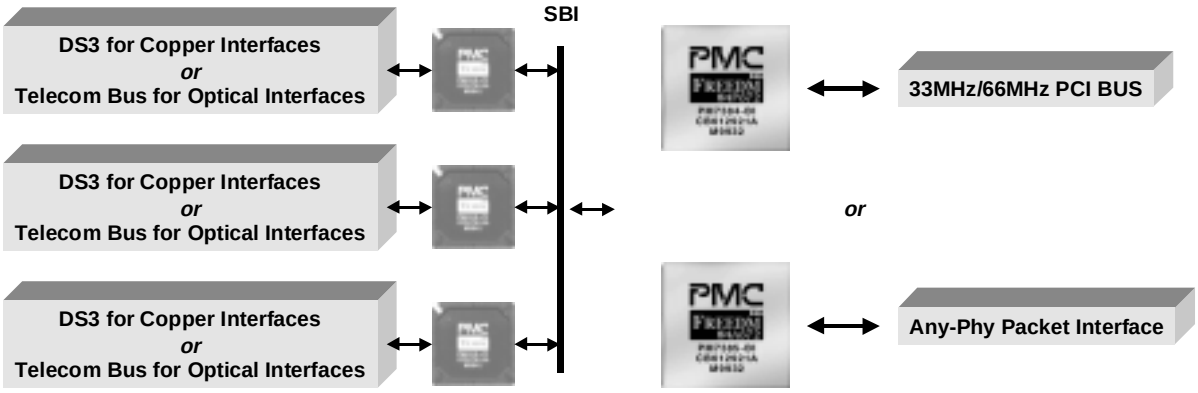
2.5 Enhanced Diagnostic Tools

This chipset offers a suite of diagnostic tools that include different types of loopbacks and various pseudo-random bit sequences. These diagnostic tools enable more extensive system and board diagnostics, not only at DS3, T1, and E1 line rates, but also at N x DS0 rates. Without any external logic or test equipment, these diagnostics even support in-service testing on any of the tributaries. Offering pseudo-random binary sequence (PRBS) generation and detection not only increases diagnostic abilities, but also reduce or eliminate the use of expensive bit-error-rate testers. This not only simplifies the testing and verification of these port card designs but provides an invaluable tool to the end-user for equipment installation and operation.

3 FLEXIBILITY WITH TEMUX AND FREEDM-84

Greater flexibility on both the line side and system side interfaces comes along with the density and cost savings the TEMUX and FREEDM-84 bring to the board designer. This flexibility offers the system architects and board designers an opportunity to develop a single card to satisfy multiple applications across the different transmission standards that are used throughout the world. Figure 5 illustrates both the different line side interfaces this chipset offers and the different system side interfaces that are available.

Figure 5 Line and System Side Interface Options



3.1 System Side Interfaces

FREEDM-84 is offered in two variants to support the popular system side architectures. FREEDM-84P672 supports 84 physical links, processing up to 672 HDLC channels, that interface to the traditional PCI bus structure that earlier generations of FREEDMs interfaced to. For some of the newer architectures however, a higher performance system side interface was needed. For these applications, PMC-Sierra has also introduced the FREEDM-84A672. This FREEDM also supports 84 physical links, processing up to 672 HDLC channels and interfaces to the newer Any-Phy Packet Interface (APPI).

Modelled after POS-PHY, the de-facto standard for PPP-Over-SONET applications, APPI offers the system architect a lower latency, a high bandwidth of 800 Mbit/s, lower bus overhead and more support for multiple classes of service. Using an external bus controller, a single Any-Phy Packet Interface can support up to seven FREEDM devices.

Figure 6 illustrates the PCI bus using FREEDM-84P672 and external packet memory.

