OpenCon Systems, Inc.
WORLDWIDE COMMUNICATION SOLUTIONS

GR-303 Solution
For
Access Gateways

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1. Overview

Since 1970s, Digital Loop Carrier (DLC) systems have been extensively used by Service Providers in delivering a reliable, robust and high quality voice service to their customers. DLC systems are primarily designed to deliver narrowband services such as voice and low bit-rate data and are not suitable as a delivery platform for high bandwidth services such as data and video. The deregulation action of 1996 and explosive growth of internet traffic in 1990s provided the impetus for service providers to examine alternate technologies that can be used to deliver voice, video and data over the same access transport.

The first generation integrated access systems served as a platform for delivering voice, data and video services over multiple T1/E1 lines and in some cases over OC-3 fiber link. The first generation integrated systems were primarily based on TDM technology and therefore were not so efficient in transporting packet traffic. Access gateways are designed to not only address bandwidth inefficiencies involved in transporting packet traffic but also serve as an conduit into PSTN for voice/video traffic carried over variety of access transport technologies such as xDSL, ATM over Passive Optical Network (APON), Ethernet over PON (EPON), Wireless Local Loop (WLL) and Cable networks. Although the buzz words associated with such access platforms are broad-band and multimedia, however, from a service provider point of view, unless the platform can be integrated with the existing network assets to deliver voice services in a cost effective manner, it cannot be considered for a large scale deployment. In this white paper, we will examine how Telcordia’s GR-303 plays an important role in transporting voice traffic through these type of access gateways and how GR303 enables a brand access platform to effectively provide voice service through the existing switches owned by the service providers.

2. Digital Loop Carrier Systems

In the 1960s, telephony service was provided to the subscribers by a pair of copper wires (commonly referred to as subscriber loops). These copper wires connected the subscribers' phones directly with a class 5 switch located in the central office. Analog transmission techniques were used to transmit signals between the phone and the switch. Figure 1, illustrates an analog subscriber loop network. There were number of problems associated with this technology- distance limitation and interference from atmospheric noise and other sources of noise affected quality of voice services tremendously. As such, analog subscriber loops were difficult to maintain and quality of voice signals could not always be assured. In spite of all these problems, analog subscriber loops are still in use, even though they have been mostly replaced by digital loop carrier systems and other alternate loop technologies.

