CISCO CERTIFIED CCDE DESIGN

CCDE Practical Studies

Practice Lab Exam 2 – "Diamond TV"

Full Practice Lab Examination & Debrief

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About the Author

Martin J Duggan CCDE™ 2016::6 and CCIE™ #7942 is a Senior Network Architect and Cisco Press author. Martin gained his CCIE™ in 2001 and has been passionate about Cisco qualifications and mentoring ever since. Martin successfully passed his CCDE™ practical in 2016.

Previous Publications include:

Author of CCDE Practical Studies, Practice Lab 1
https://leanpub.com/ccdepracticalstudies-practicelab1

Author of Cisco CCIE Routing and Switching v5.0 Configuration Practice Labs ISBN-10: 0-13-378631-5
http://www.ciscopress.com/store/cisco-ccie-routing-and-switching-v5.0-configuration-9780133786316

Author of Cisco CCIE Routing and Switching v5.0 Troubleshooting Configuration Practice Labs ISBN-10: 0-13-378633-1 http://www.ciscopress.com/store/cisco-ccie-routing-and-switching-v5.0-troubleshooting-9780133786330

Co Author of CCIE Routing and Switching Practical Studies ISBN: 1587051478 (Ciscopress)
http://www.ciscopress.com/title/1587051478

Technical Editor of Cisco Field Manual, Catalyst Switch Configuration ISBN:1587050439 (Ciscopress)
http://www.ciscopress.com/title/1587050439

Want to know more about Martin's journey to CCDE™?

https://learningnetwork.cisco.com/blogs/unleashing-ccde/2016/06/17/60-limit-by-martin-duggan

Want to know more about Martin's CCIE book?

http://www.gocertify.com/articles/interview-martin-duggan-author-of-ccie-routing-and-switching-v5-0-configuration-practice-labs.html

Technical Editors

Nicholas (Nick) Russo, CCDE #20160041, CCIE #42518, holds active CCIE certifications in both Routing and Switching and Service Provider. Nick served 6 years in the US Marine Corps, many of which were in a technical networking capacity, then went on to become a professional network engineer as a civilian. Nick also holds a Bachelor's of Science in Computer Science, and a minor in International Relations, from the Rochester Institute of Technology (RIT). Nick lives in Maryland, USA with his wife, Carla, and their daughter, Olivia.

Kim Pedersen, CCIE #29189, CCDE 2017:0021, is a network engineer at Lytzen IT A/S, where he focuses on network design and the maintenance and development of international MPLS networks. He has a passion for learning new technical topics and is an avid reader of all things networking. He lives in Denmark with his wife and enjoys travelling!

Malcolm Booden, CCDE #20170037 has been working in the IT industry since 2003. Upon graduation from Napier University in Edinburgh, Scotland with a BSc Network Computing degree Malcolm worked as an IT Support Engineer between 2003 - 2007 in the enterprise space, before moving into network administration at a UK construction company. Since 2009 Malcolm has operated as a Network Engineer, Consultant and Architect for VARs, ISPs and global outsourcing companies where he was regarded as a subject matter expert on LAN, WAN, Security, Wireless and DC technology. Malcolm holds an active CCDE, along with several Cisco professional and specialist certifications. Malcolm lives in Edinburgh, Scotland with his wife and young family and operates as a network consultant globally to various organisations in different verticals

Cristian Sirbu, CCIE #43453, is a network engineer, trainer, and community builder with a particular interest in design/architecture, automation, and solving business problems with technology. He's been in the industry for a while, building, breaking, and fixing networks of various sorts and sizes, while also having fun with a bit of coding and system administration. He currently lives in Dublin, Ireland, working as a consulting network architect advising customers across the country.

About the Book

This book is the second part of a 3 part series. I intended to release a single publication which included 3 complete CCDE practice lab exams and full debriefs for each but quickly realized that I could help CCDE candidates approaching their lab examinations if I released a lab at a time. Once all 3 lab exams have been completed I will release a bundled publication and include additional hints, tips and background information on the CCDE exam. These practice labs are the culmination of my journey towards CCDE and the thousands of hours of study I undertook in order to be successful.

Taking the CCDE lab exam was a real challenge for me, personally I found it significantly harder than achieving my CCIE back in 2001. The certification has been running for some 9 years at time of writing and there are only approximately 350 certified individuals to date. My biggest issue in joining the 349 others was practice, I just couldn't get enough quality practice exams that would prepare me for the technical marathon that is the CCDE lab exam. That's why I wrote this lab exam and why I will create an additional practice lab to help you achieve your goal of joining the CCDE club.

The book is in two parts, Part 1 covers the practice lab exam and Part 2 is the debrief to the exam. Don't even think about reading the debrief section until you have taken the practice lab.