Figure 6 PCI System Side Interface

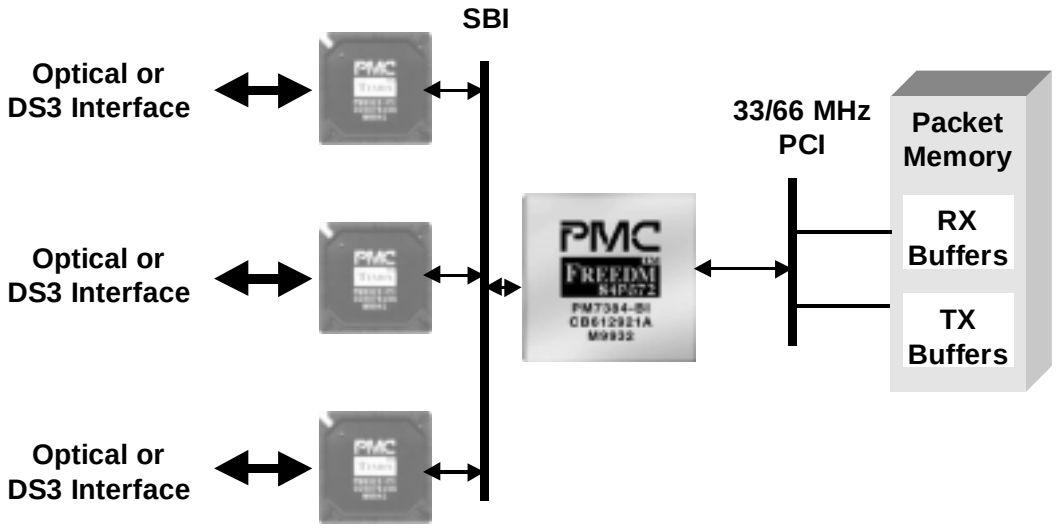
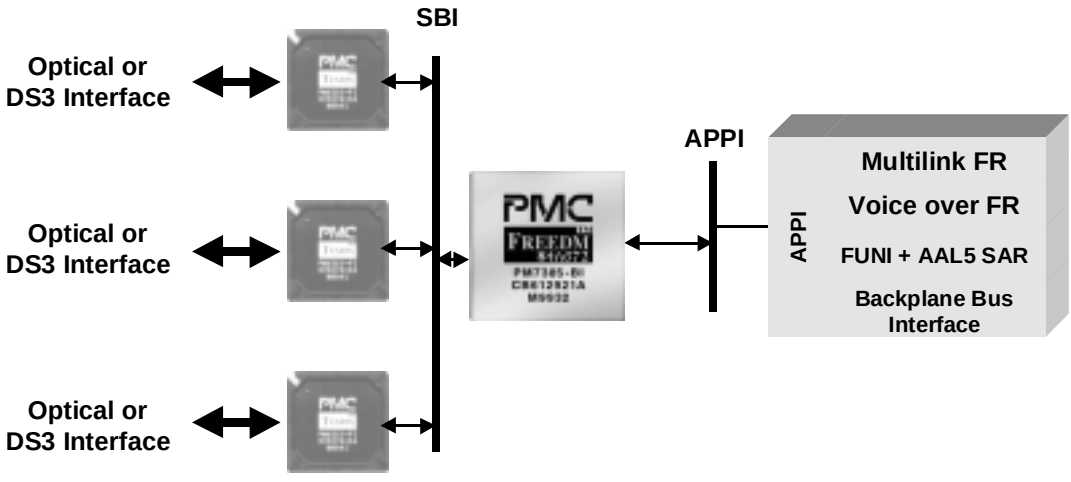


Figure 7 illustrates the use of the Any-Phy Packet Interface and how it can be used for multiservice applications that include multilink Frame Relay, Voice over Frame Relay, and Frame Relay over ATM.

