The ML-IP main link module provides a cost-effective and versatile, modular TDM over IP (TDMoIP) solution for legacy TDM services over IP networks. It converts the TDM bit stream delivered by the internal Megaplex-2100/2104 backplane from the I/O modules, into IP packets that can be transmitted over IP networks.

ML-IP provides standard Ethernet connectivity for Megaplex. The module works opposite 10/100BaseT or 100BaseF Ethernet equipment, including RAD’s iPMux family of TDMoIP Gateways, to be part of an integrated corporate or campus IP network.

A Megaplex chassis equipped with ML-IP can be deployed at a main site to provide voice and data services over IP to multiple sites. It can also operate at the local site level, opposite an iPMux unit at a main site, for extending digital PBX services over IP to the other sites (see Figure 1).

The module is equipped with three Ethernet ports. Net 1 and Net 2 are Ethernet uplink ports with 10/100BaseT or 100BaseF interface. One of the uplinks can serve as the main link to the IP network, while the second uplink can be connected to other ML-IP equipped Megaplex units, iPMux units or any other IP equipment. The second uplink enables daisy-chaining other Megaplex units for a single connection to the IP network (see Figure 4). Alternatively, the two uplinks can be used for redundancy or constructing ring topologies. User is a 10/100BaseT Ethernet port for connecting a local LAN or PC directly to ML-IP. The user port can be used for interlinking other ML-IP modules or iPMux units to extend the bandwidth capacity of a single node. In RFER topology, in addition to the TDM payload protection, up to 32 IP addresses connected to the user port can be added to the 50 ms protected stream. The user port traffic can be switched directly into the IP network by ML-IP’s internal switch, via one of the uplinks.
All copper UTP Ethernet interfaces operate in both full- or half-duplex modes, at either 10 or 100 Mbps speed. Each interface terminates with an RJ-45 connector.

The two uplinks can be ordered with full duplex 100BaseF interfaces. The following fiber optic interface options are currently available:

- 850 nm for multimode fiber with ST or FC connectors, typical range up to 2 km (1.2 miles)
- 1310 nm for single mode fiber using a laser transmitter with ST or FC/PC connectors, typical range up to 20 km (12 miles).

The total TDMoIP payload of a single module is 4 Mbps (other Ethernet traffic connected to the ML-IP module is switched from one port to another in the Ethernet layer, and does not affect the payload capacity of ML-IP). To increase the TDMoIP payload capacity of a single chassis to a maximum of 8 Mbps, an additional ML-IP module can be installed. The uplinks of the two ML-IP modules can be interconnected (the traffic is switched in the Ethernet layer) so that the combined payload is transmitted via a single Ethernet link to the IP network (see Site A in Figure 4).

**TIMING**

ML-IP operates in three timing modes:

- **Internal mode**: Megaplex’s internal oscillator is the source for the timing used by the Ethernet links, as well the other I/O modules. ML-IP is the sole clock source for all the units in the network.
- **External mode**: One of the I/O modules is the source for the system timing.
- **Adaptive mode**: The ML-IP timing clocks are regenerated using the Adaptive method, according to the monitored received packet rate from the IP network. The timing is then also passed on to the I/O modules.

Figure 1. Megaplex with ML-IP in Daisy-Chain Topology in a Campus
ML-IP uses an enhanced packet delay variation (jitter) buffer to store incoming IP packets. The buffer compensates for up to 300 msec of delay variation in the IP network.

**QOS SUPPORT**
ML-IP complies with all relevant Ethernet LAN standards. At the Ethernet level, it supports VLAN tagging and priority labeling according to IEEE 802.1D-2004 and 802.1Q to provide reliable, high quality of service (QoS).

The user can configure the ToS (Type of Service) of the outgoing IP packets. This allows an en-route Layer-3 router or switch that supports ToS (or DiffServ), to give higher priority to ML-IP traffic for delay-sensitive applications.

Assigned, IANA-registered UDP socket number for TDMoIP simplifies flow classification through switches and routers.

**TIMESLOT BUNDLING & CROSS-CONNECT**
ML-IP supports the same cross-connect features as the Megaplex ML-2E1/T1 TDM main link module family. The internal cross-connect matrix of the ML-IP module routes voice and data channels from any I/O module installed in the chassis, to any installed main link. In addition, traffic can be routed from one link to another, including between IP and regular TDM links. The non-blocking full cross-connect feature allows more flexibility in assigning timeslots for improved link bandwidth utilization.

