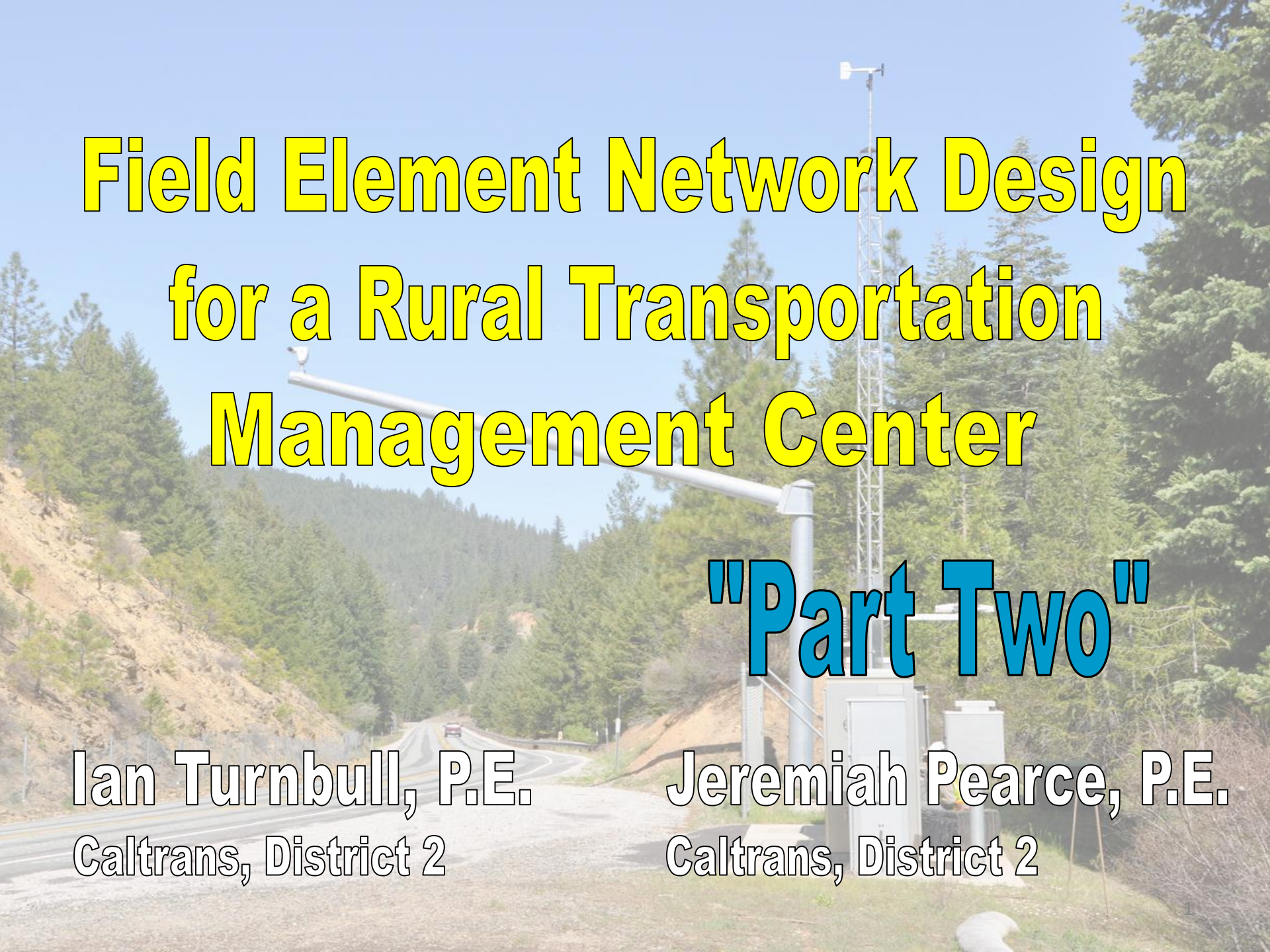

Field Element Network Design for a Rural Transportation Management Center

"Part Two"

Ian Turnbull, P.E.
Caltrans, District 2

Jeremiah Pearce, P.E.
Caltrans, District 2

District Info

- Field Element Network (FEN): Machine-to-machine network hosts District 2 TMC/ITS Field devices

District Info

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- Currently District 2 employs
  - 60 CCTV sites
  - 21 RWIS sites
  - 19 HAR sites
  - 46 HAR flashing beacon sites
  - 41 CMS sites

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  - 60 CCTV sites
  - 21 RWIS sites
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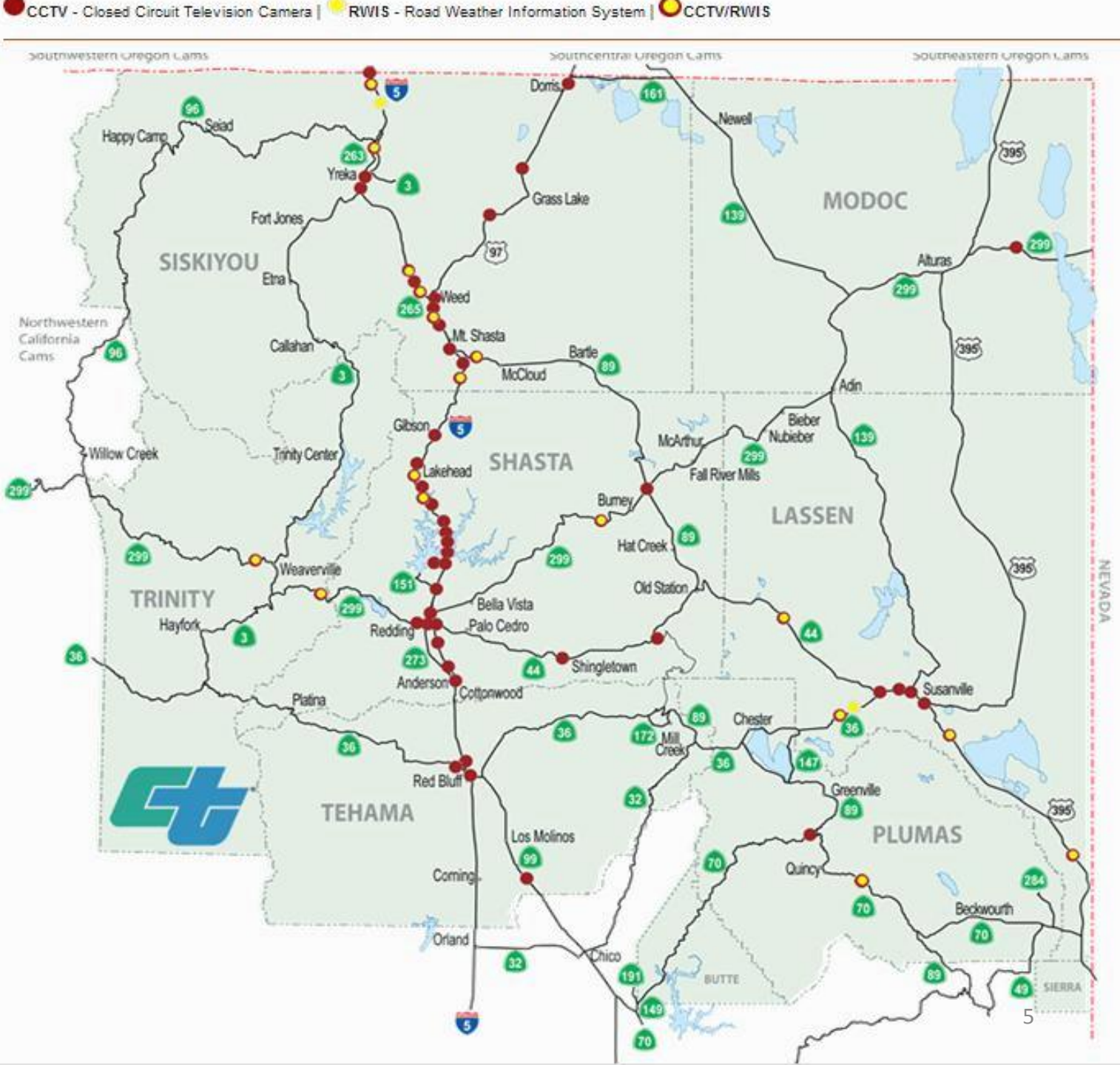
  - 41 CMS sites
- 30 new elements to be added next year

Caltrans District 2 FEN Map



Presentation Outline

- Basic Topology and Architecture

Presentation Outline

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- FEN Core Architecture and Configuration

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- Basic Topology and Architecture
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- Video Distribution
- Technical Considerations

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- Basic Topology and Architecture
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- ITS Nodes
- Video Distribution
- Technical Considerations
- Other Design Considerations

Presentation Outline

- Recent District 2 Core Router Upgrade

Presentation Outline

- Recent District 2 Core Router Upgrade
- Future Communications Subtypes

Presentation Outline

- Recent District 2 Core Router Upgrade
- Future Communications Subtypes
- Areas we're improving and need improvement


FEN Topology

District 2 FEN Topology

- FEN is a “one-to-many” network
  - One “Core” machine(s) connected to many remote machines

District 2 FEN Topology

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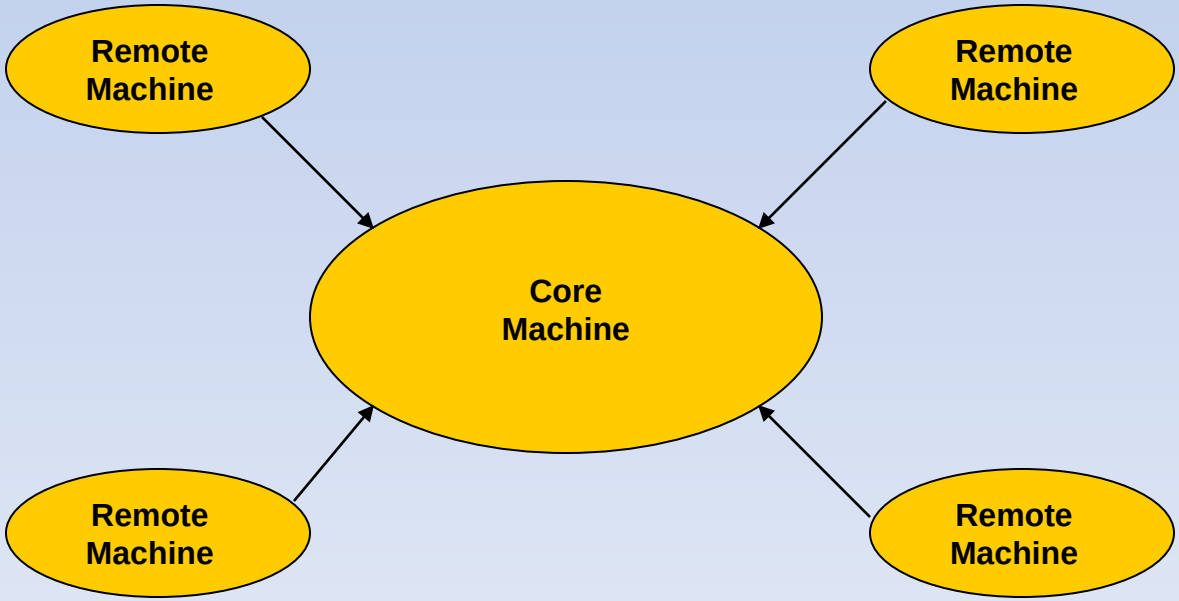
  - One “Core” machine(s) connected to many remote machines
  - Star topology