Figure 7 Any-Phy Packet Interface System Side Interface

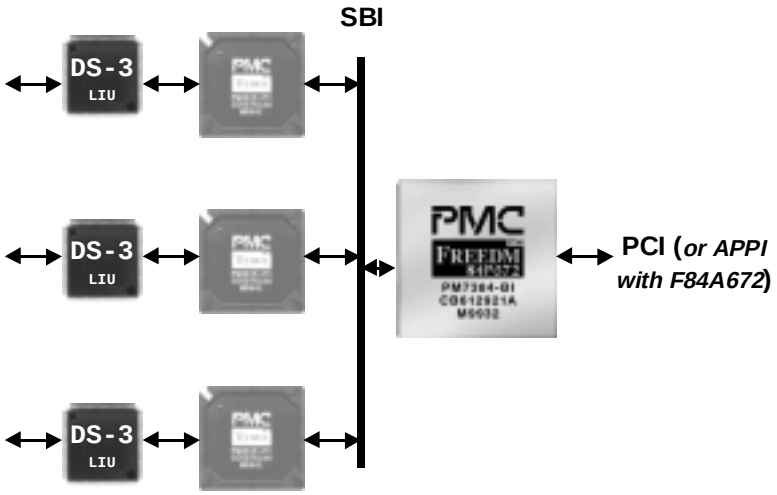


3.2 Line Side Interfaces

The flexibility on the line side interfaces allow the board designer to develop port cards that can either support optical or DS3 interfaces. A simple external DS3 LIU is all that is

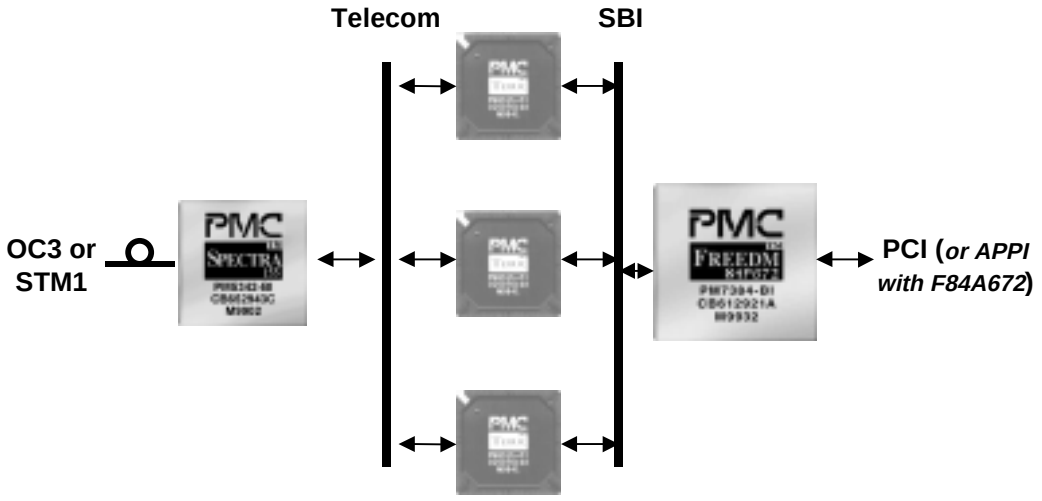
needed to convert the digital DS3 signal from the TEMUX to an analog format suitable for transmission across copper wire.

Figure 8 TEMUX and FREEDM-84 in DS3 Designs



With TEMUX and FREEDM-84, a single software-switchable port can now be designed to support T1 interfaces, E1 interfaces and Japanese J1 interfaces for transmission over either STS-3 formatted or STM-1 formatted optical fibers. The FREEDM-84 processed the packet data while the TEMUX frames and maps the T1, E1 or J1 data streams onto a telecom bus. The Spectra155 aligns and formats the data for optical transmission on either and OC-3 fiber or an STM-1 fiber. This now allows multi-service edge equipment to be developed which can be deployed anywhere in the world provisioned simply by software commands.