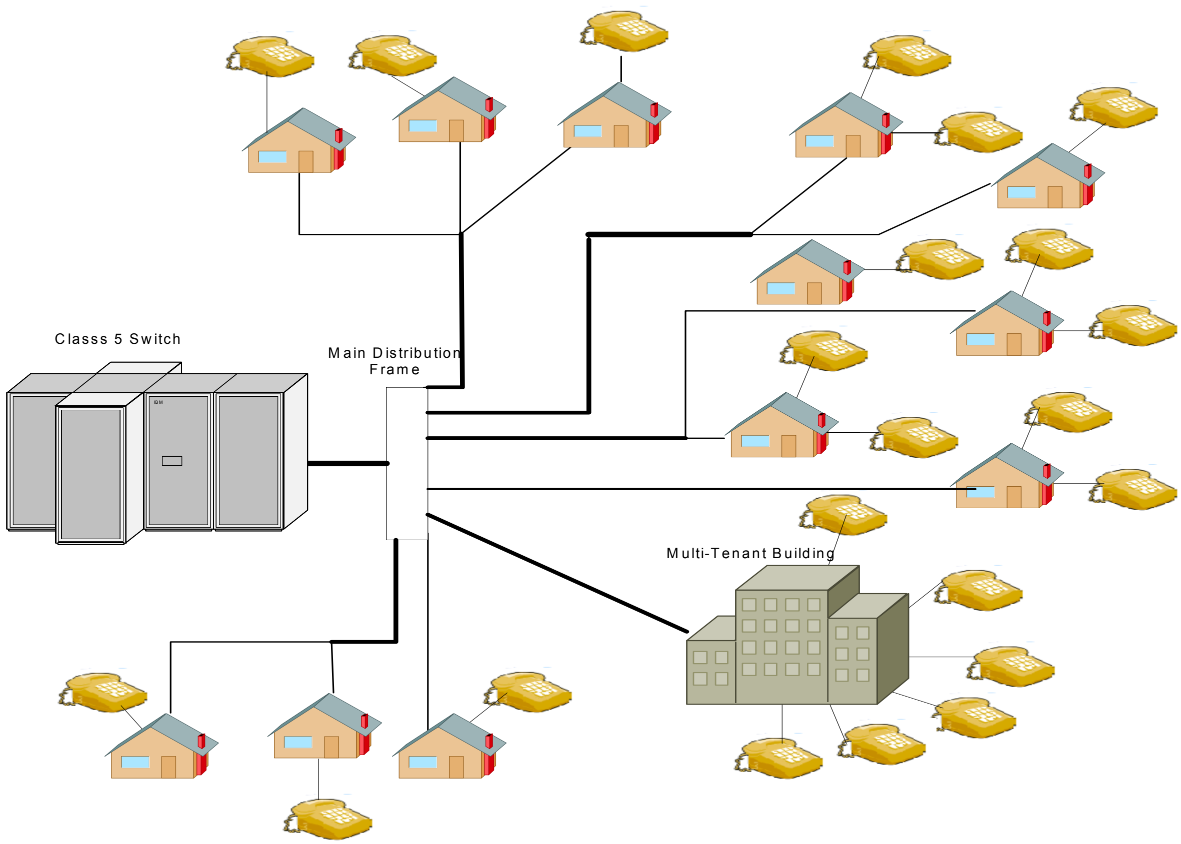

Figure 1: Analog Subscriber Loop

Early attempts to address the problems associated with analog loop carrier systems were focused mainly on increasing the distance between the switch and subscriber and to improve the quality of signals transmitted over the subscriber loops. The first generation digital loop carrier systems, also known as Universal Digital Loop Carrier Systems (UDLC), were based on a network architecture that included two new network elements: Remote Terminal (RT) and Central Office Terminal (COT). RT, also known as Remote Subscriber Terminal, was placed in the subscriber neighborhood and typically served between 24 to 96 subscribers. Subscribers were connected to the RT using a pair of copper wires for each telephone connection. COT was placed close to the switch in a central office and was connected to the switch using (analog) copper wires, one pair for each subscriber's telephone line. Digital transmission lines (T1 lines) were used to connect the RT and COT together. By using T1 lines between RT and COT service providers were able to extend the limits of the serving area of the switch located in the central office without affecting the quality of the signals transmitted between the switch and subscriber's telephone.

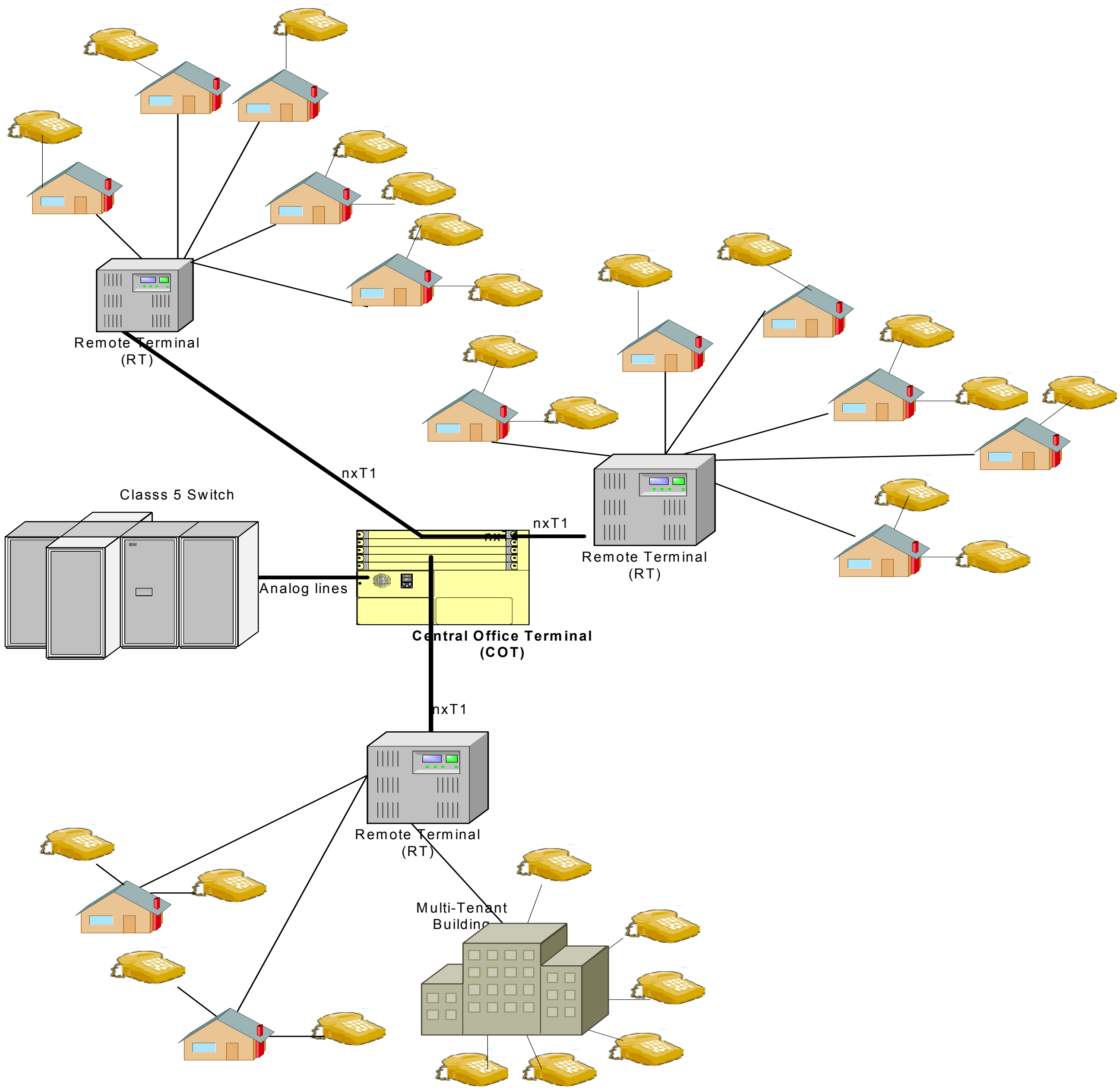

Figure 2: Universal Digital Loop Carrier System

UDLC systems have evolved into what are now known as Integrated Digital Loop Carrier (IDLC) Systems. In an IDLC system, the Remote Terminals are directly connected to the switch through nxT1 or OC-3 lines. IDLC systems eliminated the need for COT systems in central office and thereby providing substantial cost and space savings to the service providers. IDLC systems also allowed service providers to roll out new services such as Digital Data Service (DDS) and ISDN, providing new sources of revenues. Telcordia's TR-008 and TR-057 standards define the interface specification for IDLC systems.