District 2 FEN Topology

- FEN is a “one-to-many” network
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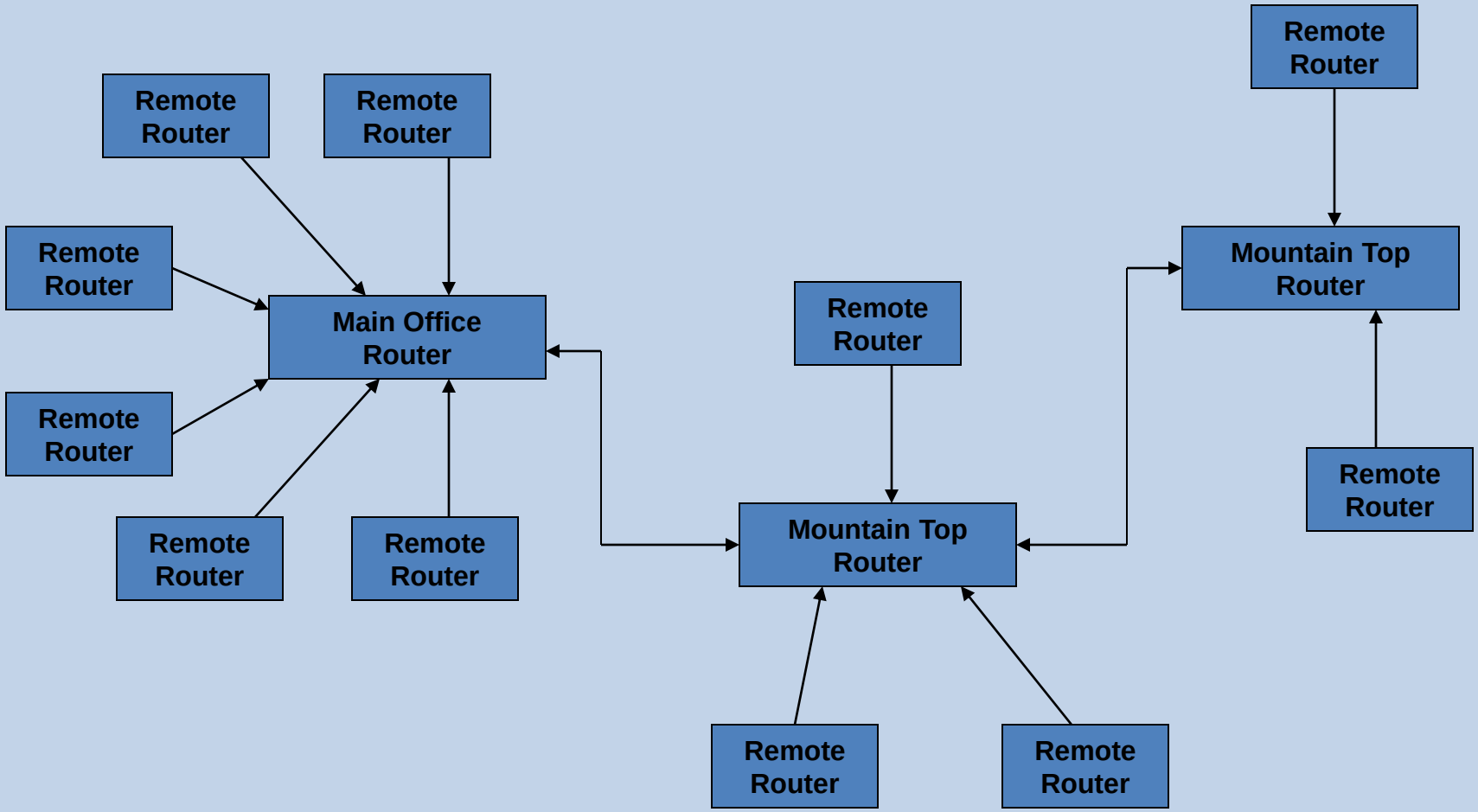
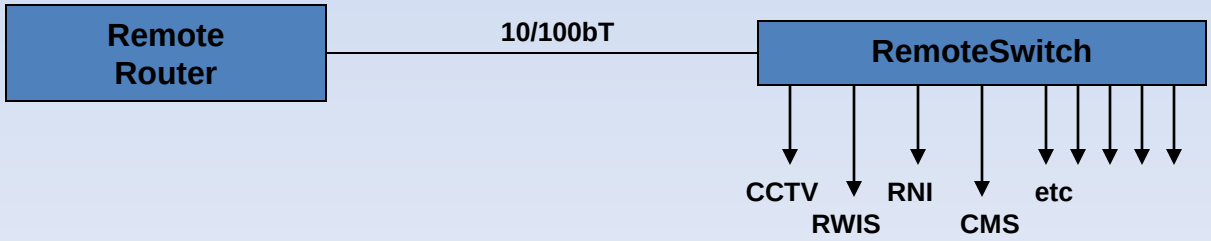
  - Star topology
- Build out of Point-to-Point Microwave system creates an extended star topology



Extended Star Topology

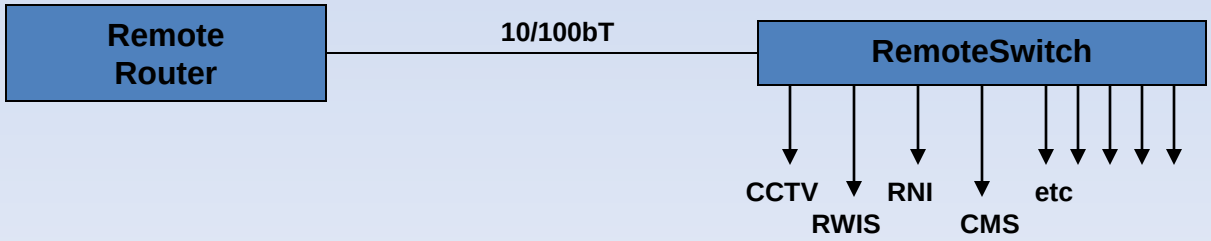
District 2 FEN Topology

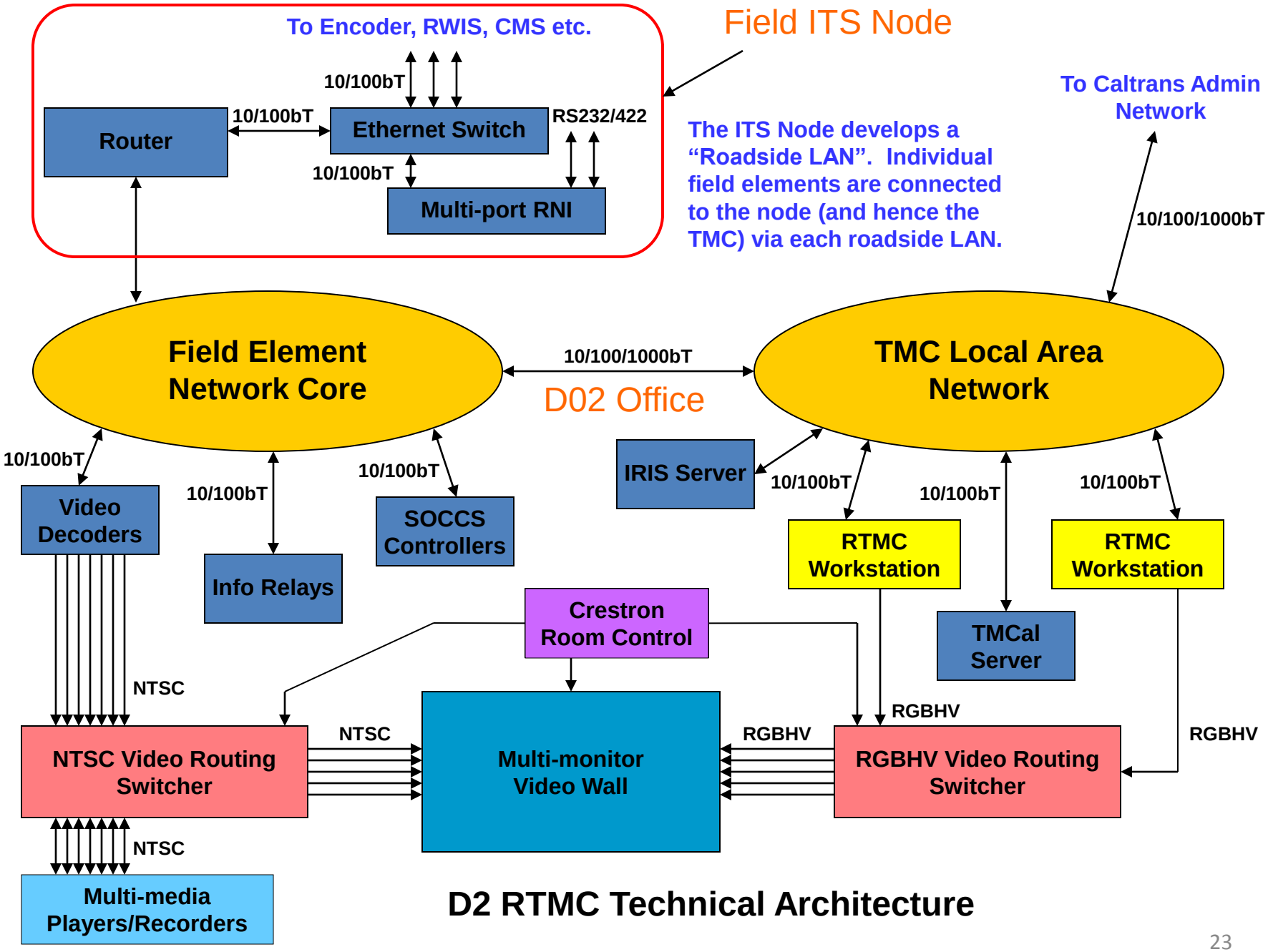
- FEN is a “one-to-many” network
  - One “Core” machine(s) connected to many remote machines
  - Star topology
- Build out of Point-to-Point Microwave system creates an extended star topology
- Remote routers connected to a Roadside LAN



