ISDN Voice, Video and Data Call Switching with Router TDM Switching Features

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Introduction

This document describes the use of router time-division multiplexing (TDM) switching features for the performance of ISDN voice, video, and data call switching. The document describes this Cisco IOS® feature in detail, as well as how to use and troubleshoot the feature on Cisco Integrated Services Router (ISR) platforms. The configuration presents a network scenario where implementation of this feature is likely. This document also provides TDM switching capability matrices for all voice modules and platforms.

Prerequisites

Requirements

On the Cisco 2800 and 3800 Series ISRs, you can use this feature with digital interface cards. Install the cards in either the high-speed WAN interface card (HWIC), extension voice module (EVM), or network module (NM) slots across the platform. On the Cisco 2600 and 3700 series routers, the digital interfaces that use the TDM switching feature must be on the same NM; on these routers, you cannot switch nonvoice traffic across a router backplane to a different NM.

Note: Cisco IOS Software does not necessarily support all features that some ISDN service providers provide. The information in this document is for basic call switching only, which includes ISDN speech or data calls between voice ports. Do not assume that there is support for any other supplementary ISDN feature.

Components Used

This document is not restricted to specific software and hardware versions. However, the information in this document was tested with these hardware and software versions:

- Cisco 2851 router

- Two-port E1 multiflex trunk interface voice WAN interface card (VWIC-2MFT-E1) that you have installed in HWIC slot 0

- Four-port digital voice/fax expansion module (EM-4BRI-NT/TE) that you have installed in the EVM-HD slot of the Cisco 2851

- A router that is loaded with Cisco IOS Software Release 12.3.11T2 IP Voice feature set

The information in this document was created from the devices in a specific lab environment. All of the devices used in this document started with a cleared (default) configuration. If your network is live, make sure that you understand the potential impact of any command.

Conventions

For more information on document conventions, refer to the [Cisco Technical Tips Conventions](#).

Background Information

The Cisco 2800 and 3800 series ISRs have enhanced TDM switching capabilities across the backplane of the router. On the Cisco 2600 and 3700 series routers, some NMs also have TDM switching capabilities, such as the NM-HD-2V, NM-HD-2VE, and NM-HDV2. These NMs can perform TDM switching if the call remains confined within the ports on a single NM and does not cross the backplane. This capability allows for the TDM switch of synchronous digital voice, video, and data bit streams between different ISDN interfaces on the router.

TDM switching allows the drop of the Digital Signal Processor (DSP) resources from the media path for the duration of the call. However, the provision of DSPs on the router for the initial call setup is a requirement. The switch of media occurs with a plain old telephone service (POTS)-to-POTS call hairpin, and the capability allows these types of call switching:

- PRI-to-PRI

- PRI-to-BRI

- BRI-to-PRI

- BRI-to-BRI

The ISDN data channel (D channel) for each interface processes locally inside Cisco IOS Software. The process uses the called numbers, or the Dialed Number Identification Service (DNIS), that are in the ISDN Q.931 setup message. Use of other POTS dial peers enable the match and route of the call.

Possible applications for this technique include:

- ISDN BRI dial-on-demand routing (DDR) tests

- The connection of BRI-based video conferencing units to PRI services

- The integration of BRI-based PBXs to PRI services

- BRI-to-PRI data call switching

TDM Features Configuration

While the ISDN TDM switching feature can switch any type of traffic, the main application for the feature is video traffic. This scenario, which was tested for this document, uses ISDN video endpoints for TDM switching.

The ISDN PRI to the ISDN network uses E1 interface 0/0/0 with the configuration of 10 B channels. The video endpoints use EM-4BRI-NT/TE BRI interfaces on an EVM-HD-8FXS/DID, slots 2/0/16, 2/0/17, and 2/0/18.

The EVM-HD has a 50-way amphenol Champ RJ-21 connector. The connector connects to a Black Box JPM2194A special patch panel. A male-to-female 50-way cable connects the EVM ports to the patch panel.

Note: For more information about the RJ-21 connector, refer to the document Cisco High-Density Analog and Digital Extension Module for Voice and Fax.

No special configuration for TDM switching is necessary. The setup uses the default Cisco IOS Software ISDN interfaces and a router platform that support this feature.