IDLC systems required fixed time-slots to be provisioned on the T1 lines from RT to the switch, for each customer. By assigning fixed time-slots capacity of the T1 lines was not fully utilized, especially when the lines are idle. . The Next Generation DLC (NGDLC) addressed this issue by dynamically assigning a time-slot to a subscriber and reassigning the same time-slot to a different subscriber after the first subscriber completes his call. The NGDLC systems also provided the capability to remotely configure and monitor the operation of remote terminals.

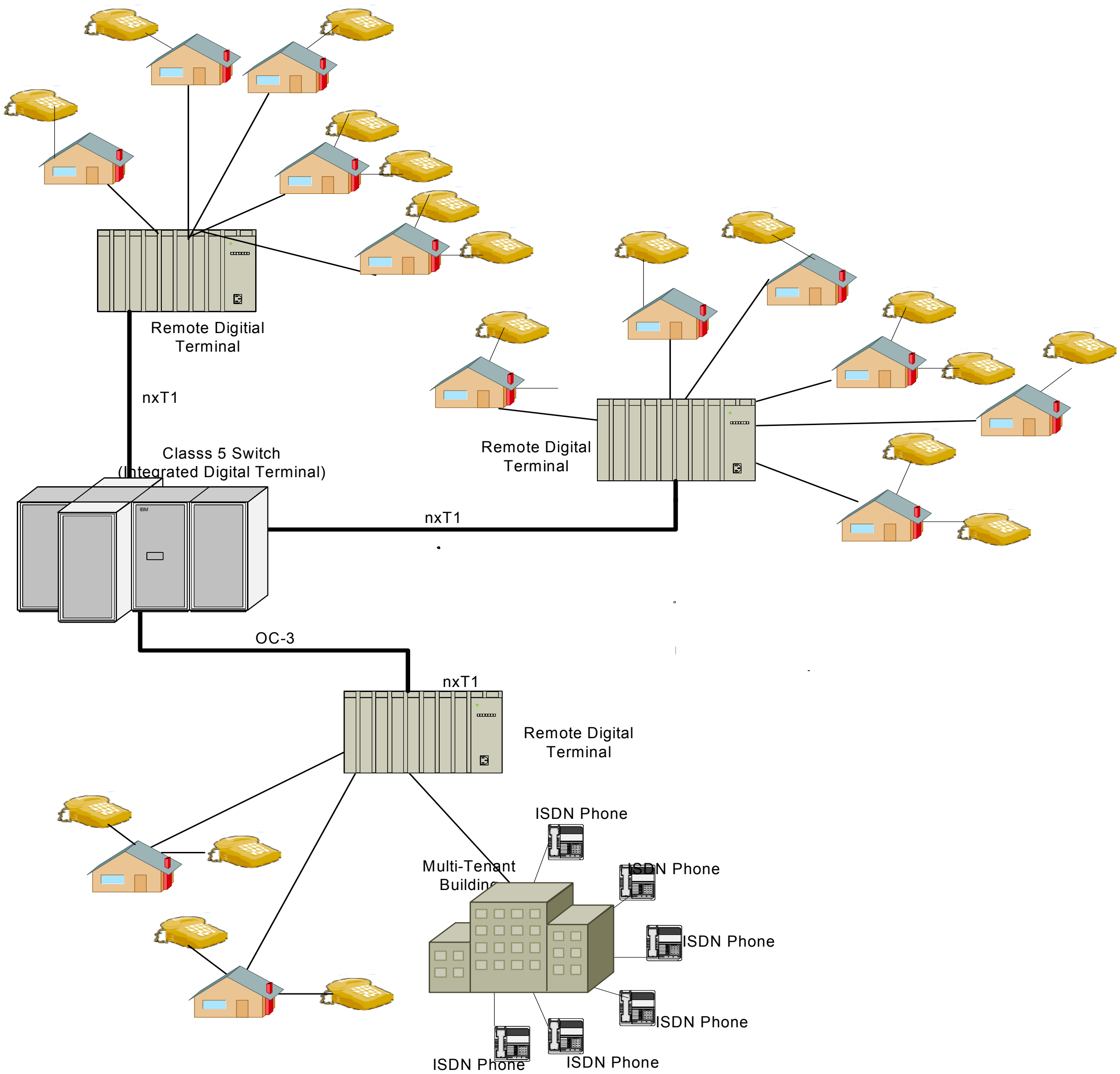

Figure 3: NextGen Integrated Digital Carrier Loop Systems

Next Generation IDLC systems include two main elements: Remote Digital Terminal (RDT) and Integrated Digital Terminal (IDT). RDT is located closer to subscriber premise and delivers services to subscribers over POTS, T1/E1 or ISDN lines. IDT is an integral component of the switch and interacts with the RDT to support dynamic time-slot assignment and remote provisioning. RDT and IDT are connected together by T1 lines or OC-3 fiber connections. Telcordia's GR-303 standard defines interface specification (physical layer as well as application layers) between IDT and RDT. Dynamic time-slot assignment capability defined by GR-303 allows up to 2048 subscribers to be served by group of T1 trunks with an aggregate capacity of 672 timeslots. That is roughly about 4:1 oversubscription. The group of trunks serving a set of subscribers is called an Interface Group (IG). Each IG can serve a maximum of 2048 subscribers. An RDT can be configured to support multiple interface groups (multi-IG). Each interface group in the multi-IG collection can be logically connected to the same switch or to different switches. Multi-IG feature provides the flexibility to connect subscribers from the same location to different switches.