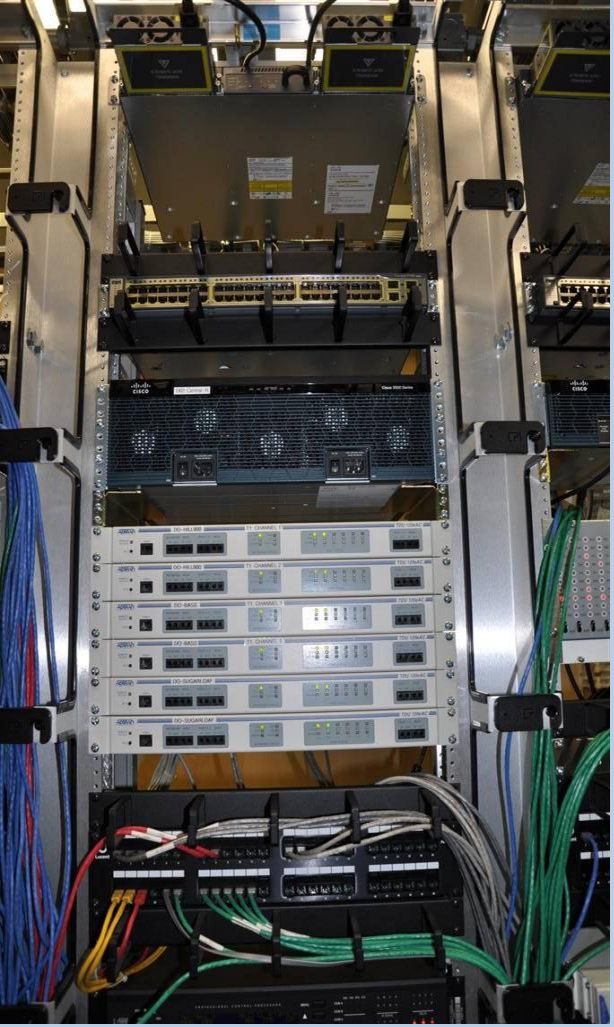
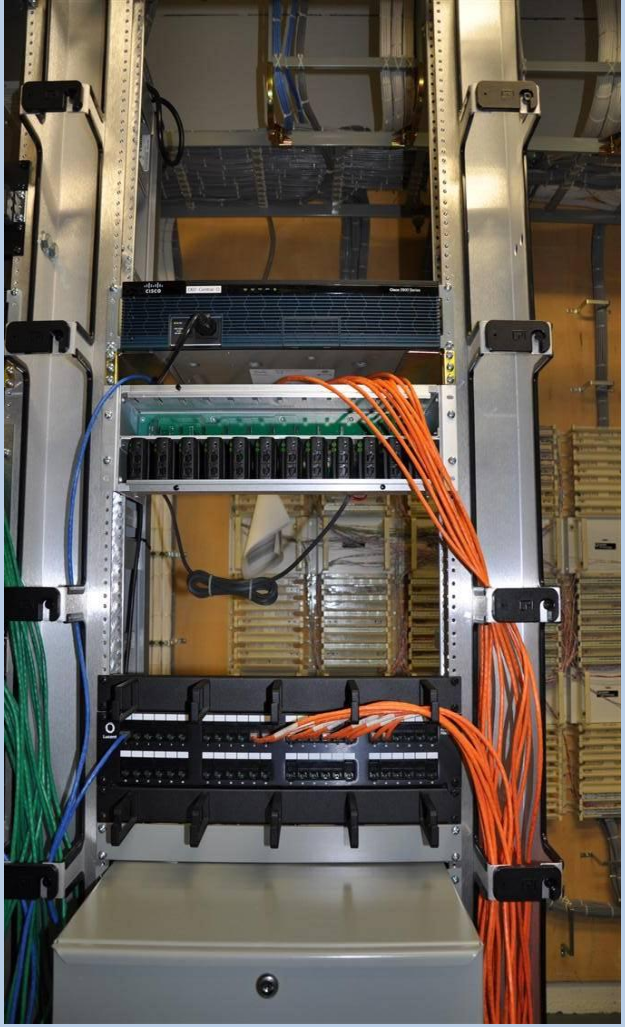
District 2 FEN Topology

- FEN is a “one-to-many” network
  - One “Core” machine(s) connected to many remote machines
  - Star topology
- Build out of Point-to-Point Microwave system creates an extended star topology
- Remote routers connected to a Roadside LAN
  - Allows expansion for future field elements