Figure 9 TEMUX and FREEDM-84 in Optical Designs

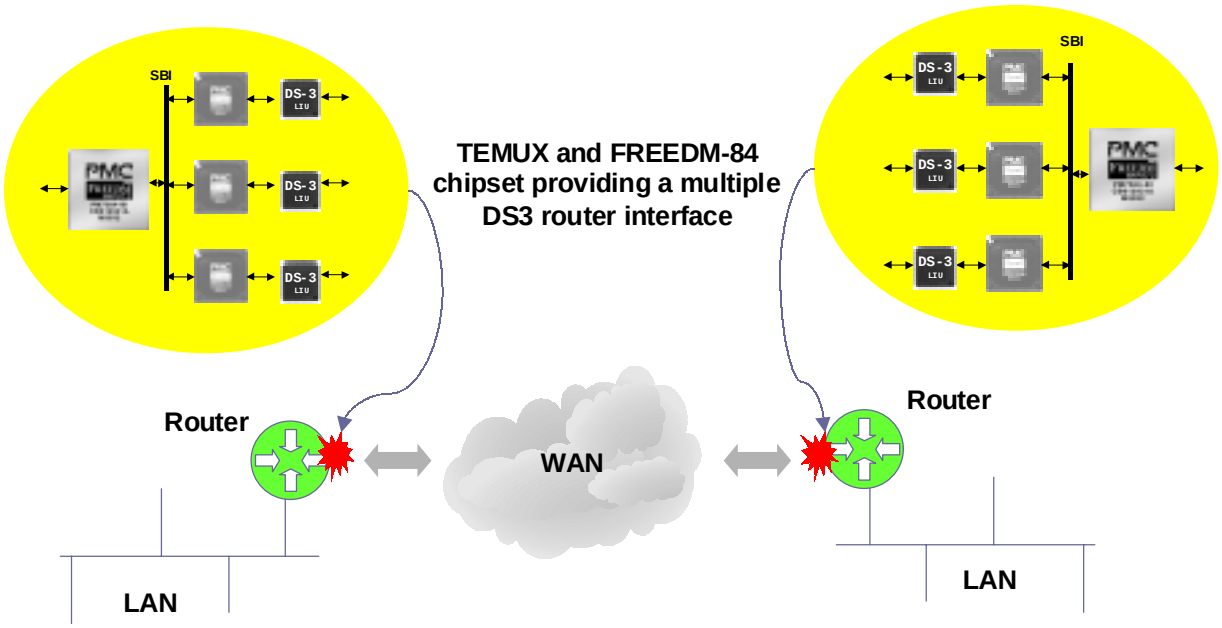


4 APPLICATION EXAMPLES USING TEMUX AND FREEDM-84

4.1 Routers

One of the ideal applications for the TEMUX and FREEDM84 chipset is high denstiy packet port cards for Edge Routers. As bandwidth requirements have increased, router interfaces have grown to support multiple DS-3s and even multiple OC-3s. In router designs, TEMUX and FREEDM provides the needed physical and datalink functionality in a small footprint solution. This not only simplifies the router design but significantly reduces both board and system costs. The use of TEMUX and FREEDM84 in a typical Edge Router application is shown in Figure 10.