TDM Switching Capability of Interface Cards and Network Modules

There are two possibilities for the hairpin of an ISDN call on a router. The type depends on whether the call crosses the backplane of the router:

- Intramodule switching—TDM switching for an ISDN call that hairpins within the same VWIC or NM

- Intermodule switching—TDM switching for an ISDN call that hairpins between an NM, EVM, or HWIC interface

Intramodule TDM Switching Capability

Table 1 describes the intramodule TDM switching capability of the interface cards and NMs. Intramodule TDM switching applies to all Cisco 1700, 2600, 2800, 3600, 3700, and 3800 platforms that support the interface cards that the table lists.

Table 1: Intramodule TDM Switching Capability

17xx WIC	28xx HWIC	38xx HWIC	NM-1V/2V	NM-HDA	NM-HDV	AIM-[ATM]-VOICE-30	NM-HD-1V/2V/2VE	NM-HDV2	EVM
No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes

Intermodule TDM Switching Capability

With the enhanced ISDN TDM switching capability of the ISR platforms, the Cisco 2800 and 3800 series routers are able to switch ISDN voice, video, and data calls across the backplane. Table 2 describes the intermodule TDM switching capability of the interface cards and NMs for calls that hairpin between two slots. Intermodule TDM switching applies to all Cisco 2800 and 3800 platforms that support the interface cards that the table lists.

Table 2: Intermodule TDM Switching Capability

	28xx HWIC	38xx HWIC	NM-HDA	NM-HDV	NM-HD-1V/2V/2VE	NM-HDV2	EVM
28xx HWIC	Yes		No	No	Yes	Yes	Yes
38xx HWIC		Yes	No	No	Yes	Yes	Yes
NM-HDA			No	No	No	No	No
NM-HDV				No	No	No	No
NM-HD-1V/2V/2VE					Yes	Yes	Yes
NM-HDV2						Yes	Yes
EVM							Yes

System Clocking

You must set up correct system clocking in order to ensure that the voice, video, or data call traffic that passes on a B channel remains error-free. The example in this document derives the clock signal that comes in from the ISDN network on controller E1 0/0/0. The clock signal drives the router backplane and other digital voice ports on the router. If you do not set the system clocking correctly, the router sees regular clock slips. The clock slips are a result of differences in timing between the transmit and receive lines of the channelized interface. These clock slips cause data packets to register cyclic redundancy check (CRC) errors. If the error count is too high, the video stops, and many voice, video, or data calls simply fail.

These Cisco IOS commands handle the internal propagation of system clocking:

- **network-clock-participate slot 2 ß**—Adds the voice card in slot 2 to the clocking domain

- **network-clock-participate wic 0 ß**—Adds the voice card in HWIC slot 0 to the clocking domain

- **network-clock-select 1 E1 0/0/0 ß**—Sets port 0/0/0 as the external master clock source

The router synchronizes all ports in the clocking domain to the external clock source that comes in from the PRI port, controller E1 0/0/0. This synchronization ensures that all devices reference a common clock source.

Note: You must configure the **network-clock-participate** command for all digital ports that use the TDM switching feature. This configuration enables the common network clocking within the router.

Always assume that any connection to a telephone company (telco) or service provider has a more stable clock reference than the router internal oscillator. Use the external clock source as the master clock reference for the entire system.

BRI ports with configuration for ISDN User Side mode use external, or line, clocking. If you configure the BRI port for the Network Side mode, the port uses an internally generated clock reference. The router voice card or TDM backplane generates the clock reference in this case. You cannot change this behavior.

ISDN Network Side and User Side Operation

In this example, PRI port 0/0/0:15 connects to an external ISDN network. The example leaves the port as the default User Side operation. Configuration of the BRI ports is for Network Side operation for the video endpoints to connect directly.

There is support for Network Side operation for these ISDN Basic Rate and Primary Rate switch types:

- Net5

- Net3

- Q Signaling (QSIG)

- National ISDN (NI)

- 5ESS

- DMS100

For full BRI Network Side operation, the router voice ports must also act as Layer 2 network termination (NT) devices and supply line power. Refer to Configuring Network Side ISDN BRI Voice Interface Cards for more information.