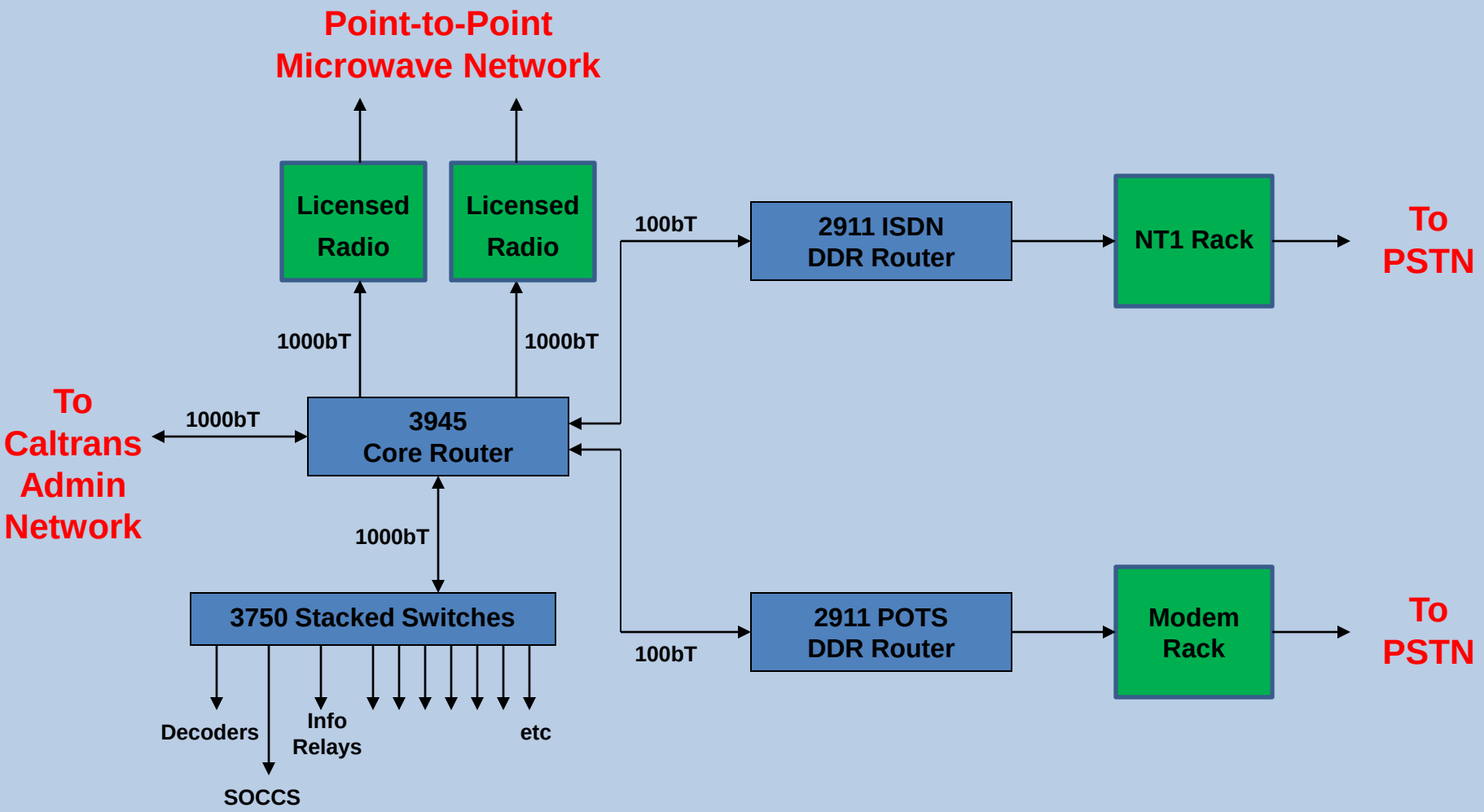


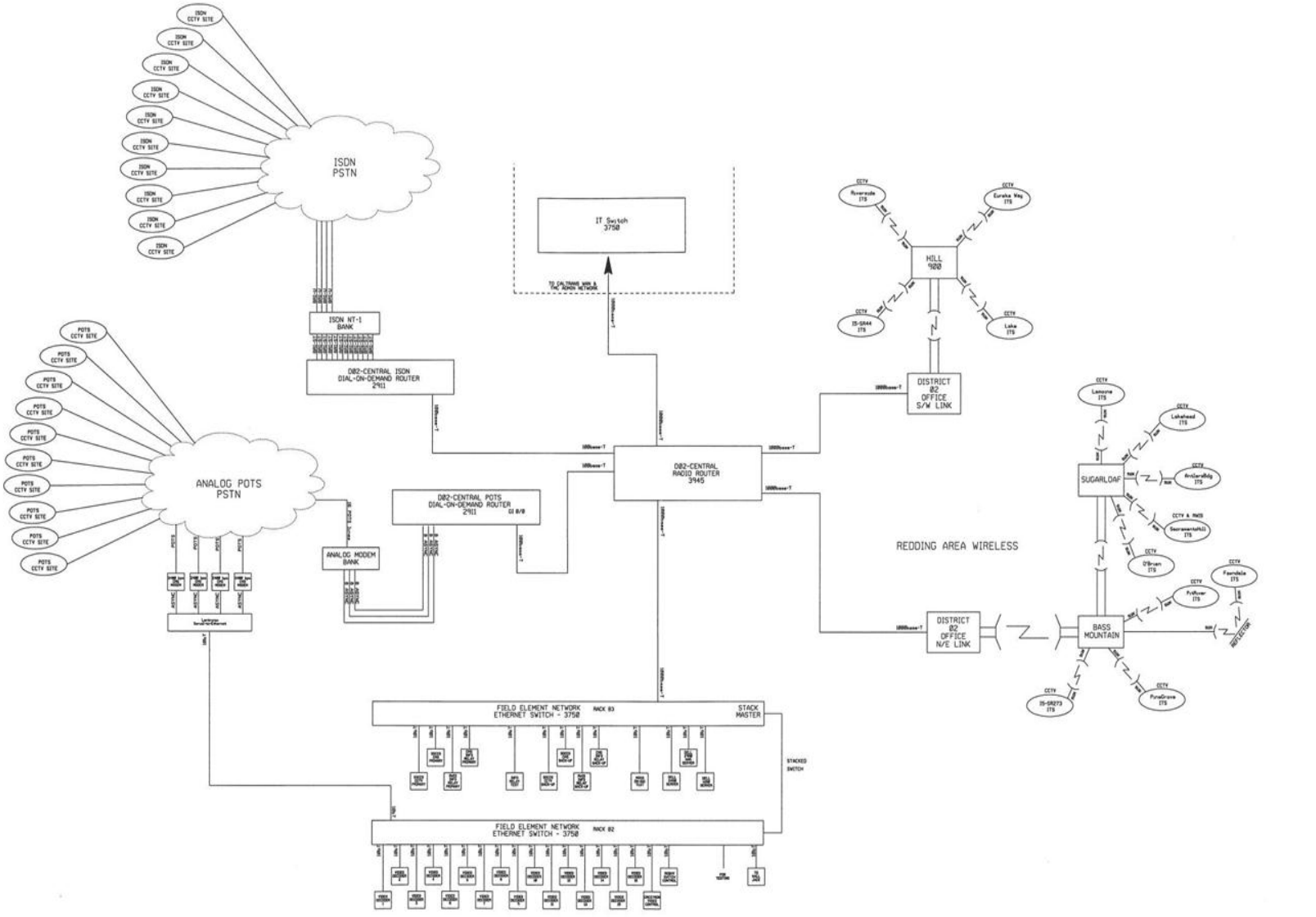
D2 RTMC Technical Architecture


FEN Core

FEN Core


Point-to-Point
Microwave Network
Licensed
Radio
Licensed
Radio
1000bT
1000bT
100bT
2911 ISDN
DDR Router
NT1 Rack
To
PSTN
To
Caltrans
Admin
Network
1000bT
3945
Core Router
1000bT
3750 Stacked Switches
100bT
2911 POTS
DDR Router
Modem
Rack
To
PSTN
Decoders
Info
Relays
etc
SOCCS



SYSTEM DIAGRAM
DISTRICT 2
FIELD ELEMENT NETWORK

NOTE: DISTRICT Ø2 HAR AND HAR FLASHER NETWORK ARE DIRECT DIAL AND NOT SHOWN

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
Caltrans ITS ENGR and SUPPORT

CALCULATED-DESIGNED BY	CHECKED BY	REVISED BY	DATE REVISED
Jeremiah Pearce	Ian Turnbull	JP	1/12

c:\Documents and Settings\s131744\Desktop\Projects\Control Router-BER Upgrade\Proposed Network\FieldElementNetworkproposed.dgn

DATE PLOTTED => 20-APR-2012
TIME PLOTTED => 08:23
LAST REVISED 12-28-10

BORDER LAST REVISED 3/1/2007 | RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3 | USERNAME => s131744 DGN FILE => FieldElementNetworkproposed.dgn | CU 02 369 | EA 0200000215

FEN Core

- Core initiates FEN traffic

FEN Core

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- Core is the interface to Caltrans Admin Network
- Core interfaces to FEN communications subtypes (ISDN, POTS, Microwave, etc.)
- Uses external devices to interface with Telco via modems, NT1's, CSU/DSU, etc to provide additional layer of protection from unwanted line surges, etc.

FEN Core Configuration

- Configuration examples and explanation will be provided in detail in next sections of presentation

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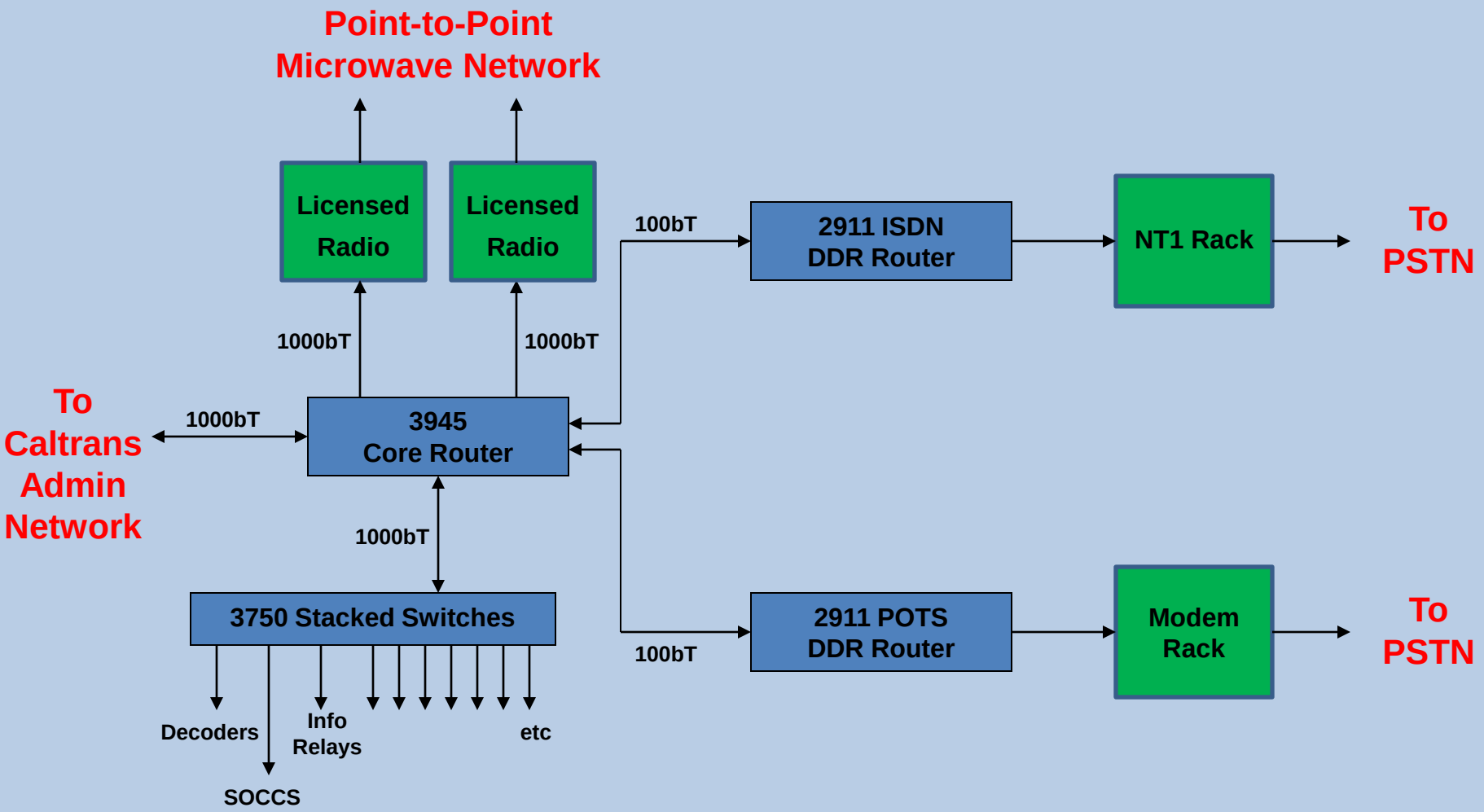
- We have a static route network, the configuration of the core 3945 router must have all networks in the routing table

FEN Core Configuration



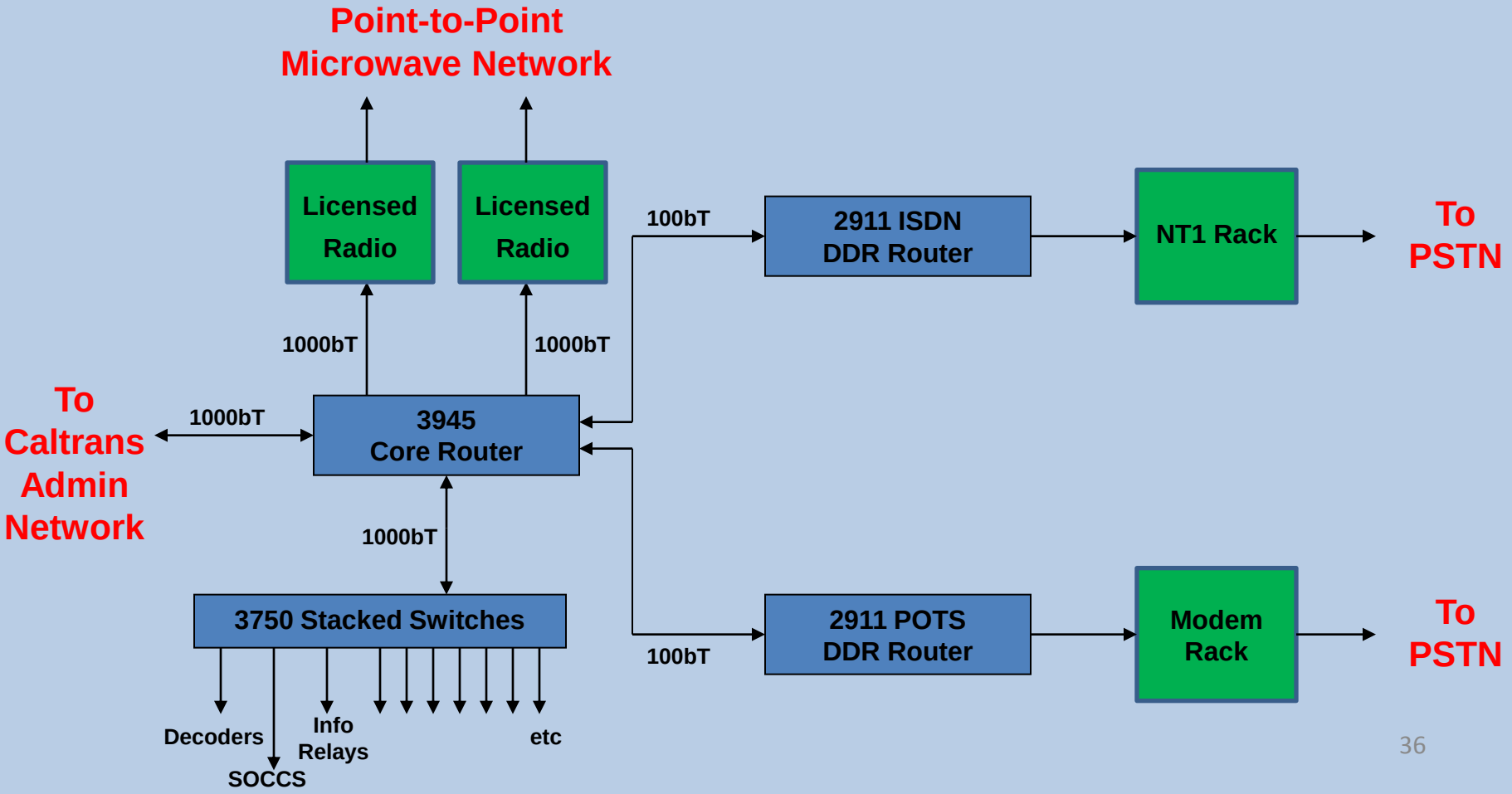
FEN Core Configuration

- Configuration examples and explanation will be provided in detail in next sections of presentation
- We have a static route network, the configuration of the core 3945 router must have all networks in the routing table
- All connected interfaces of 3945 core router are Ethernet, with the exception of the legacy microwave radios which will be slowly phased out as we move to an IP backbone