You need to treat this practice lab as if you were taking the real exam, get somewhere quiet and comfortable where you can focus and imagine you are taking your exam for real. Follow the rules of the real lab exam and do not go backwards or forwards on the questions but feel free to read the background information and any emails that come in as much as you want to. Have a piece of paper to make notes and create drawings on as some of the questions will require diagrams and if possible highlight relevant information within documents to help you detail the facts which are ultimately requirements or constraints.

Read the background information and make notes but do so quickly, highlight what you to be relevant facts if you have editing tools at your disposal (as you will within the real lab exam) you should save as much time as possible for the questions. If you feel you don't have sufficient information to answer a question then head back to the documentation or emails as the information you need is there.

Don't worry about stopping at 2 hours and seeing how you have done, carry on until completion but do make a note of your time, if you only managed to get half way through by following the status bar included in the questions and you are at 2 hours just make a note that you need to improve your speed, significantly!

The best piece of advice I can give you for this practice lab and your real exam is that if you feel you cannot choose easily between the presented options then you haven't absorbed the requirements or constraints given to you, you'll need to go back and check before you can make an informed decision.

This practice lab is about as close as you can get to taking the real exam, I hope you enjoy it.

Part 1: Practice Lab

Diamond TV 💎

CCDE Lab Practice Exam 2

From: JR Hartley
To: CCDE Candidate
Subject: Welcome to the team

Hi

Welcome to the team at Diamond TV, we appreciate that you are not an expert in regards to Cable TV but we are reliant on you to use your extensive expertise in networking in order to help us grow our business, you come highly recommended so I'm looking forward to working with you!

Please take a look through the attached documentation to familiarise yourself with our company and Cable TV network.

Rgds

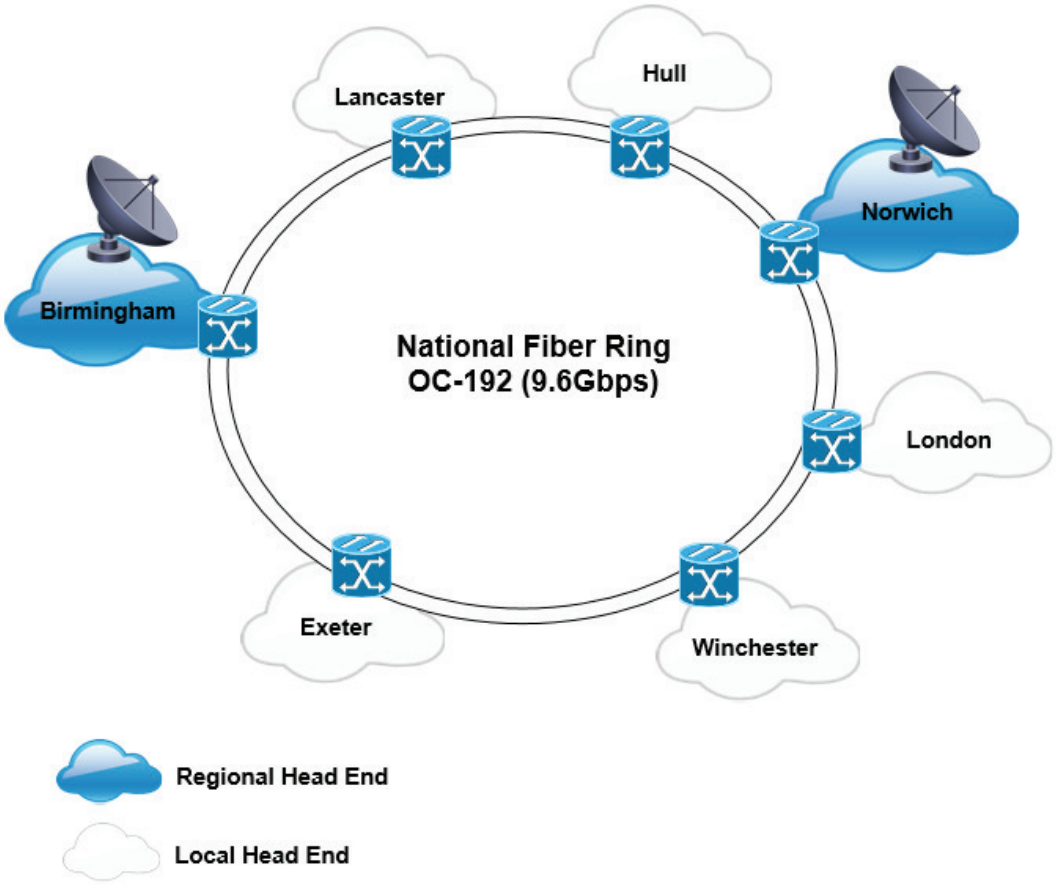
JR Hartley
Manager Transmission Team

Document 1 – Network Background

Core network connectivity

Diamond TV was formed in 1993 and provide Cable TV, Internet & Telephony services to residential customers from their national dual fiber ring running around the North and South of the UK. The ring is constructed of a clockwise and counter clockwise ring from dark fiber, it is owned outright by the company and operates as a protected SONET OC-192 dual ring.