3. Access Gateways

Integrated access systems were first developed to address the needs of large corporations which wanted to use leased lines (nxT1 or OC-3) to transport voice, video and data traffic between their corporate head quarters and branch offices. Figure 4 illustrates a network deployment using integrated access systems. First generation integrated access systems used channelized T1/T3 links to transport voice, data and video traffic between them and required bandwidth (i.e., time-slots) to be assigned statically for each type of traffic. Even though these types of systems enabled corporations to reduce their communications related expenses significantly, utilization of the available bandwidth between the corporate locations was very poor. Increase in voice and data traffic between the office locations forced corporations to lease additional trunk lines and thereby slowly erasing the cost savings achieved by deployed of integrated access systems. Packet-based technology was later incorporated into these systems to transport for voice, data and video traffic over the trunk lines and achieve better utilization of available bandwidth.

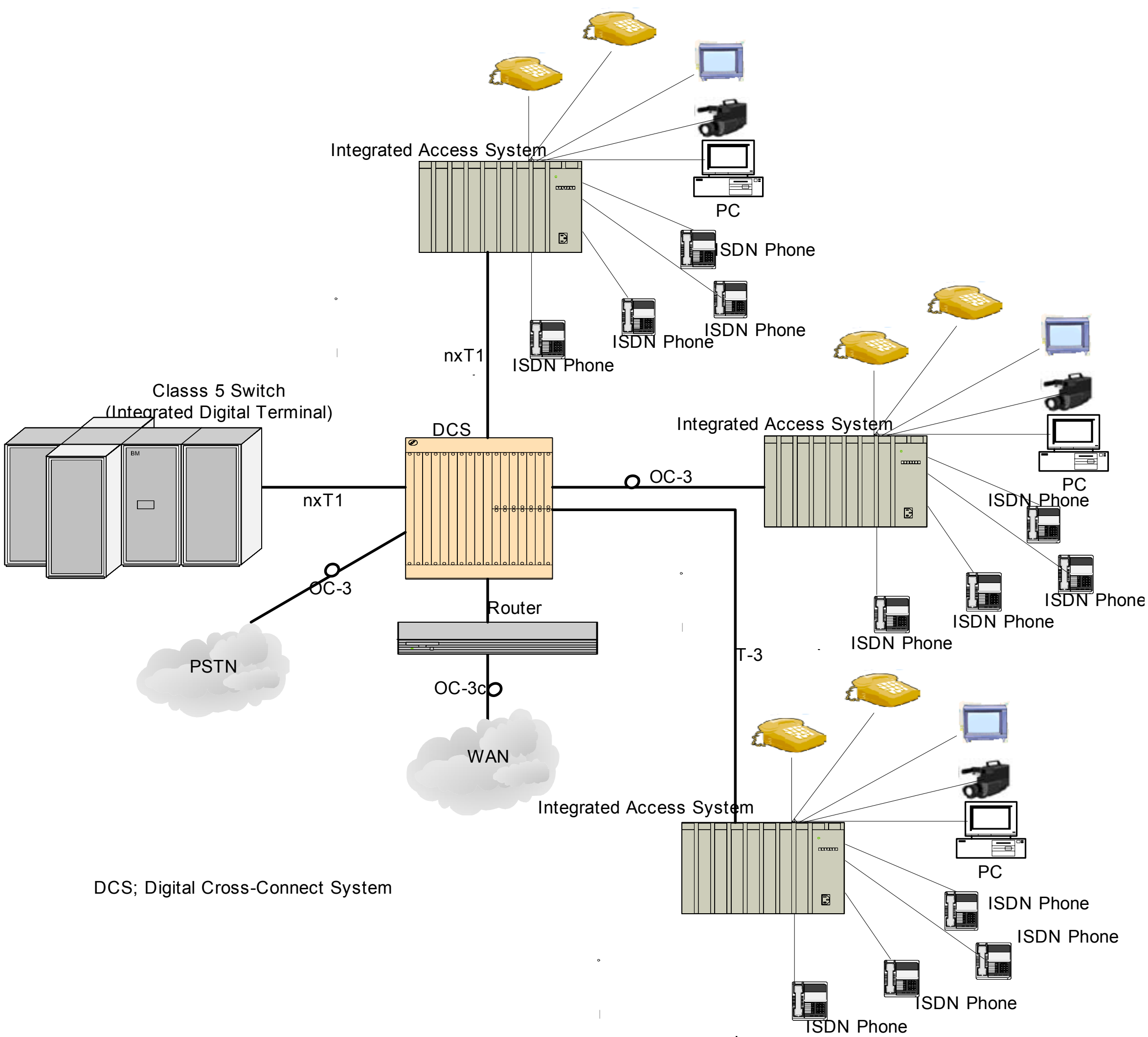

Figure 4: Integrated Access Systems

Even though the integrated access systems were first developed to address the needs of business customers, the concept of delivering multiple services over the same physical transport media was used to build access gateway platforms for residential customers. Access gateways are now available to support wide variety of access transport technologies such as xDSL, Cable, WLL and xPON. The primary objective of these access gateways is to provide high bandwidth internet access and deliver high quality voice services. Depending on the access transport technologies, some of these gateways also deliver video services such as live TV and video-on-demand.

The following three applications are selected to describe how GR-303 is used to deliver voice services through the access gateways:

- Voice Over xDSL (VoxDSL)
- Voice over Cable (VoCable)
- Voice over xPON (VoxPON)

An access gateway can be implemented as a stand-alone device or an add-on card for a given access platform. However, for the sake of easy understanding, in the following paragraphs, only the stand-alone access gateways (VoxDSL, VoCable, or VoxPON) are presented.