Dial-on-Demand Routing

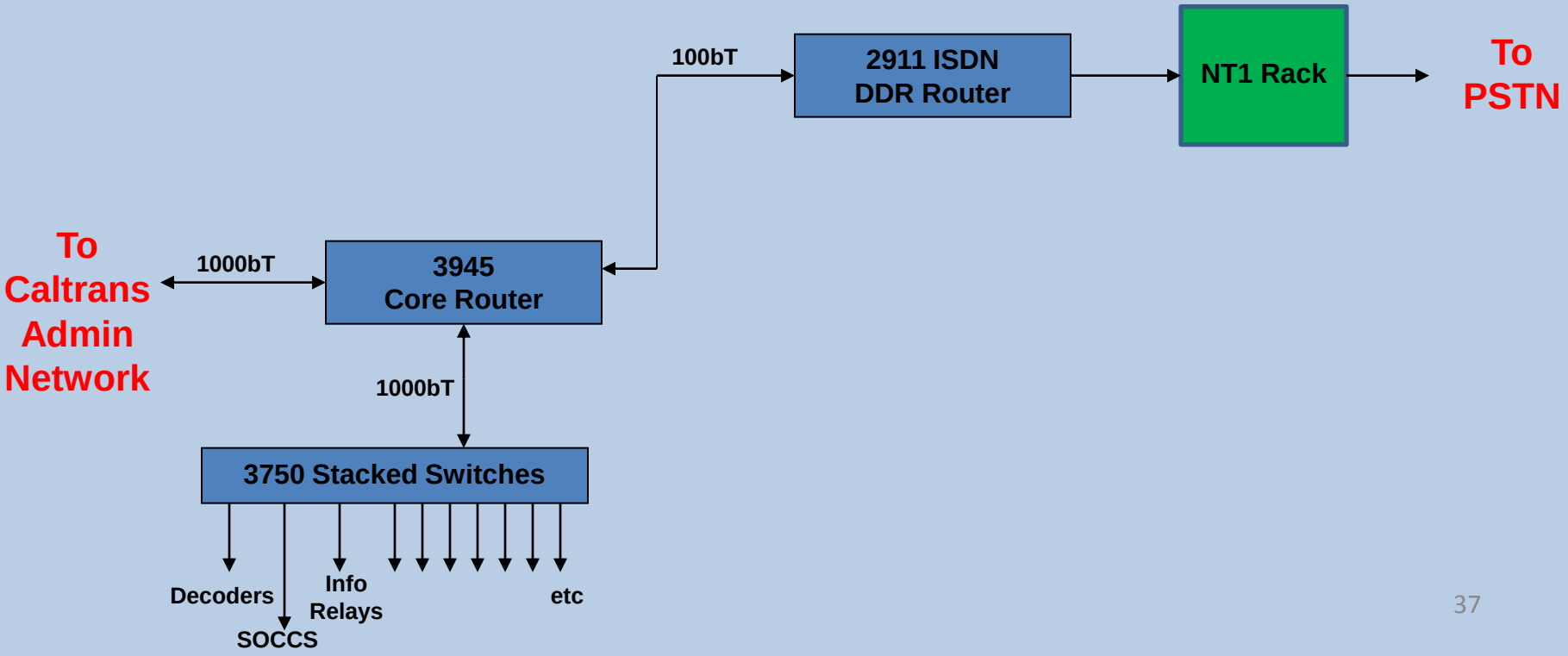
Dial-on-Demand Routing

- Two communications subtypes use DDR



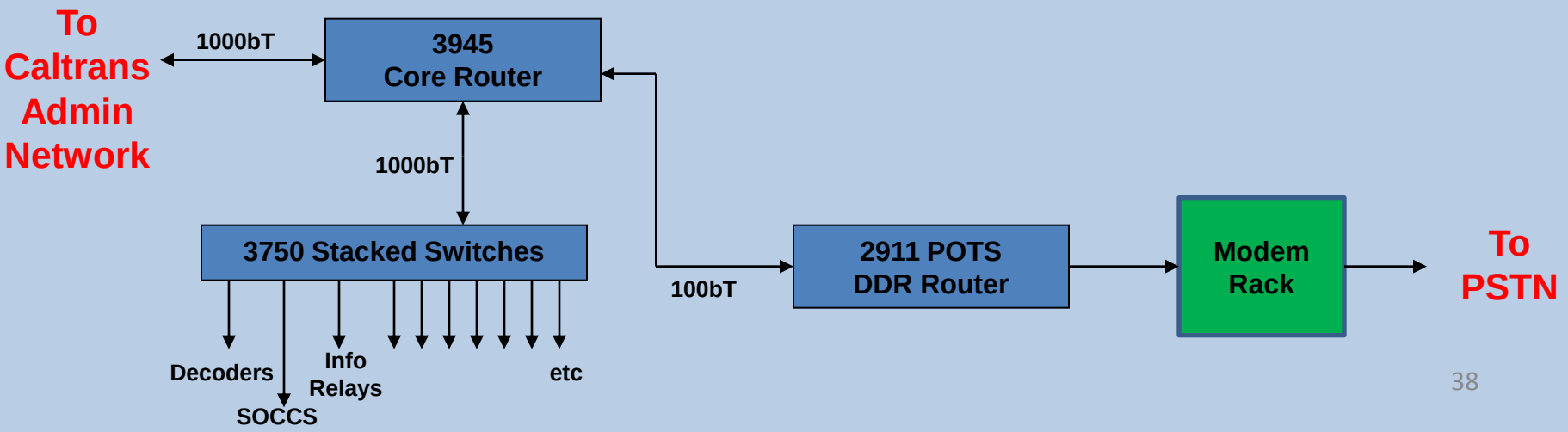
Dial-on-Demand Routing

- Two communications subtypes use DDR
  - ISDN



Dial-on-Demand Routing

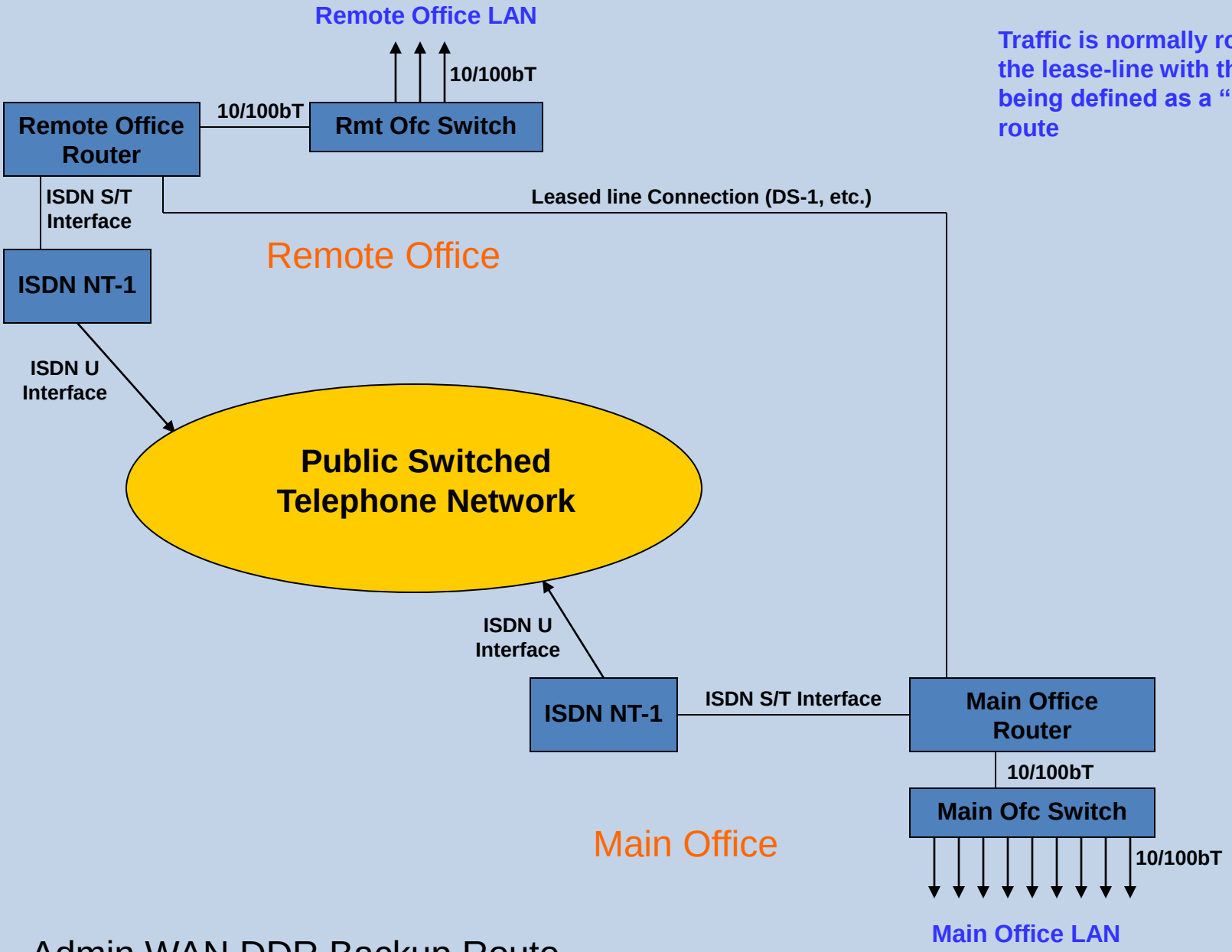
- Two communications subtypes use DDR
  - ISDN
  - POTS