ML-IP places individual or multiple (up to 31) TDM timeslots into bundles with a single IP destination address. Point-to-multipoint applications are achieved by using multiple bundles with different IP addresses (each bundle can be considered as a Fractional E1/T1 link in TDM network applications). Up to 24 bundles (without CAS, or 12 bundles with CAS) are supported by the module. To support more timeslot bundles, a Megaplex chassis can be equipped with additional ML-IP modules.

**BUNDLE REDUNDANCY**
For redundancy, bundles can be duplicated and transmitted simultaneously. This provides functionality similar to “parallel transmit redundancy” used with E1/T1 TDM links: if the active bundle stream fails, Megaplex will switch to the other bundle stream.

To provide different levels of network and hardware protection, redundant bundles can be transmitted in the following ways:
- Via the same Ethernet uplink for IP connection redundancy (Figure 2A). Both bundles have the same IP address, but are tagged differently. Switching takes place within 50 msec.
- Via the same ML-IP module, but using different uplinks, to also provide physical link redundancy (see Figure 2B). Both bundles have the same IP address, but are tagged differently. This option requires a Layer-2 (VLAN supporting) switch, which can block untagged IP packets to prevent packet storming. Switching takes place within 50 msec.
- Via different Ethernet uplinks on separate ML-IP modules (see Figure 2C) to provide module (hardware) redundancy, in addition to physical link and IP connection redundancy. Both bundles have different IP addresses and are tagged differently. Switching takes place within 2 seconds.

In each of the above applications, two types of redundancy are available:
- 1+1 Redundancy. When this redundancy type is enabled, both bundles transmit data packets all the time, offering potentially faster recovery at the expense of doubling the bandwidth. This provides functionality similar to the parallel transmit redundancy used for TDM fractional E1 and T1 links.
- 1:1 Redundancy. When this redundancy type is enabled, one of the bundles transmits and receives data packets, while the other bundle transmits OAM packets to verify connectivity.

![Figure 2. Redundant Bundling for IP Link Backup](image-url)
RESILIENT FAST ETHERNET RING
ML-IP’s two uplink ports employ RAD’s Resilient Fast Ethernet Ring (RFER) technology to construct self-healing 100-Mbps Fast Ethernet fiber or copper ring topologies (ring resiliency functions similarly to that of STM-1 networks). In case of link failure on any segment of the ring, RFER reroutes the TDMoIP traffic within 50 ms, fast enough to maintain the required voice quality. (For other Ethernet traffic, recovery takes longer, approximately 20 seconds.) An extended protection mechanism allows adding up to 32 IP addresses connected to the user port, to the 50-ms protected stream. ML-IP’s resilient ring performance was independently tested and verified by a well-known European network test center. It was found to provide superb service resilience and voice quality, with proper prioritization of TDM traffic.

RFER enables enterprises, campuses, power companies, transportation companies and utilities to create highly reliable networks, using dark fiber or dry copper in a ring topology (see Figure 3). Survivability is further enhanced by RFER’s scalable support for multiple rings, which eliminates the risk of a single point of failure. This is ideal for dispersed applications, such as commuter railroads.

REUNDANCY BETWEEN ML-IP AND TDM MAIN LINK MODULES
ML-IP modules can be used as backup for TDM E1/T1 links (and vice versa). Redundancy between ML-IP modules and TDM main link modules is accomplished by configuring different databases for each Megaplex: one for transferring the traffic via TDM main link modules through E1/T1 networks, and the other for using the ML-IP modules to transmit the same traffic through IP networks. Appropriate flipping conditions are then specified to switch between the two databases.

ECHO CANCELLER
A built-in echo canceller option can be ordered for canceling the echo signals that may be generated on the local (near-end) voice channel analog interface. When enabled, the echo canceller operates on the timeslots carrying voice, providing acceptable voice quality even on networks with long delay. Echo delays of up to 4 msec are tolerated.

The echo canceller is enabled/disabled by the user, for all voice timeslots assigned to one of the two ML-IP internal ports. Up to 30 voice channel timeslots can be supported. The echo canceller automatically detects fax and modem transmissions and does not affect them.

Figure 3. Resilient Fast Ethernet Ring (RFER) Enables Self-healing Networks
DIAGNOSTICS
The following diagnostic tools are available to facilitate monitoring and testing:
- LAN performance monitoring and statistics
- Bundle performance monitoring and statistics
- ICMP Ping
- Tone injection per timeslot, for checking any voice channel in either the local or remote direction
- BERT and Loop+BERT for any timeslot at the TDM level
- Internal loop on any bundle at the TDM level, towards the I/O modules.