The example uses ISDN switch type basic-net3 for the BRI ports that connect to the video endpoints. The configuration under the BRI interface differs when you select different switch types. The configuration within the video endpoints and BRI vary as well. For more information, refer to the endpoints vendor guides. Also, refer to these documents for ISDN BRI and PRI configuration information:

- *Configuring TEI Negotiation Timing* section of Configuring ISDN BRI

- *Overriding the Default TEI Value* section of Configuring ISDN PRI

Video Channel Bonding

The router is not aware of the traffic type, whether voice, video, or data, that passes via a TDM-switched connection. The router does not interpret the traffic and treats each B channel or time slot independently of all others. The delay that TDM switching incurs in the router is negligible, and the video units that connect to the ISDN interfaces are responsible for video channel bonding and synchronization.

Dial Plan Information

POTS dial peers handle the call switching between the different voice ports. The router first examines the called number in the Q.931 setup messages. The router then

matches the number on an outgoing dial peer and switches the call. Once the call connects, the DSPs are removed from the media stream. Then, an internal TDM connection between the ingress and egress B channels is made on the TDM bus within the router. To allow flexibility in the switching, the dial peers need the configuration of specific destination patterns to match the required dial plan. In this example, the dial plan is:

Voice port	Direction	Called Number Range	Description
Voice port 0/0/0:15	Router to network	0T	Outward dial toward network, 0 stripped
Voice port 2/0/16	Router to ISDN video endpoint 1	9884250 [0-9]	ISDN video endpoint 1 number range
Voice port 2/0/17	Router to ISDN video endpoint 2	9884250 [0-9]	ISDN video endpoint 2 number range
Voice port 2/0/18	Router to ISDN video endpoint 3	9884250 [0-9]	ISDN video endpoint 3 number range

Support for Voice and Data Bearer Capability

The Bearer Capability field in the Q.931 setup message differentiates the ISDN call types. This field allows the sending and receiving device to determine if the call is either one of these:

- Voice/speech, with a-law or μ-law coding

- A data call with an unrestricted 64 K digital bit stream

Because of the removal of DSPs from the ingress and egress B channel after the TDM connection, there is a fully synchronous connection between the connected time slots. This connection allows for the switch of ISDN data calls with no impact on the actual data bit stream. Cisco IOS Software does not distinguish between data and voice bearer capabilities when the calls are switched internally on the TDM bus. This allows a basic ISDN service emulation.

Gateway Sample Configuration with TDM Features

This section provides the configuration of the voice gateway scenario that appears in TDM Features Configuration.

Note: Notice the TDM configurations in the router configuration.