Dial-on-Demand Routing

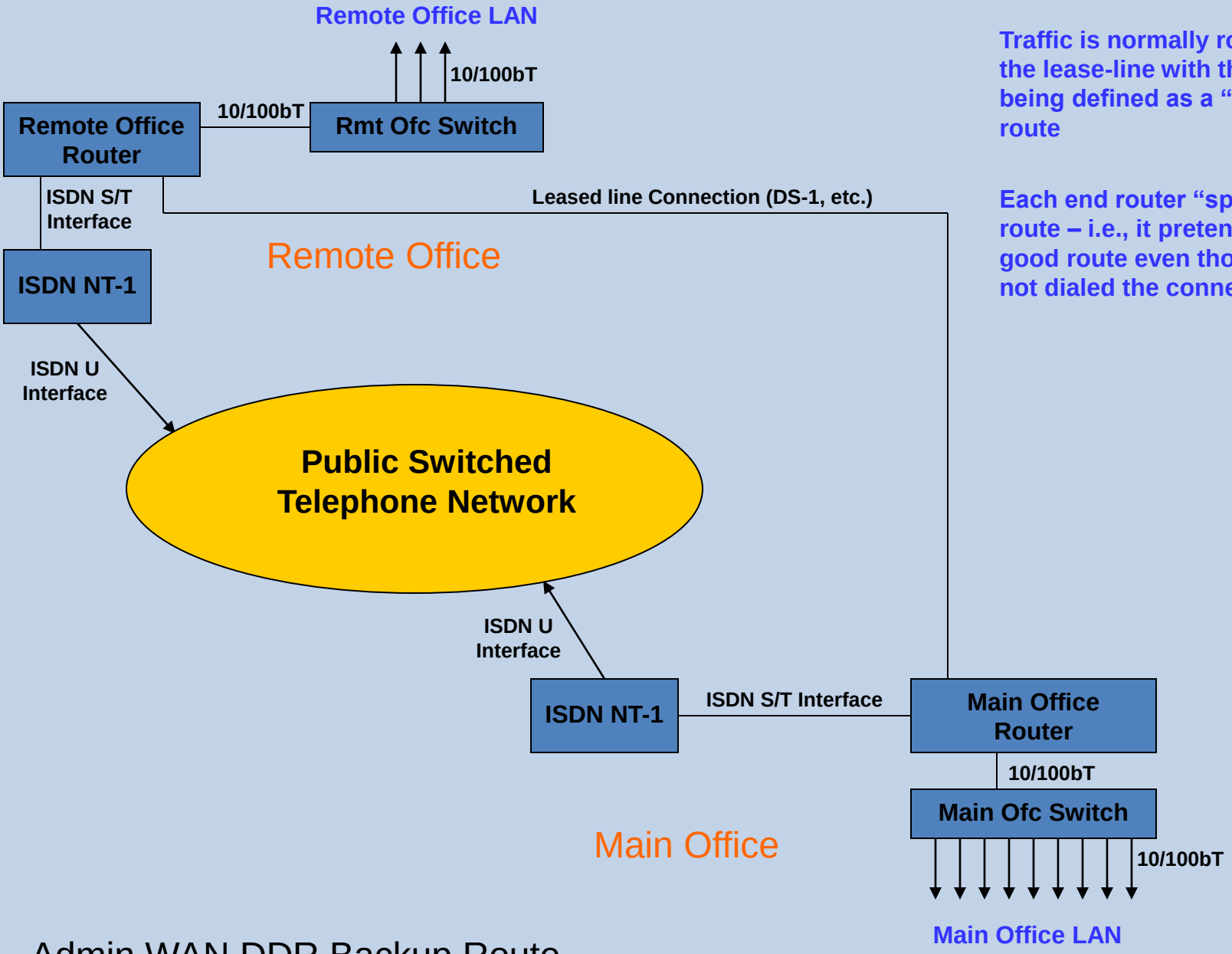
- Two communications subtypes use DDR
  - ISDN
  - POTS
- Benefits of using DDR
  - IP routing to distant field sites w/ limited connectivity
  - Scalable
  - Charges only accrued when connected

How Dial-on-Demand Works



Traffic is normally routed over the lease-line with the DDR route being defined as a “higher cost” route

Admin WAN DDR Backup Route



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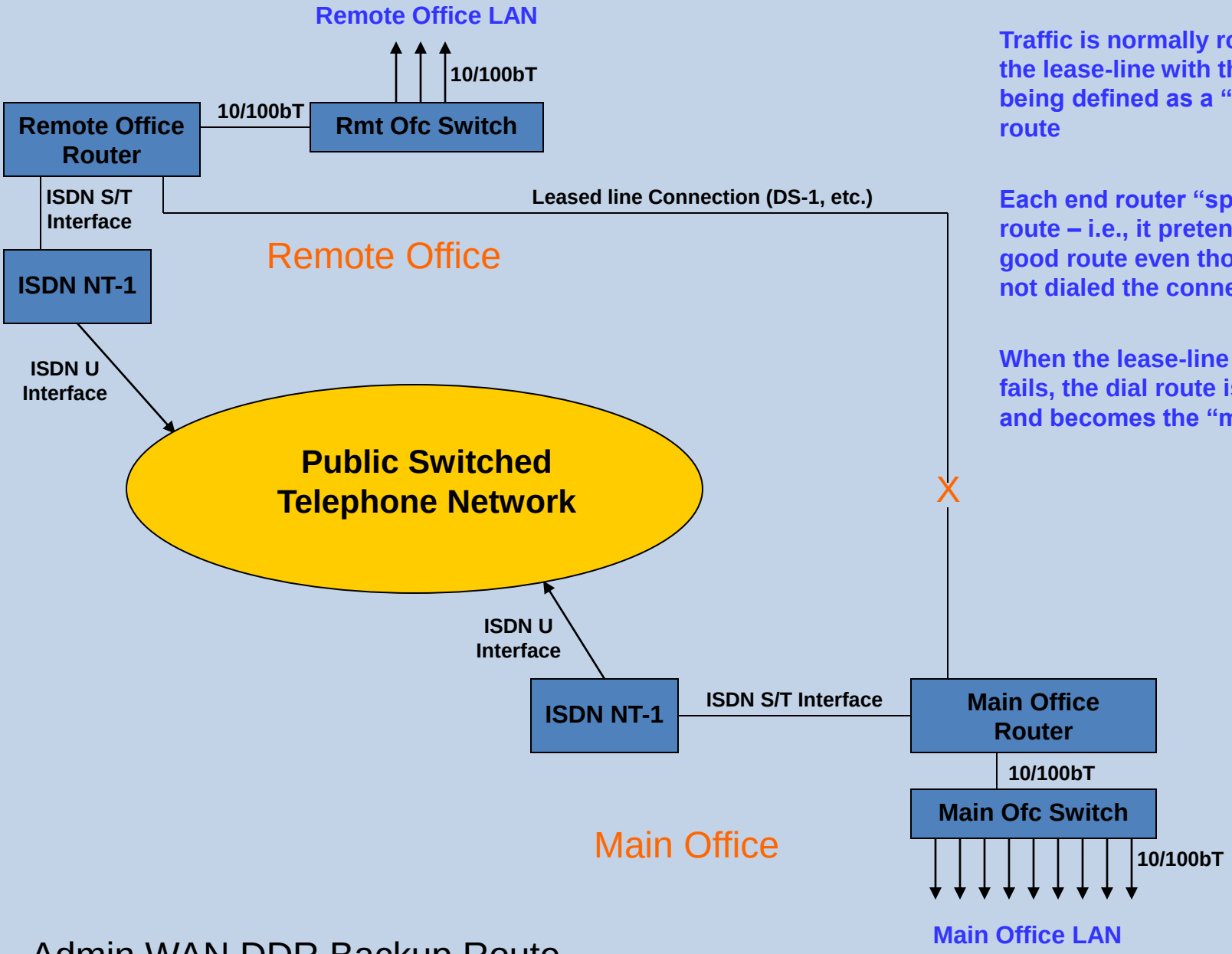