There are two site types within the national network - RHE (Regional Headend) & LHE (Local Headend). Both site types are shown in the following figure at high level.



RHE Information

The Regional Headends (RHEs) are located in Birmingham & Norwich. RHEs are the Cable TV (CATV) site location where channel and video content are acquired and distributed locally to CATV subscribers within the local CATV network and onto the CATV National fiber ring for transmission to LHEs (Local Headends) throughout the UK. Birmingham RHE is the production RHE for content distribution and Norwich RHE is the Disaster Recovery (DR) location for content distribution. DR is dynamically invoked within the Norwich RHE by the CATV systems actively monitoring the ring for channel transmission from the primary RHE, should transmissions not be present on the ring then the DR RHE automatically adds the required content onto the ring. Failover takes in the order of 10 seconds and is tested annually.

In terms of channel distribution the CATV equipment within RHEs encode content into the following formats:

MPEG-2 standard definition

MPEG-2 high definition

H.264 standard definition

H.264 high definition

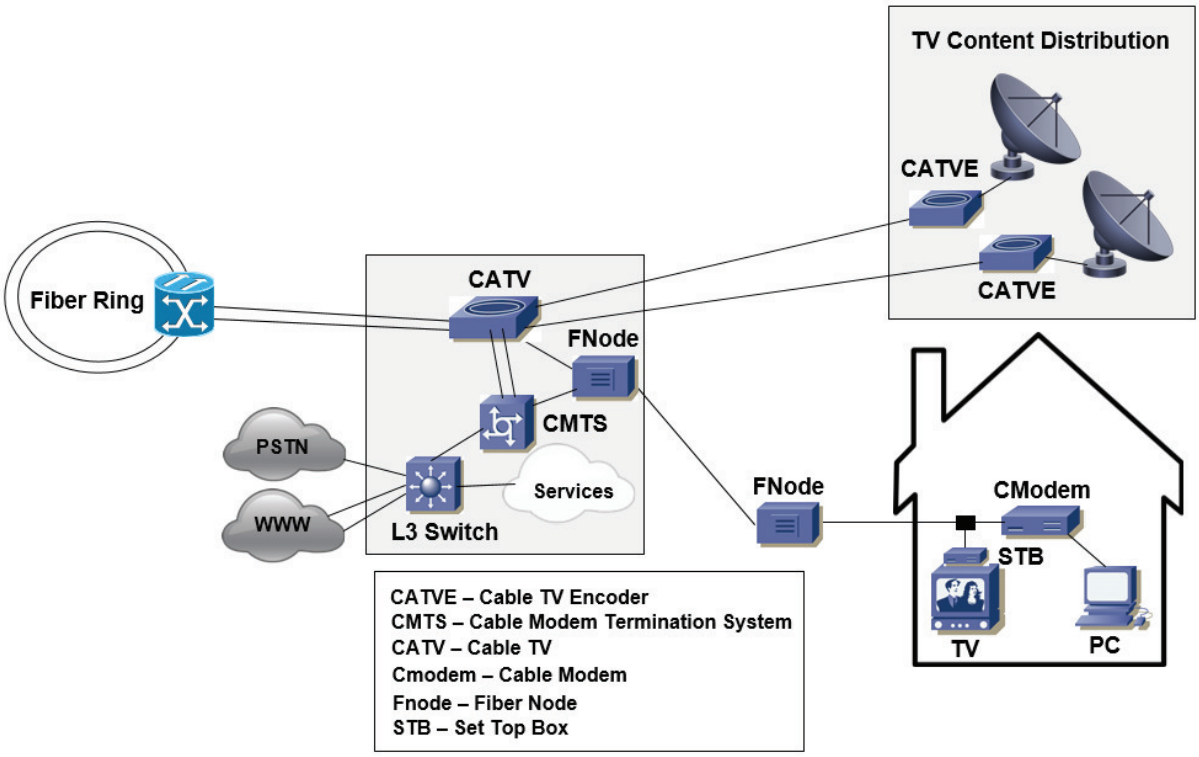
Video multiplexers within the CATV system are responsible for sending and recovering the encoded video streams.

Internet access is provided through the RHE for local subscribers utilizing cable modems. Each RHE is dual homed to two ISPs for resilience through a single Layer 3 switch which also connects to the PSTN for local digital “off net” access for telephony subscribers who also have Cable TV services.