ISR Gateway Configuration

```
!--- Output suppressed.

network-clock-participate slot 2
network-clock-participate wic 0
network-clock-select 1 E1 0/0/0
```

```
controller E1 0/0/0
  pri-group timeslots 1-10,16

interface GigabitEthernet0/1
  ip address 10.1.1.1 255.255.255.0
  duplex full
  speed 100

interface Serial0/0/0:15
  no ip address
  isdn switch-type primary-net5
  isdn incoming-voice voice
  isdn calling-number 98842500
  no cdp enable

interface BRI2/0
  no ip address
  isdn switch-type basic-net3
  isdn protocol-emulate network
  isdn tei-negotiation first-call
  isdn layer1-emulate network
  isdn incoming-voice voice
  isdn skipsend-idverify
  line-power

interface BRI2/1
  no ip address
  isdn switch-type basic-net3
  isdn protocol-emulate network
  isdn tei-negotiation first-call
  isdn layer1-emulate network
  isdn incoming-voice voice
  isdn skipsend-idverify
  line-power

interface BRI2/2
  no ip address
  isdn switch-type basic-net3
  isdn protocol-emulate network
  isdn tei-negotiation first-call
  isdn layer1-emulate network
  isdn incoming-voice voice
  isdn skipsend-idverify
  line-power

interface BRI2/3
  no ip address
  isdn switch-type basic-net3
  isdn protocol-emulate network
  isdn tei-negotiation first-call
```

```
  isdn layer1-emulate network
  isdn incoming-voice voice
  isdn skipsend-idverify
  line-power

voice-port 0/0/0:15
  cptone AU

voice-port 2/0/16
  description - corresponds to int BRI 2/0
  compand-type a-law

voice-port 2/0/17
  description - corresponds to int BRI 2/1
  compand-type a-law

voice-port 2/0/18
  description - corresponds to int BRI 2/2
  compand-type a-law

voice-port 2/0/19
 description - corresponds to int BRI 2/3
 compand-type a-law

dial-peer voice 1 pots
  description - enable DID on PRI voice port 0/0/0:15
  incoming called-number .
  direct-inward-dial
  port 0/0/0:15

dial-peer voice 2 pots
  description - enable DID on BRI voice port 2/0/16
  incoming called-number .
  direct-inward-dial
  port 2/0/16

dial-peer voice 3 pots
  description - enable DID on BRI voice port 2/0/17
  incoming called-number .
  direct-inward-dial
  port 2/0/17

dial-peer voice 4 pots
  description - enable DID on BRI voice port 2/0/18
  incoming called-number .
  direct-inward-dial
  port 2/0/18

dial-peer voice 10 pots
  description - outwards call to BRI voice port 2/0/16
  preference 1
```

```
    destination-pattern 9884250[0-9]
    port 2/0/16
    forward-digits all

dial-peer voice 11 pots
    description - outwards call to BRI voice port 2/0/17
    preference 2
    destination-pattern 9884250[0-9]
    port 2/0/17
    forward-digits all

dial-peer voice 12 pots
    description - outwards call to BRI voice port 2/0/18
    preference 3
    destination-pattern 9884250[0-9]
    port 2/0/18
    forward-digits all

dial-peer voice 20 pots
    description - outgoing calls towards PRI. Leading 0 access code is
 stripped off.
    destination-pattern 0
port 0/0/0:15

!--- Output suppressed.
```

Verify

In order to confirm that an ISDN interface has a connection to a downstream device, issue the command **show isdn status**. The output for this command displays the status of all ISDN interfaces.

Note: Certain **show** commands are supported by the Output Interpreter Tool (registered customers only) , which allows you to view an analysis of **show** command output.

```
Gateway# show isdn status serial 0/0/0:15

Global ISDN Switchtype = primary-net5
ISDN Serial0/0/0:15 interface
dsl 0, interface ISDN Switchtype = primary-net5
Layer 1 Status:
ACTIVE
Layer 2 Status:
TEI = 0, Ces = 1, SAPI = 0, State = MULTIPLE_FRAME_ESTABLISHED
Layer 3 Status:
0 Active Layer 3 Call(s)
Active dsl 0 CCBs = 0
The Free Channel Mask: 0xFFFF7FFF
Number of L2 Discards = 0, L2 Session ID = 1
Total Allocated ISDN CCBs = 0
Gateway#
```

The Layer 2 status `MULTIPLE _FRAME_ESTABLISHED` indicates that there is correct framing between the terminal equipment (TE) device and the NT device. The TE device is the User Side device, and the NT device is the Network Side device. In this case, the controller E1 0/0/1 is set to the default User Side ISDN mode of operation.

Note: The earlier configurations defined controller E1 0/0/1.

```
Gateway# show isdn status serial 0/0/1:15

Global ISDN Switchtype = primary-net5
ISDN Serial0/0/1:15 interface
******* Network side configuration *******
dsl 0, interface ISDN Switchtype = primary-net5
Layer 1 Status:
ACTIVE
Layer 2 Status:
TEI = 0, Ces = 1, SAPI = 0, State = MULTIPLE_FRAME_ESTABLISHED
Layer 3 Status:
0 Active Layer 3 Call(s)
Active dsl 0 CCBs = 0
The Free Channel Mask: 0xFFFF7FFF
Number of L2 Discards = 0, L2 Session ID = 48
Total Allocated ISDN CCBs = 0
Gateway#
```

In this case, the controller E1 0/0/1 is set to the ISDN Network Side mode of operation. This example is for illustration only. An E1 0/0/1 interface does not exist in the configuration in this document.

Troubleshoot

Issue the **debug isdn q931** command. This command confirms that the called number in the ISDN Setup message matches the configured destination pattern on the relevant outgoing POTS dial peer.

Note: Before issuing **debug** commands, refer to Important Information on Debug Commands .

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