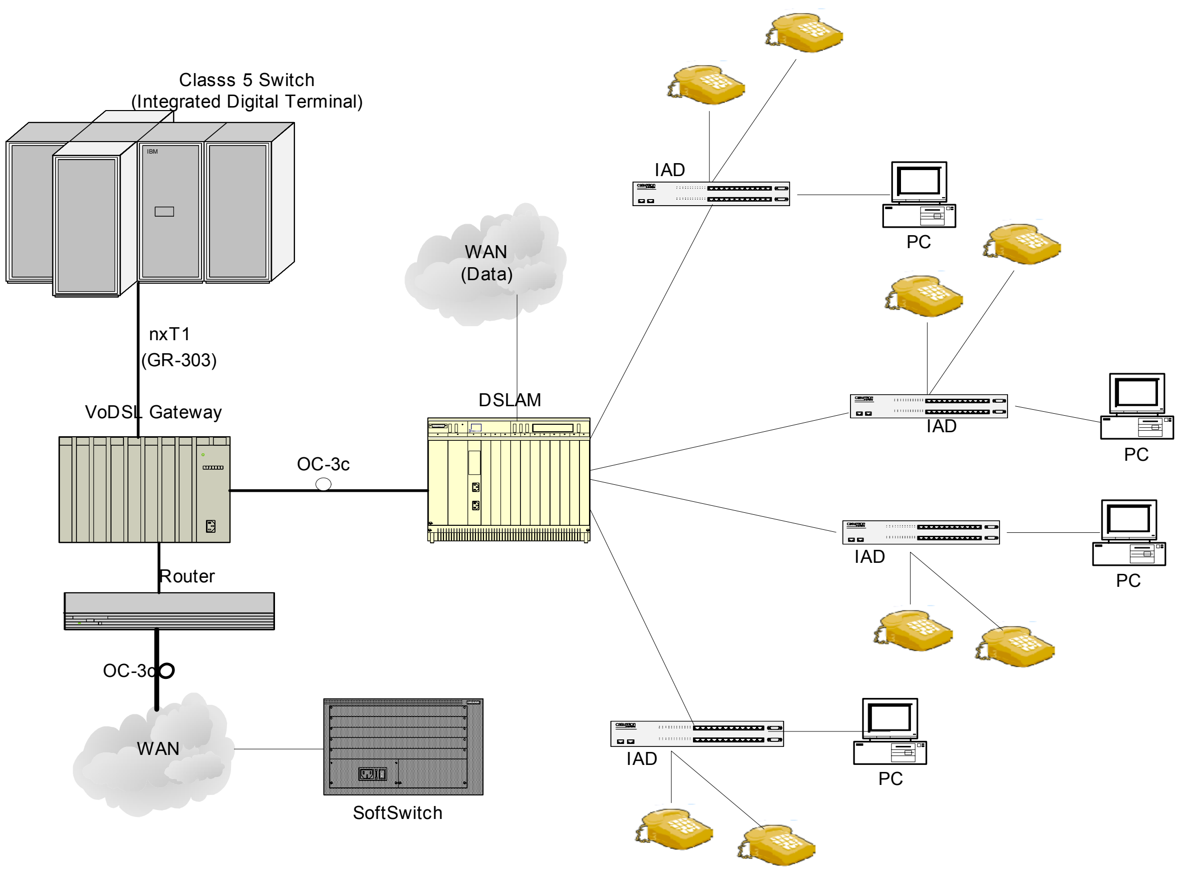

Figure 5: Voice Over xDSL Application

Figure 5 illustrates network configuration used in a voice over xDSL application. An Integrated Access Device (IAD) located in customer premise provides connections to telephones for voice traffic and PC for data traffic. Voice and data traffic from IAD are transported over xDSL lines to DSLAM where the voice and data traffic are separated and voice traffic is transported over an OC-3c link to a VoDSL gateway. The VoDSL gateway is an access platform, which can direct the voice traffic to PSTN network or to VoIP network. Communication for VoxDSL gateway and PSTN switch conforms to GR-303 standard.