Each RHE offers the following services:

1) Satellite TV & channel content distribution (locally and to ring).
2) Local subscriber access to Cable TV services through a mix of fiber and coaxial cabling dependent on customer location and CATV package.
3) Internet access for local area cable subscribers, including services such as DNS, web caching etc.
4) Local PSTN breakout for telephony subscribers in the Cable TV network
5) Local Control Centres for management of CATV system infrastructure

The following diagram outlines the RHE services:



LHE Information

The Local Headends (LHEs) are located throughout the UK, LHEs are the sites where channel transmissions are terminated from the national fiber ring and distributed locally.

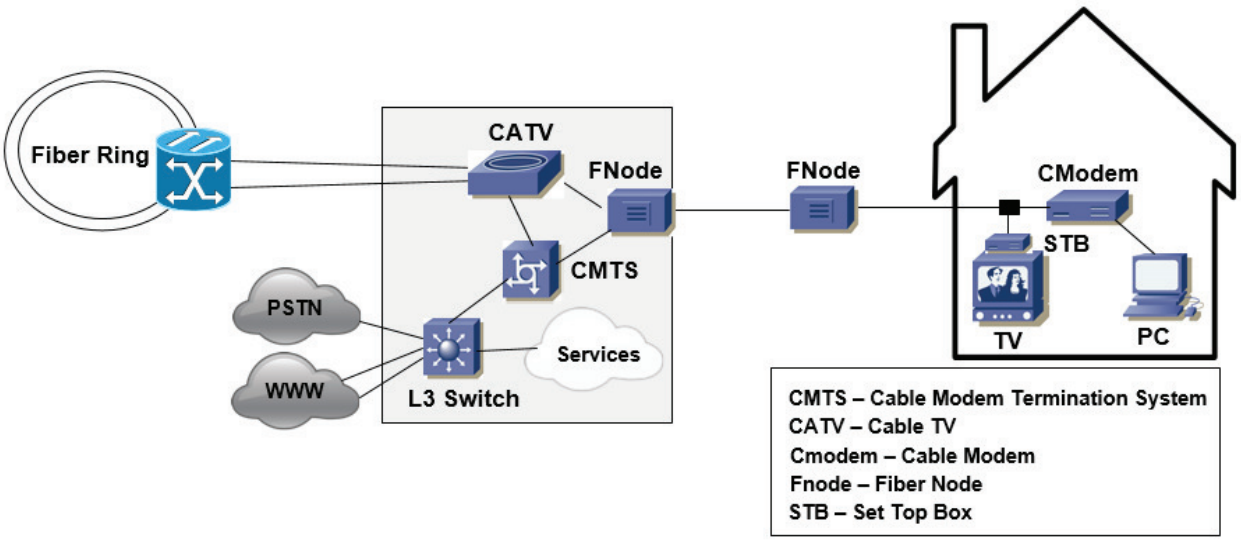
Video multiplexers within the CATV system are responsible for recovering the encoded video streams.

Internet access is provided through the LHE for local subscribers utilizing cable modems. Each LHE is dual homed to two ISPs for resilience through a Layer 3 switch which also connects to the PSTN for local digital “off net” access for telephony for voice subscribers who also have Cable TV services.

Each LHE offers the following services:

1) Local subscriber access to Cable TV services through a mix of fiber and coaxial cabling dependent on customer location and CATV package.
2) Internet access for local area cable subscribers, including services such as DNS, web caching etc.
3) Local PSTN breakout for telephony subscribers in the Cable TV network

The following diagram outlines the LHE services:

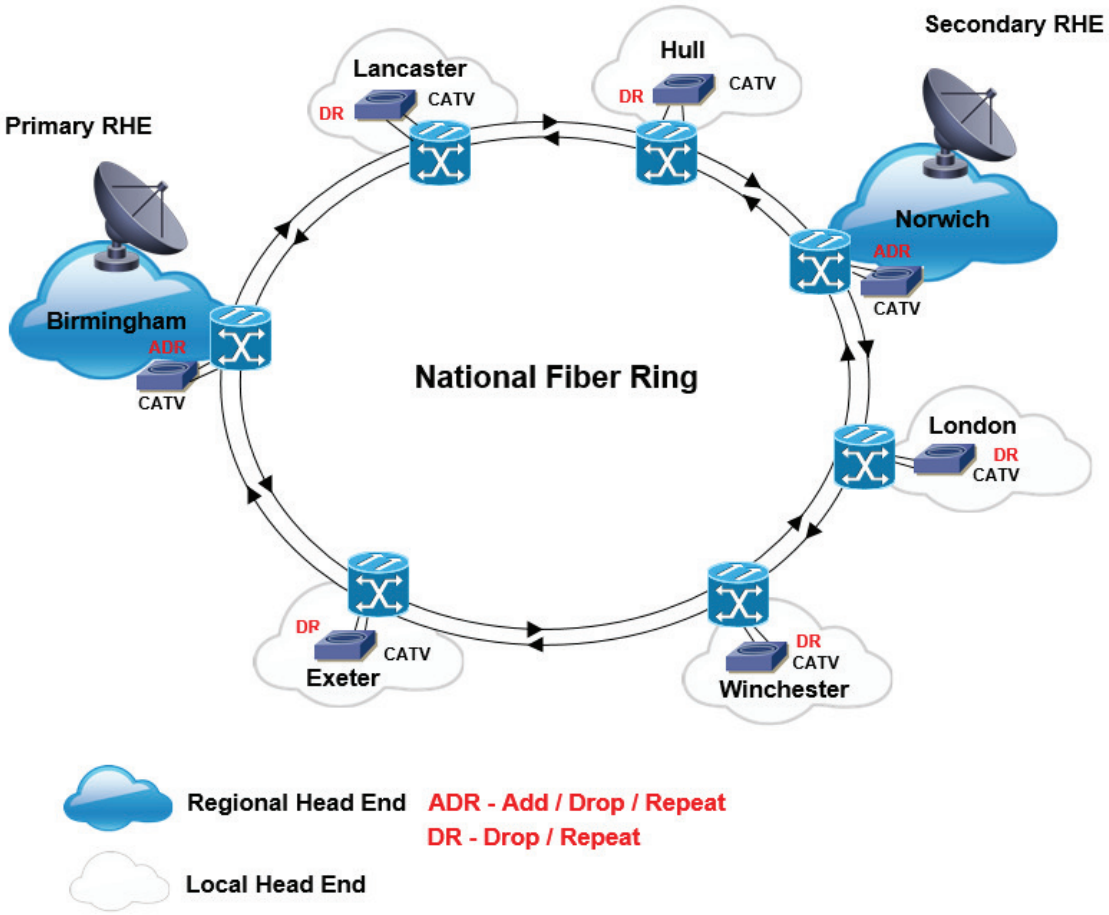


CATV Distribution through Fiber Ring

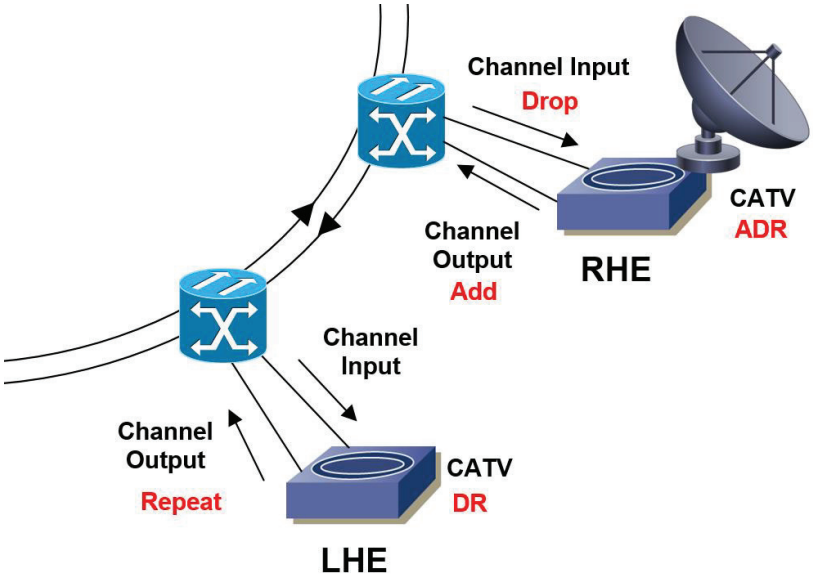
The national fiber ring is a composite protected SONET OC-192 two ring in ring architecture, one ring (one fiber pair) runs clockwise and the other runs counter clockwise. The primary path is known as the clockwise ring, the backup path is known as the counter clockwise ring. The failure of one path of the circuit is restored within 50ms by use of SONET APS protection. Fiber terminates onto Optical ADM (Add / Drop Multiplexors) within each RHE & LHE which are highly resilient with dual PSUs. Dual backplanes, separate line cards per ring connection with dual phase power & UPS within each location. The ADMs provide the required connectivity between RHE & LHE CATV systems over the fiber rings and protect the communications from failure by use of SONET. Although the Optical ADMs offer multiple speeds through ports on their local cards the rings are fixed at OC-192.