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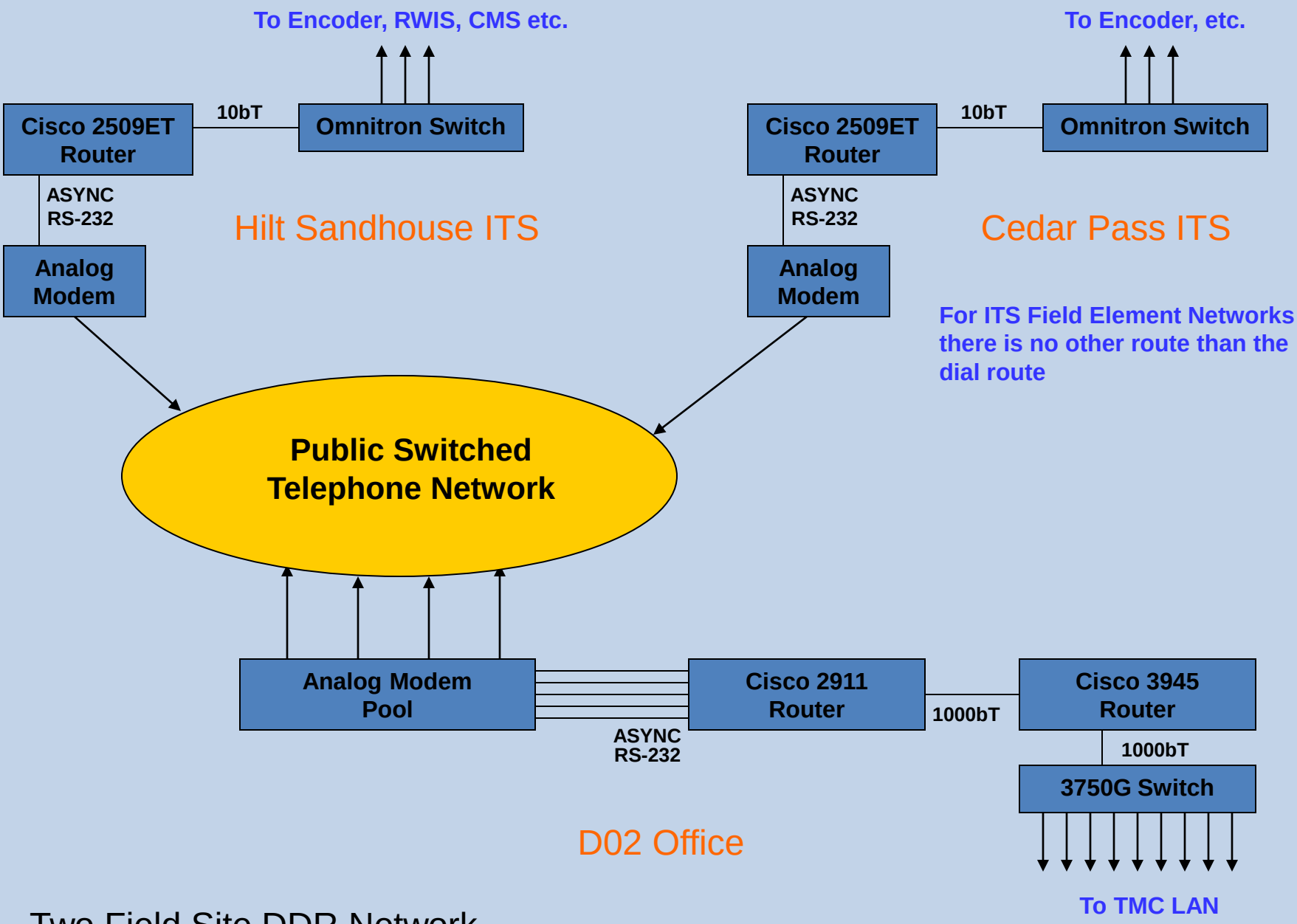
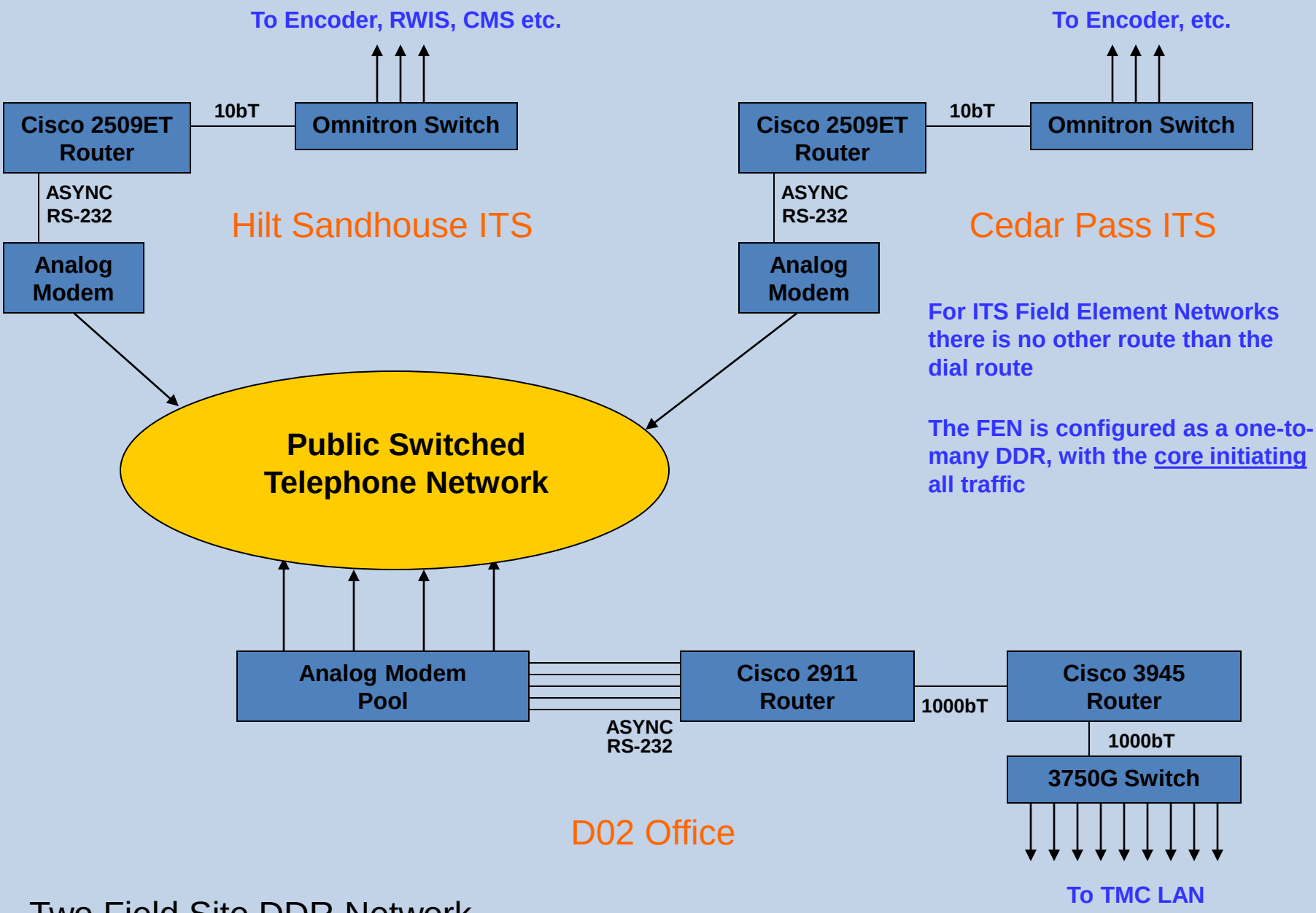
When the lease-line connection fails, the dial route is connected and becomes the "make good"

Admin WAN DDR Backup Route



Two Field Site DDR Network



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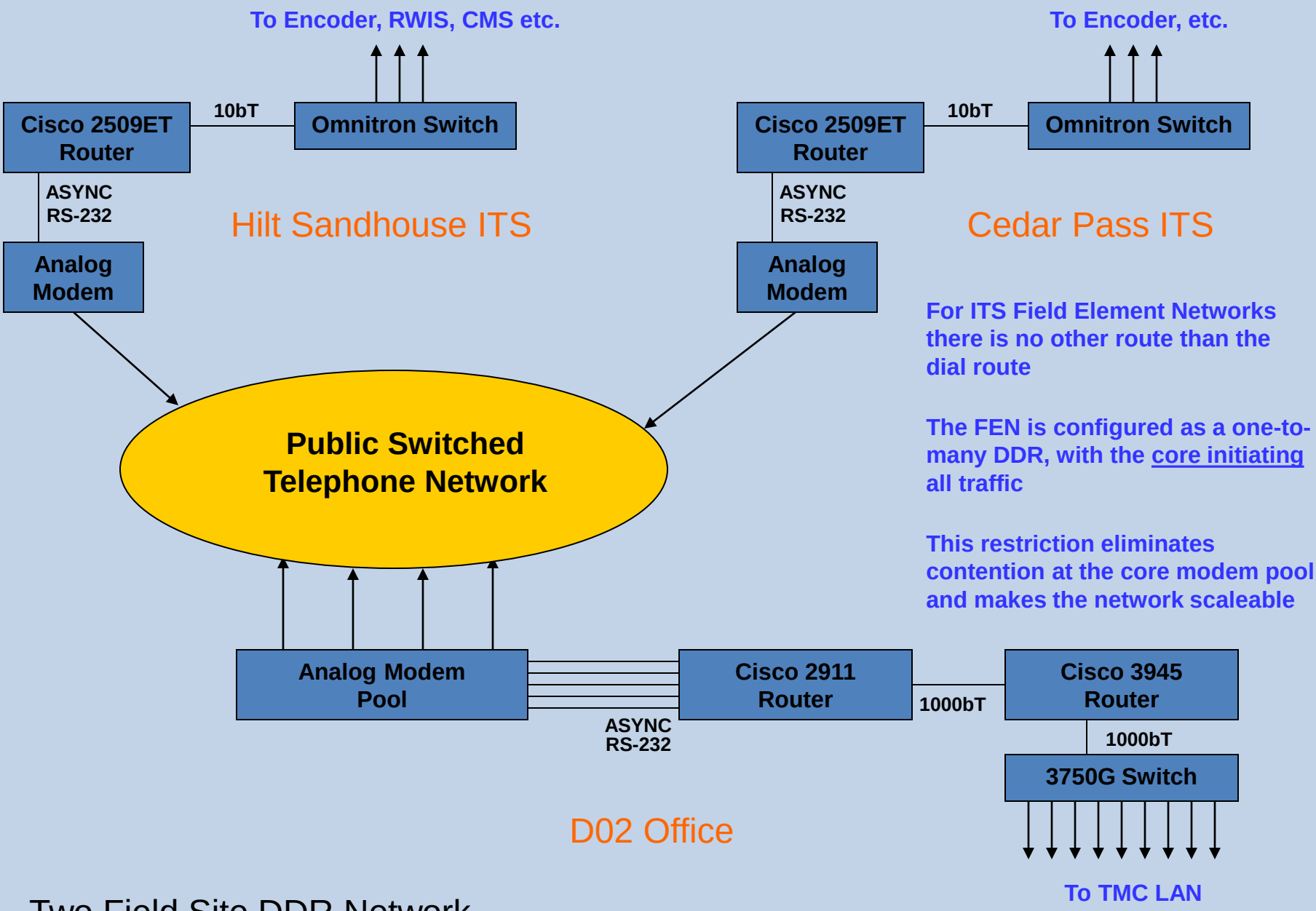