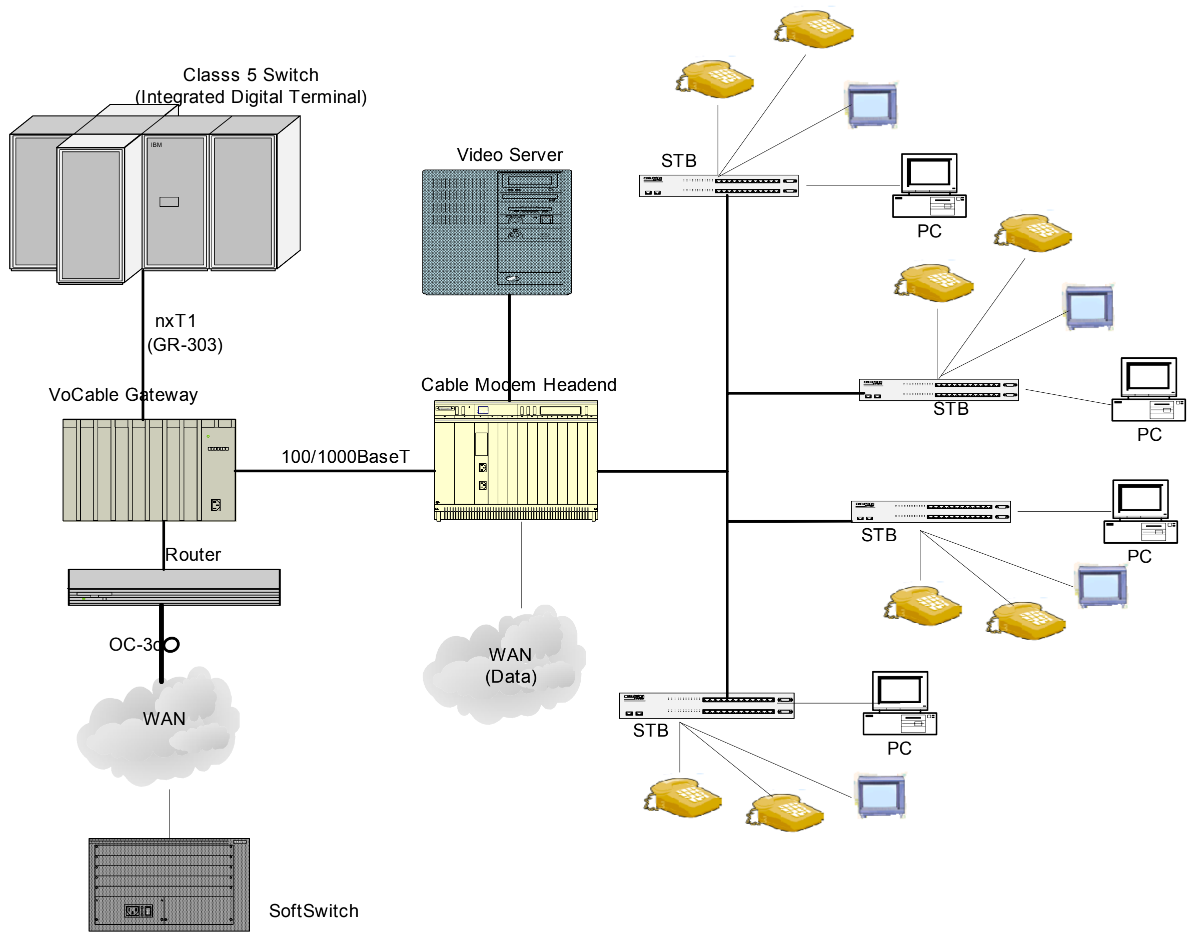

Figure 6: Voice Over Cable Application

Figure 6, illustrates network configuration used in a voice over cable application. A Set Top Box (STB) located in customer premise provides connections to TV, telephones and PC. It is assumed that the STB has built-in modem for data communications. Otherwise, an external cable modem would be required for data traffic. Voice and data traffic from STB are transported to cable modem termination headend where the voice and data traffic are separated and voice traffic is transported over a 100/1000BaseT link to voice over cable gateway[1]. Voice traffic from subscribers is transported in packet form is converted by VoCable gateway into TDM stream and sent to class 5 switch. VoCable gateway uses GR-303 for communication with the PSTN switch. Video services are typically delivered from a video server located near the cable modem termination headend.

Figure 7 illustrates network configuration used in a voice over EPON/APON application. In Fiber to the home (FTTH) architecture, an Optical Network Termination (ONT) is used in customer premise to deliver voice, data and video services. In the Fiber-to-the-curb (FTTC) architecture, an Optical Network Unit (ONU) is located close to customer location and services are delivered to customer premises over copper wire using VDSL technology. A Set Top Box (STB) is required inside customer premise to provide connections to TV, telephones and PC. Voice and data traffic from ONT or STB are transported to Optical Line Termination (OLT) unit where the voice and data traffic are separated and voice traffic is transported over an OC-3c link to voice over xPON gateway located in the central office. Voice Over xPON gateway uses GR-303 interface to

[1] If Cable Modem Termination Headend and Voice over Cable Gateway are not co-located then a WAN link such as T1/T3 or OC-3c should be used to connect them together.

communicate with a class 5 Switch.