Specifications

ETHERNET PORTS

Number of Ports
2 uplink ports (Net 1 and Net 2)
1 user port (User)

Uplink Payload
Combined payload of Net 1 and Net 2 ports of a single module is up to 4 Mbps
Two modules together can support up to 8 Mbps maximum by a single chassis

Data Rate
8.448 Mbps

Compliance
IEEE 802.3, 802.1D, 802.1Q

Clock Modes
Internal, External, Adaptive

Statistics
According to RFC 2665:
- Received Frames: Correct Frames, Correct Octets, FCS Errors
- Transmitted Frames: Correct Frames, Correct Octets

IP Network Delay Variation Tolerance
300 msec

IP Network Requirements
ToS support for IP level priority
802.1p and 802.1Q support for MAC level priority

Table 1. Fiber Optic Interface Characteristics

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>Fiber Type</th>
<th>Connector Type</th>
<th>Transmitter Type</th>
<th>Power Coupled into Fiber [dBm]</th>
<th>Receiver Sensitivity [dBm]</th>
<th>Maximum Range [km] [miles]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[nm]</td>
<td>[μm]</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>850</td>
<td>62.5/125 multimode</td>
<td>ST, FC</td>
<td>VCSEL</td>
<td>-9 to -3</td>
<td>-32</td>
<td>2 [1.2]</td>
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<tr>
<td>1310</td>
<td>9/125 single mode</td>
<td>ST, FC</td>
<td>Laser</td>
<td>-15 to -8</td>
<td>-34</td>
<td>20 [12]</td>
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</tbody>
</table>

Figure 4. Daisy Chain Connection of Megaplex-2100 Units, to Maximize Utilization of a Single 10/100 Mbps Connection to the IP Network
ML-IP
TDMoIP Main Link Module

UTP INTERFACE (UPLINK AND USER PORTS)

Speed
10 or 100 Mbps

Operation Mode
Full or half duplex

Media
Copper

Connectors
8-pin RJ-45 (one per port)

Range
Up to 100m/330 ft using UTP cat. 5 cable

FIBER OPTIC INTERFACE (UPLINK PORTS ONLY)

Speed
100 Mbps

Operation Mode
Full duplex

Optical Specifications and Range
See Table 1

ECHO CANCELLER (OPTIONAL)

Voice Channels
Up to 30 (all timeslots must be from one internal port)

Echo Path Length
4 msec for each channel

Echo Return Loss Enhancement (ERLE)
>30 dB

GENERAL

Diagnostics
LAN diagnostics:
LAN statistics
Bundle statistics
ICMP Ping
WAN diagnostics:
Loopback on bundles
BERT, BERT+loopback
Local/remote tone injection

LED Indicators
Per module:
TEST (yellow) – On when test is run on the module (performed on any bundle or internal port)
Per port:
LINK (green) – On when Ethernet line is O.K.
FDX (green) – On when link is configured for full duplex operation
100M (green) – On when link is operating at 100 Mbps

Power Consumption
13.1W (2.62A @ +5V)

Ordering

MP-2100M-ML-IP/*/@

Legend

* Uplink interface type (User port is always UTP):
  UTP copper interface with RJ-45 connectors
  ST/85 850 nm multimode fiber with VCSEL transmitter, ST connectors
  FC/85 850 nm multimode fiber with VCSEL transmitter, FC connectors
  ST/13L 1310 nm single mode fiber with laser transmitter, ST connectors
  FC/13L 1310 nm single mode fiber with laser transmitter, FC/PC connectors

@ Echo canceller (supports up to 30 voice channels; Default= no echo canceller)

1E Echo canceller

Table 1. Megaplex Main Link Modules

<table>
<thead>
<tr>
<th>Feature</th>
<th>ML-E1/T1</th>
<th>MLF-E1/T1</th>
<th>ML-8E1/8T1</th>
<th>MSL-8</th>
<th>ML-IP</th>
<th>ML-20N</th>
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<tbody>
<tr>
<td>Interface Type</td>
<td>E1/T1</td>
<td>E1/T1</td>
<td>E1/T1</td>
<td>SHDSL</td>
<td>ETH (TDMoIP)</td>
<td>n x 64 kbps</td>
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<tr>
<td>Number of Channels</td>
<td>1/2</td>
<td>1/2</td>
<td>8</td>
<td>8</td>
<td>2</td>
<td>1/2</td>
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<tr>
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<td>None</td>
<td>Bundle</td>
<td>Link</td>
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<td>E1/T1</td>
<td>None</td>
<td>None</td>
<td>RFER</td>
<td>None</td>
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</table>

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