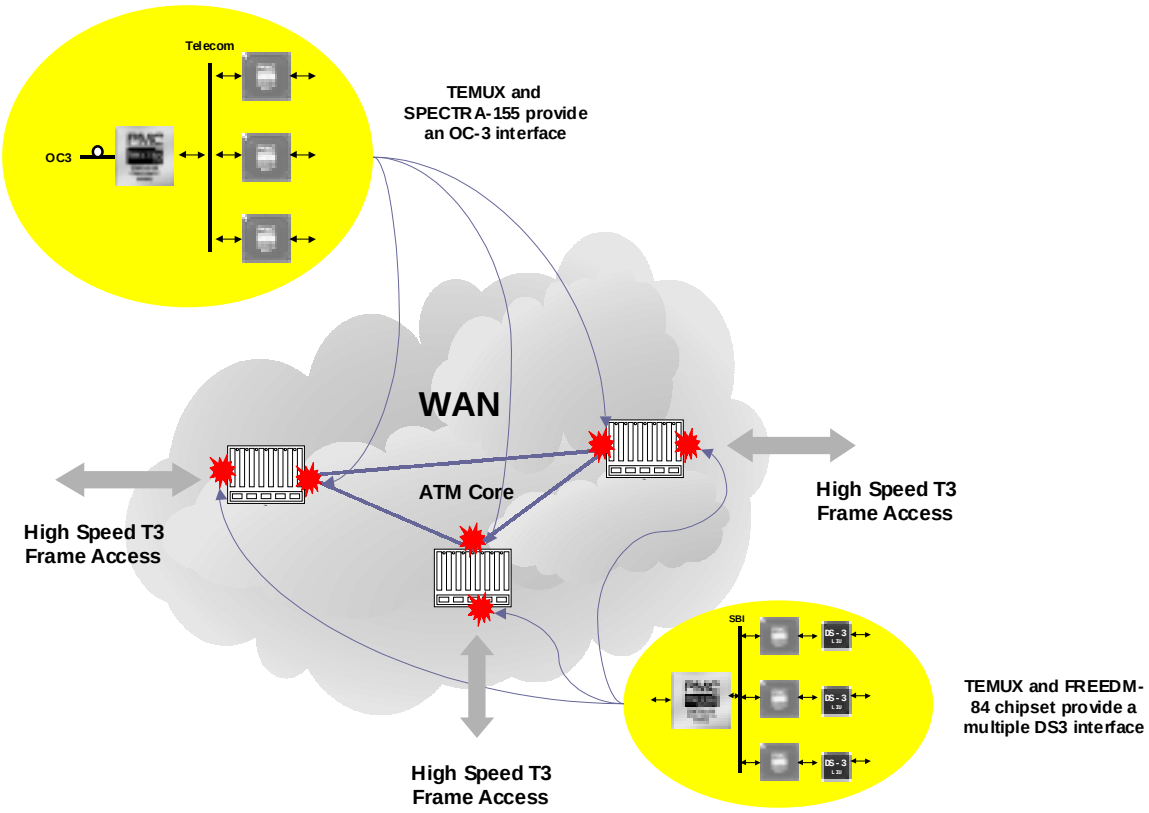
Figure 10 Internetworking with Routers



4.2 High Density Packet Port Cards

TEMUX and FREEDM-84 make an equally ideal solution in high density WAN port cards. Figure 11 shows a Frame Relay Switch with high speed DS3 port cards using TEMUX and FREEDM84. It also shows an ATM uplink using TEMUX and PMC's Spectra-155. The density that TEMUX and FREEDM-84 provide enables a design with more port cards per shelf. With its built in loopback modes and bit error rate testing, the links between the WAN and customer premise equipment can now be tested without expensive test equipment – **with the line still in service!**

Figure 11 High Density Port Card in a Frame Relay Switch



5 CONCLUSION

The TEMUX and FREEDM-84 chip set fully addresses the HDLC processing requirements for the exploding Frame Relay market and provides unprecedented density and flexibility for the system architect and board designer. Summarizing the major benefits of TEMUX and FREEDM-84, we have:

Unparalleled Density

Designers can now design full channelized frame relay solutions for OC3 and even OC12… ***on a single port card!!***

Seamless Interface with Reduced Pin Count

Use of the SBI simplifies the interface between the two devices reducing the interconnections substantially…***enables full use of the small footprints and reduces costly layers on the circuit board!!***

Enhanced Built-in Diagnostic Capability

Diagnostic tools are built in that include different types of loopbacks and various pseudo-random bit sequences simplifying test and verification…***reduces the use of costly test equipment and allows in-service testing for the end-user!!***

Flexibility for Use in Different Applications and Different Architectures

Flexible system side interfaces include the use of the traditional PCI interface and now include the newer Any-Phy Packet Interface for multi-service Frame Relay applications. Flexible line side interfaces include the use of DS3 and a telecom bus that can be used for T1, E1 and J1 formatting over both North American and international optical standards…***allows a single software-configurable frame relay port card that can be deployed anywhere in the world !!***

NOTES

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