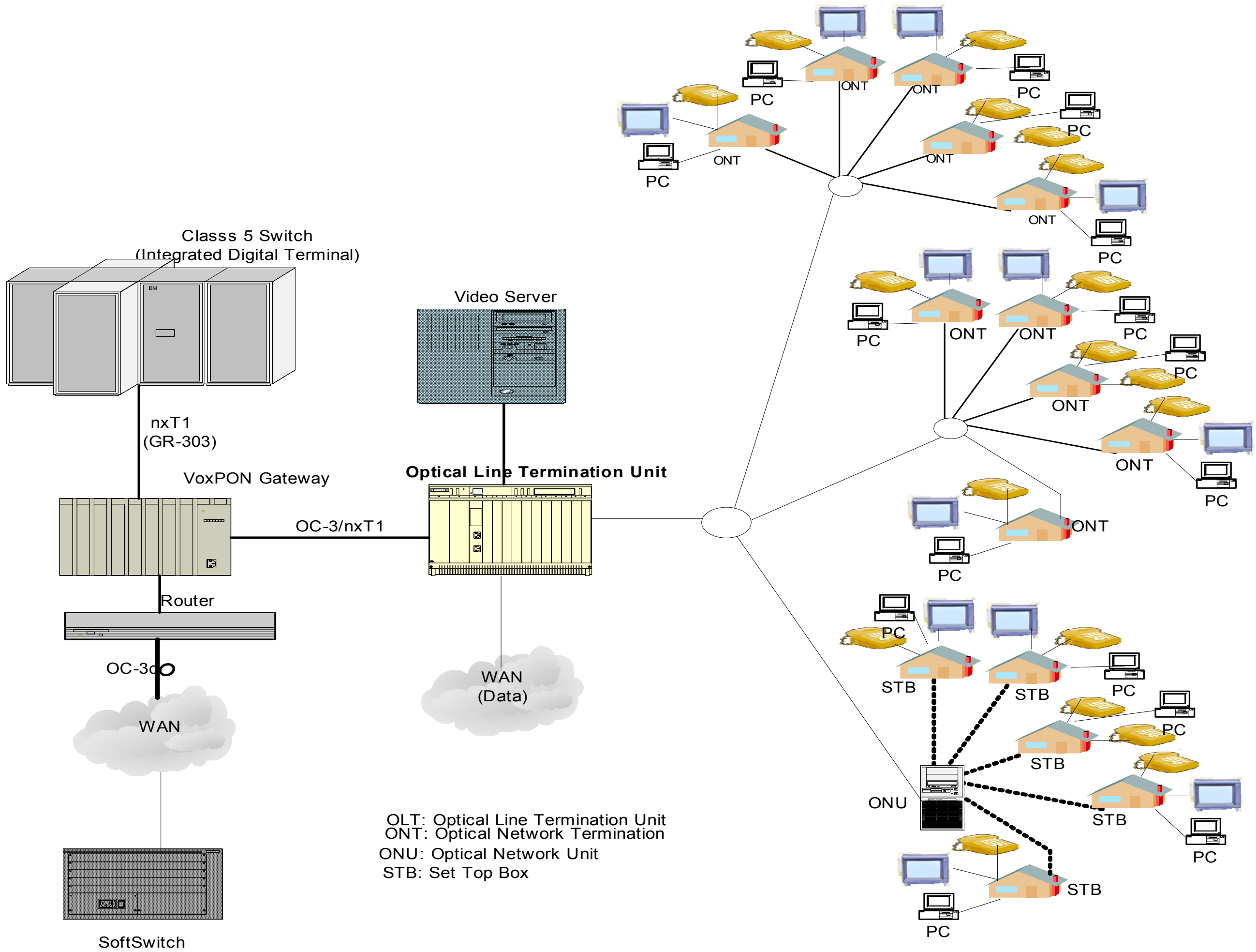

Figure 7: Voice Over xPON Gateway Application

4. GR-303 Overview

Telcordia's GR-303 standard specifies signaling, performance monitoring, alarm surveillance, provisioning and testing requirements to ensure connectivity and consistency in operations between IDT and RDT from different equipment vendors. For each Interface Group, the number of DS1 lines connecting RDT and IDT (which is a logical part of Local Digital Switch) could be from 2 to 28. GR-303 specification defines two message-based channels (TMC and EOC) for exchanging signaling and operational information between RDT and IDT. To protect against physical or logical link failures, each of these two message channels have a standby channel configured on physically separate T1 line. Both TMC and EOC use LAPD protocol (CCITT Q.920/Q.921) at the data link layer.

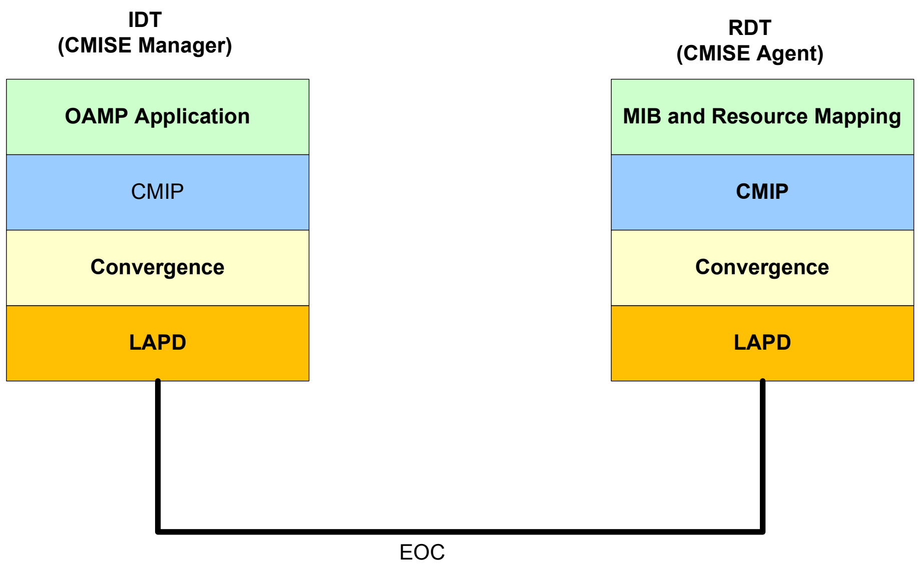

Figure 8: GR-303 EOC Protocol Stack

EOC is used by RDT and IDT to manage GR-303 related services and assets located in RDT. Time-Slot Management Channel (TMC) is based on Q.931 protocol and is used for dynamic assignment of DS1 facility timeslot to a subscriber circuit during the call setup phase, and for the timeslot release after the call is terminated.