The fiber ring requires repeaters typically every 120Km, the repeaters are installed in co-located premises as they require power and maintenance. The repeaters operate at fixed OC-192 speed & framing providing optical signal regeneration. The fiber runs between LHE sites Winchester to Exeter and LHE Exeter to RHE Birmingham are provisioned with multiple repeater technology. The devices used for repeater functionality provide no usual AIS (Alarm Indicate Signal) to the ADM if there is a breakage of the physical fiber between sites, as such ADMs in these sites rely on LOS (Loss of Signal) & LOF (Loss of Frame) alarms for SONET restoral as loss of light cannot be relied upon for a major fiber outage.

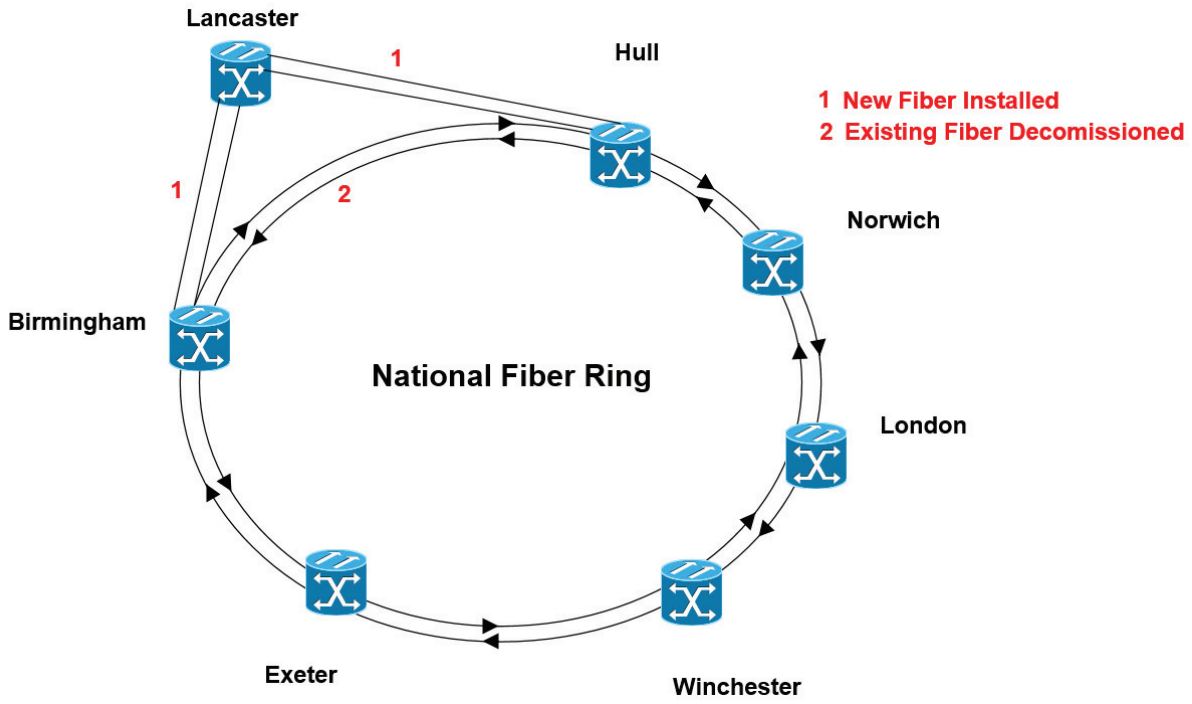
CATV nodes within in each LHE & RHE are dual homed using OC-192 local fiber links to the local ADM. CATV node equipment functions with Add / Drop / Repeat functionality, which ensures signals are not constantly transmitted around the ring (looped). The primary RHE Adds TV channel signalling to the ring, LHEs take the feeds from the ring to supply local channel distribution to subscribers and repeat the signalling onwards towards the adjacent LHE. The backup RHE at Norwich monitors the channel signalling on the ring and if the channel is absent the signal is automatically added to the ring. When channel signalling is returned to the primary or secondary RHE the channels are dropped ensuring there is no continual looping of traffic. SONET protection ensures if there is a break in the ring the counter clockwise ring provides connectivity between LHEs & RHEs within 50ms due to the native APS protection in place through the ADMs. This behaviour is outlined in the following figure:



The following figure details the “Add” functionality of a primary RHE and the “Repeat” functionality of an LHE for Channels onto the Ring, although “Drop” capability is provided within LHEs this functionality is not currently utilised. The primary RHE is shown to drop the signals on Channel Input as these were the original signals transmitted to the ring which have returned and would otherwise cause a looping of traffic around the ring.