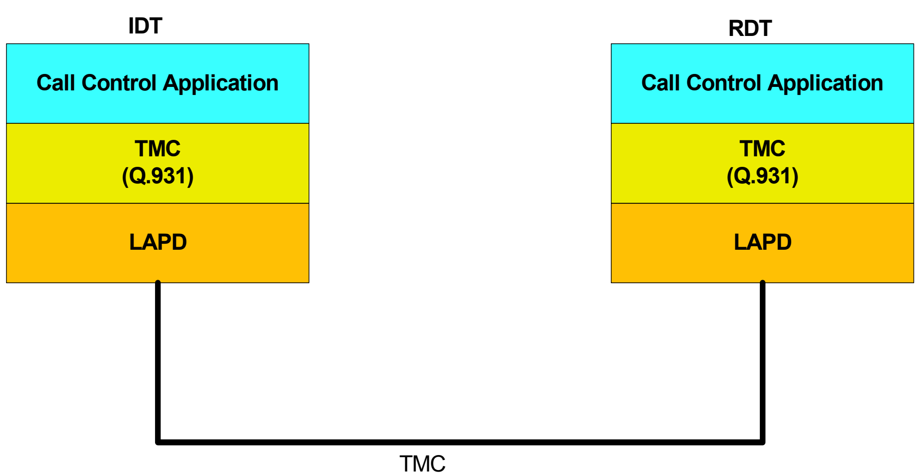

Figure 9: GR-303 TMC Protocol Stack

Figure 8 and Figure 9 illustrate the GR-303 EOC and TMC protocol stack components respectively. To protect against service disruptions due to EOC or TMC link failures, GR-303 defines a Path Protection Switching (PPS) protocol which is supported by both RDT and IDT systems. PPS protocol messages are exchanged between IDT and RDT to switch over from a failed active EOC (or TMC) link to standby EOC (or TMC) link. Since call control information is carried over TMC link, GR-303 standards requires the switching from active to standby link to be completed in a very short period of time. GR-303 also requires RDTs to support a card level redundancy to preserve the state of the calls that are in-progress when card level failure occurs in RDT or IDT. This requirement implies that the active TMC card is protected by a standby TMC card.The standby TMC card must synchronize the state of its call control protocol engine with the active card and be in a ready state to take over the call control functions when the active TMC card fails.

According to GR-303 specification, the maximum number of subscriber lines within an Interface Group (IG) is limited to 2048. To enable a class 5 switch to support large number of subscribers, GR-303 defines a concept called mult-IG. The multi-IG concept can be used by RDT to support large number of subscribers or it can be used by RDT to connect to multiple switches at the same time. Each IG within a multi-IG group has its own EOC and TMC channels and therefore can operate independently with only one restriction- i.e., a subscriber line cannot be attached to more than 1 IG.

5. OCS-303 Product Overview

The OCS-303 product is a software package that can be used to quickly implement GR-303 interface on an access gateway. The OCS-303 software package conforms to all EOC and TMC requirements of the GR-303 standards. OCS-303 package enables customers to focus mainly on equipment specific application software development and not spend their time and effort in developing GR-303 protocol software. The following is a list of features OCS-303 product provides:

- Support for EOC management interface and TMC call processing requirements - compliant with GR-303, ATT 5ESS, Nortel DMS SuperNode and Siemens EWSD switch specifications
- LAPD, Convergence, ROSE, CMIS and TMC protocols
- EOC and TMC Path Protection Switch
- Card level redundancy for TMC and EOC modules
- Performance Monitoring
- Alarms and Event Reports
- Implements MIB for POTS, ISDN and DS1 Line provisioning, DS1 and Path Protection Switch, PM and Channel Testing

The OCS-303 product consists of two major components: 303 Kernel and 303 Interface library. The 303 kernel implements essential functionality of EOC and TMC protocols of GR-303 interface, whereas the 303 library provides a generic development framework that minimizes the effort involved in porting of the OCS-303 software package into vendor-specific environment. The 303 Interface library serves as an API between the user code and the 303 Kernel and consists of a set of functions and data structures grouped by the functionality they provide. Each such group of API functions/data structures is called "Portal". For further details about the OCS-303 package, please refer to the data sheet , the user manual or access OCS WEB page: www.opencon.com.

6. References

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2. GR-8-CORE, *Digital Interface between the SLC-96 and a Local Digital Switch (formerly known as TR-008 standard)*-Telcordia October 2001.
3. GR-57-CORE, *Functional Criteria for Digital Loop Carrier (DLC) Systems (formerly known as TR-57)*-Telcordia October 2001.
4. AF-VMOA-00145, *Broadband Loop Emulation Services*, ATM Forum.
5. G.983.1, *Broadband Optical Access Systems based on Passive Optical Networks,* ITU October 1998.
6. *DOCSIS-2.0 Interface Specifications*, Cable Labs.

7. Abbreviations

APON	ATM over Passive Optical Networks
ATM	Asynchronous Transfer Mode
CMISE	Common Management Information Service Element
CMIP	Common Management Information Protocol
CO	Central Office
COT	Central Office Terminal
DLC	Digital Loop Carrier
DS0	Digital Signal 0 (64Kbps)
DS1	Digital Signal 1 (1.54Mbps)
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexer
EOC	Embedded Operations Channel
EPON	Ethernet Over PON
FTTB	Fiber To The Building
FTTC	Fiber To The Curb
FTTH	Fiber To The Home
HDLC	High Level Data Link Control
IAD	Integrated Access Device
IDLC	Integrated Digital Loop Carrier
IDT	Integrated Digital Terminal
IG	Interface Group
IP	Internetwork Protocol
ISDN	Integrated Services Digital Network
LAN	Local Area Network
LAPB	Link Access Procedure B-Channel
LAPD	Link-Access Procedure D-Channel
MDF	Main Distribution Frame
MDU	Multi-Dwelling Unit
MIB	Management Information Base
MTB	Multi-Tenant Building
NE	Network Element
NGDLC	Next Generation Digital Loop Carrier
OLT	Optical Line Termination
ONT	Optical Network Termination
ONU	Optical Network Unit
OC-x	Optical Carrier-x
OS	Operations System
OSS	Operations Support System
OSI	Open System Interface
PDU	Packet Data Unit
PON	Passive Optical Network
PPS	Path Protection Switching
RDT	Remote Digital Terminal
RFC	Request For Comment
ROSE	Remote Operations Service Element
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Network
STB	Set Top Box
STS-1	Synchronous Transport Signal-1
TCP	Transmission Control Protocol
TDM	Time Division Multiplexing
UDLC	Universal Digital Loop Carrier
VDSL	Very high bit-rate DSL
WLL	Wireless Local Loop

WAN	Wide Area Network