When new LHEs are added to the network the existing fiber ring is expanded from the closest existing LHEs to the new LHE location and then the ring is re-joined with the then redundant fiber circuits decommissioned. This procedure is not disruptive to the network due to the SONET protection in place but it has proved to be financially challenging due to cost of dark fiber runs. The procedure is outlined in the following diagram for when the Lancaster LHE was added to the network:



CATV Channelling

All of Diamond TVs channels are multiplexed using Time Division Multiplexing of the Transport Stream Packet and transmitted onto the fiber ring via the CATV equipment in the RHEs. LHE CATV equipment receives the TV channels by demultiplexing the feeds. Channels are broadcast using standard channel bandwidth of 6MHz to the fiber ring in a mix of Standard definition Terrestrial Mode @ 20Mbps & High Definition High Data Rate Mode @ 40 Mbps. A growing demand for High Definition Channels has led to a project to be initiated to convert 50% of Standard Definition channels to High Definition prior to 2020.

Current channels

Channel Format	Number of Channels
Standard Definition	280
High Definition	90

Internet Access

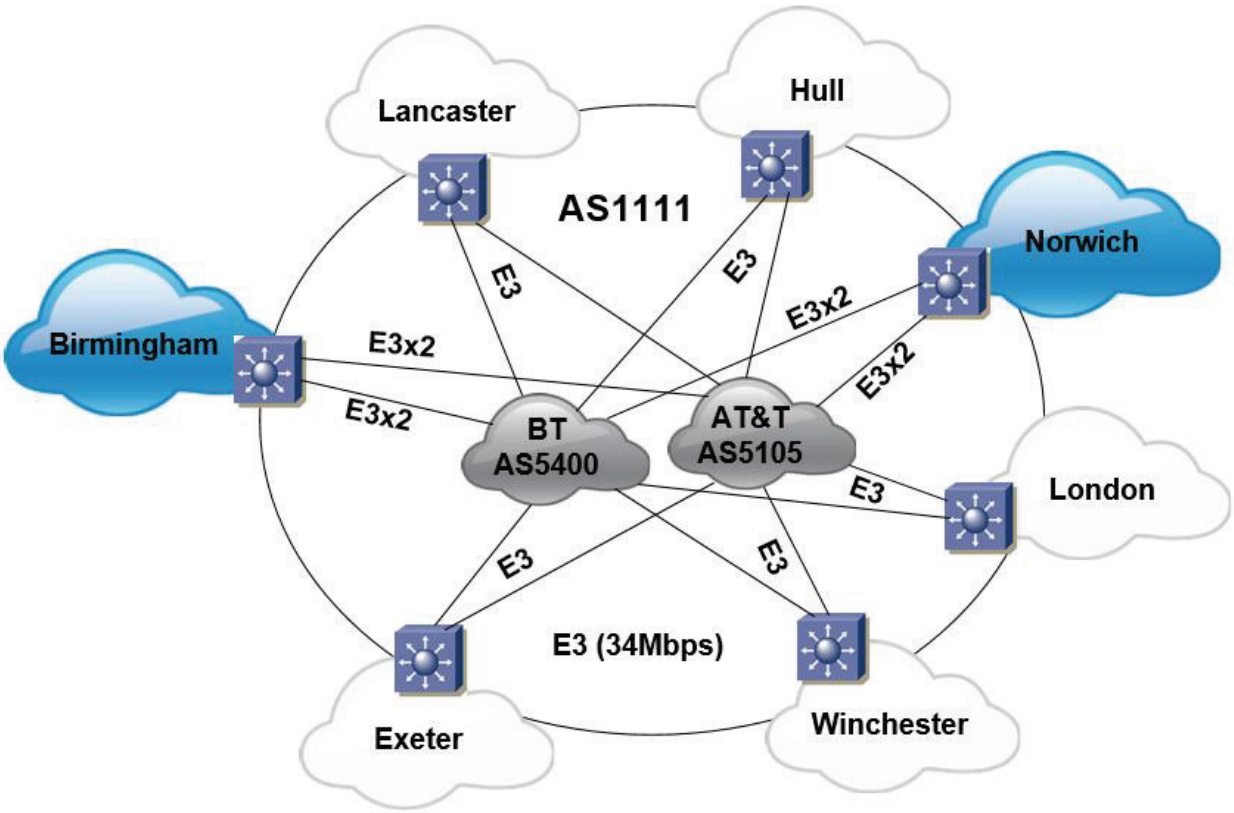
Diamond TV has a single AS (1111) and is Dual homed to two separate ISPs at each RHE & LHE (BT AS5400) (AT&T AS5105). Each RHE is connected to each ISP from a WAN card installed within the local Layer 3 switch providing 2 multi-linked PPP E3 connections to each ISP. LHEs have a single E3 connection to each ISP on a WAN card installed within the local Layer 3 switch. Diamond TV was assigned the Provider Independent (PI) block of addresses 5.5.0.0/16:

Location	PI Address Space	Current Usage
Birmingham	5.5.0.0/18	5620
Norwich	5.5.64.0/18	4534
Lancaster	5.5.128.0/19	2678
Hull	5.5.160.0/19	2823
London	5.5.192.0/19	2980
Winchester	5.5.224.0/20	1459
Exeter	5.5.240.0/20	1280

Outbound traffic from an RHE or LHE is natively load balanced over each provider due to a BGP prefix filter only permitting default routes being received from each ISP. Inbound traffic from the internet can come from either ISP depending on where the source of the traffic originates from as each ISP advertises the entire range of 5.5.0.0/16, traffic from an ISP is sent to the RHE or LHE based on BGP advertisements of local RHE & LHE prefixes. As such return traffic can enter either ISP and then be forwarded to the destination RHE or LHE based on a BGP advertisement of the local prefix range towards the ISPs.

Diamond capacity planners originally calculated that 1Mbps per subscriber would be allocated using a contention ratio of 50:1. Therefore dual E3 circuits were allocated to cater for up to approx. 3000 users per LHE & quad E3s per RHE for up to 6000 users. Circuits connect to the dual ISPs and are used in an active / active scenario.

The internet access architecture is detailed in the following figure.



Cable Modems

The CMTS (Cable Modem Termination System) within RHEs & LHEs interfaces the physical cable media from subscriber premises to the Diamond TVs local internet access switches also within RHEs & LHEs. The CMTS's offer broadband High Speed & IP services to Cable TV subscribers using DOCSIS (Data Over Cable Service Interface Specification). The CMTS system performs routing functionality between the cable RF and IP networks. Each Cable Modem provides dual Gigabit Ethernet interfaces to the subscriber.

Cable Modems within subscriber premises are allocated public IP addresses from local RHE or LHE prefixes via DHCP servers, the lease is set at 30 days. All subscribers' home networks default to subnet of 192.168.1.0/24 with the default gateway of the Cable Modem being 192.168.1.254. All DHCP & DNS services are provided locally within each LHE & RHE.

Cable Modems are managed locally from RHEs & LHEs using a variety of tools with varying product lifecycle and depending on the location. SNMP is used for up / down monitoring for premium subscribers. Utilization statistics are provided for all subscribers in all locations for tariff billing. Recently it has been determined that within London and Winchester sites users have not been capped to service levels due to the incompatibility of toolsets within these sites. Subscribers sign up to varying levels of service within the following packages:

Gold – Premium package, unlimited utilization for home workers / super users

Silver – Default package, usage limited to 20GB per day, excess usage is restricted and billed.

Bronze – Discounted package for Casual users, usage limited to 5GB per day, excess usage is restricted and billed.

Q1) What are the three key technical issues facing Diamond TV currently?

Issues	Key Technical Issues
Insufficient bandwidth on the national fiber ring to scale	
Unused bandwidth on the counter clockwise National Fiber Ring	
No onsite support or design authority	
No full mesh of iBGP between RHEs & LHE's	
Fiber Ring must be broken to add new LHEs	
Subscribers not being capped to service level	
Non deterministic internet traffic flow for Cable Modem traffic	
Cable Modem Management Tools Incompatibility	
Internet Contention ratio will be exceeded if subscribers grow	

Status %	5

Email 1

From: JR Hartley
To: CCDE Candidate
Subject: Internet Access

Hi

We've recently had a marketing campaign and taken on new customers for CATV, the campaign provides free internet access for 6 months so we are now surely going to exceed our advertised contention ratio of 50:1 on our internet backhaul links. All ISP links are heavily utilized from each site and we don't want to add new E3s to each location. We're really keen to modify the Internet access for our subscribers to allow for a 20% increase in bandwidth per location to provide the required anticipated bandwidth and work around our measured contention ratio. The individual circuit costs are very prohibitive, we have negotiated with AT&T and they have agreed they can provide a single 1G circuit offering line rate access centrally into their POP for the same cost of all of their E3 circuits combined, BT have agreed to provide 600Mbps of bandwidth over a 1G circuit for the same cost as their current E3 circuits, I'd like you to come up with a design that allows us to provide a central internet access system using these new circuits and removing our legacy infrastructure E3 circuits, let's use the AT&T as a primary circuit and use BT as a secondary for both ingress and egress traffic based on their bandwidth offerings, I want to keep things deterministic and aid troubleshooting, BT are able to provide additional bandwidth on their tail in 100Mbs incrementals but it is expensive. We'd look to installing these circuits centrally, primary in Birmingham & the secondary in Norwich, I'd like to use our existing fiber ring to access the central internet circuits from the RHEs & LHEs.

Rgds

JR Hartley
Manager Transmission Team