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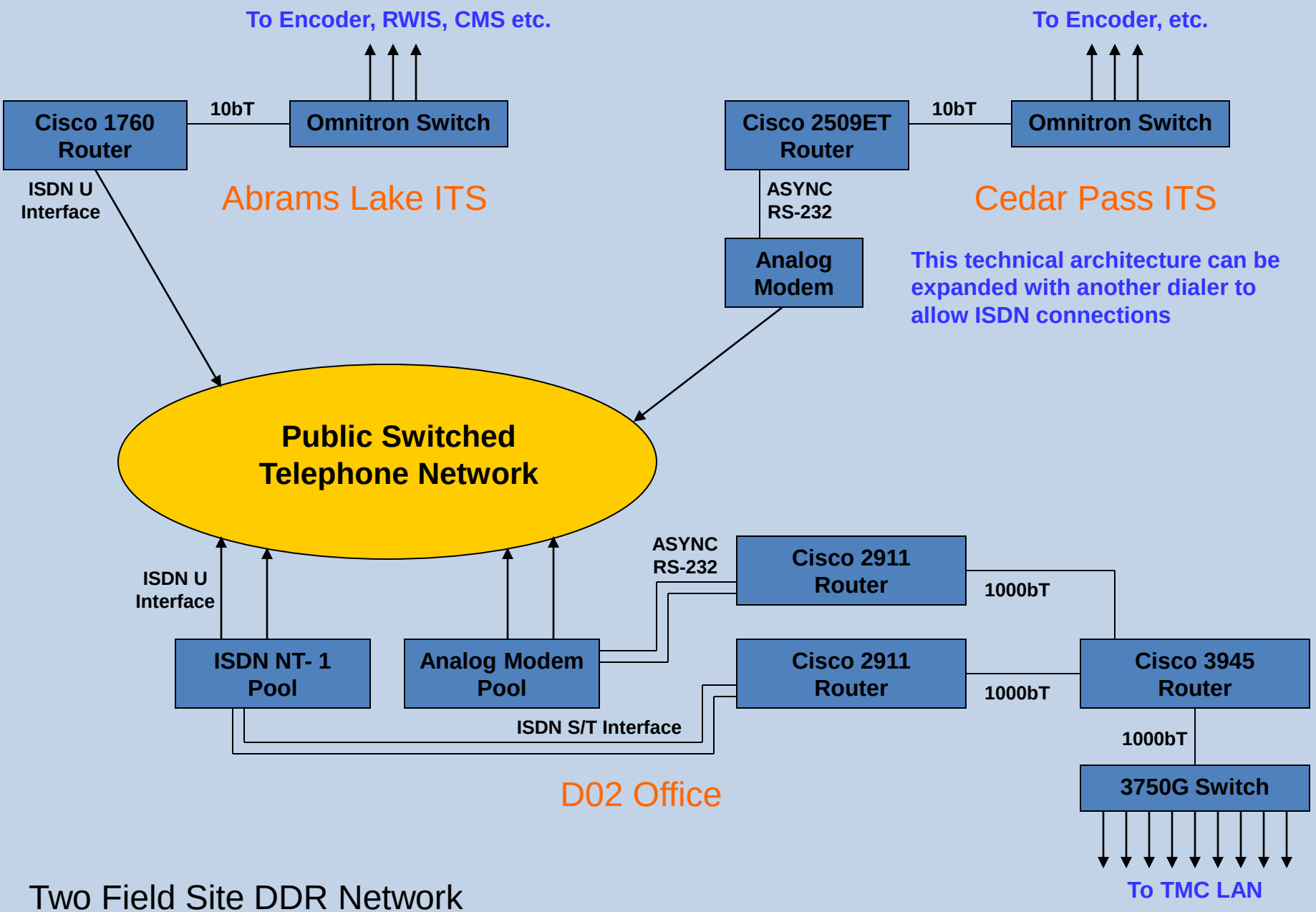

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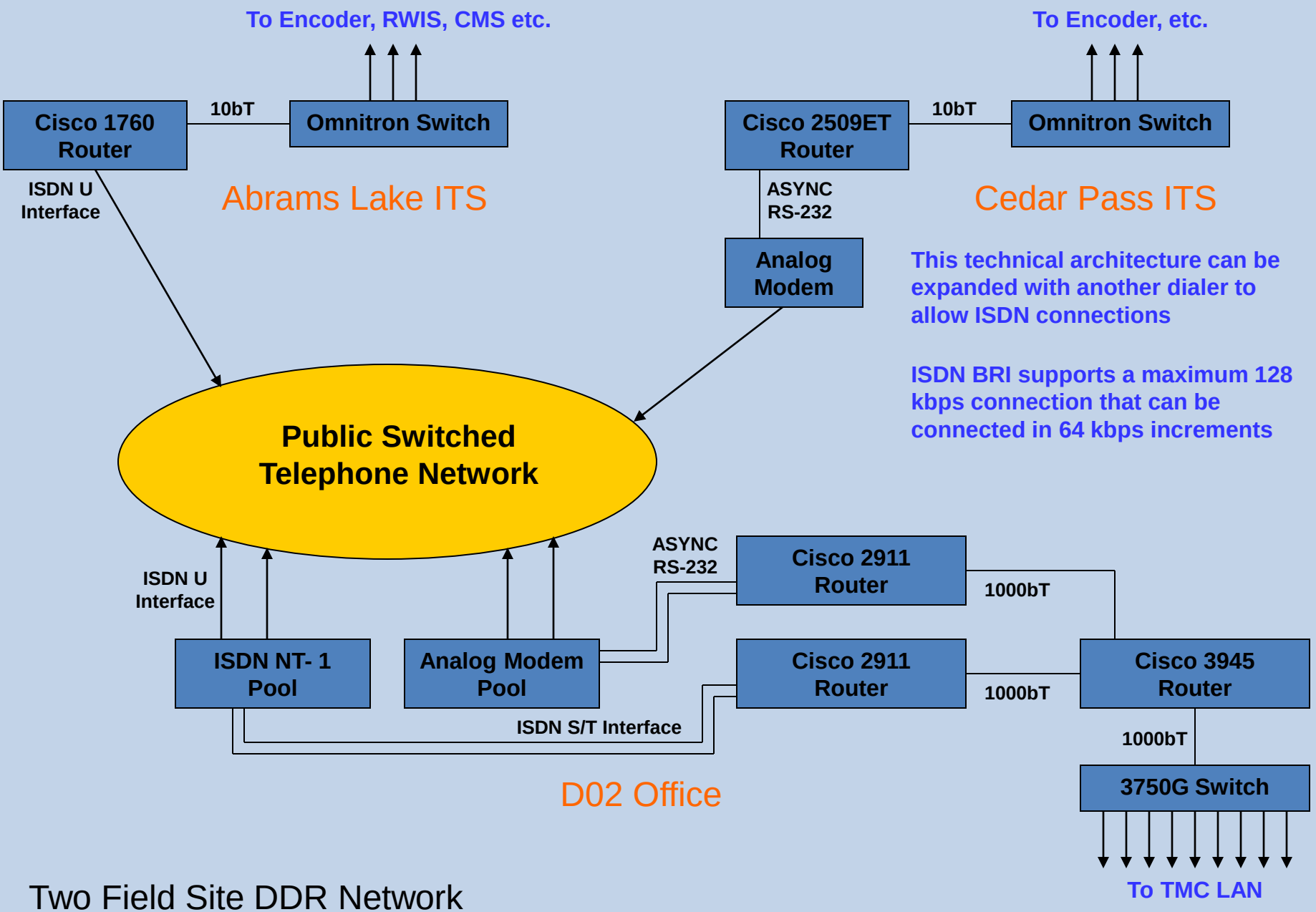

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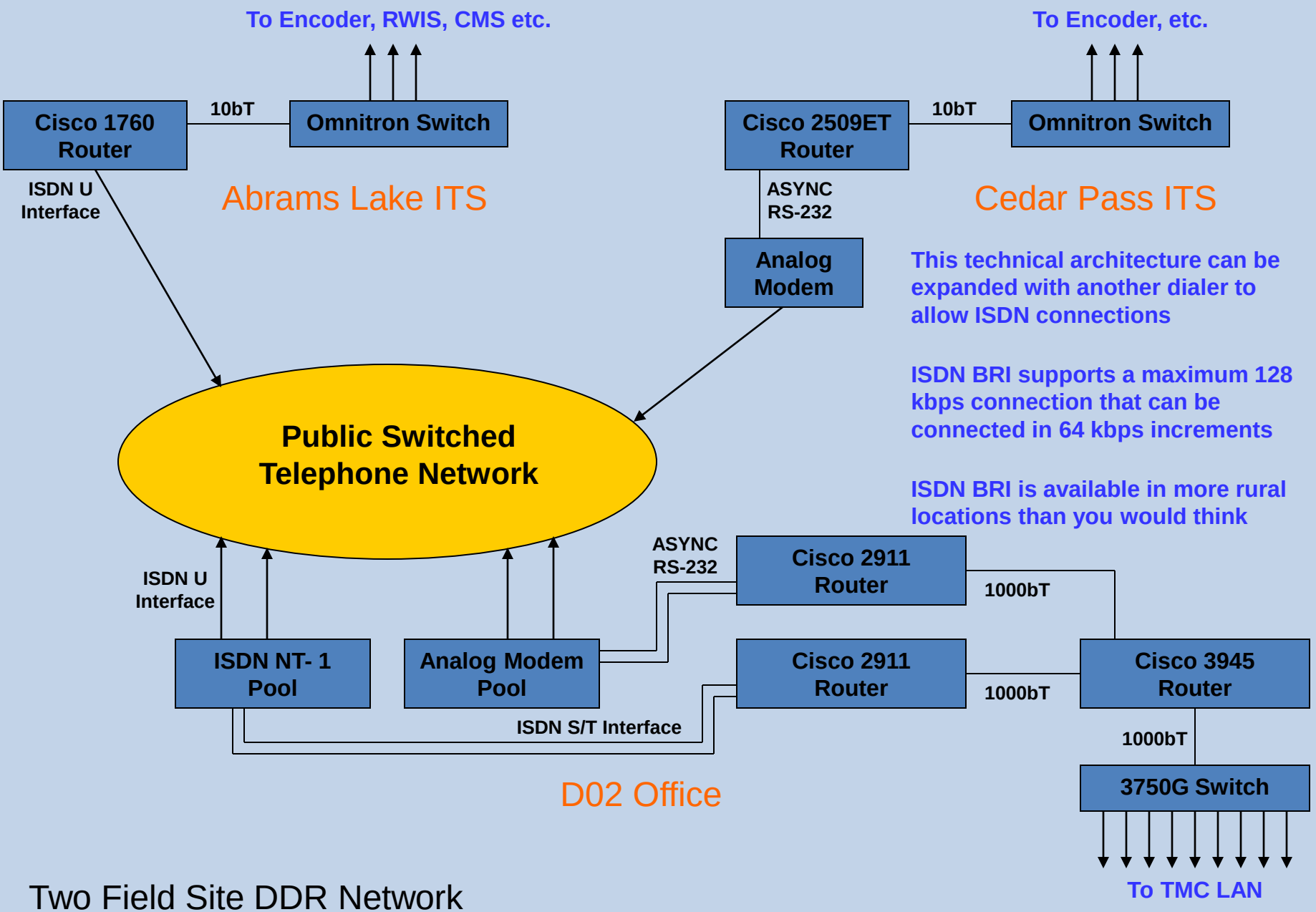

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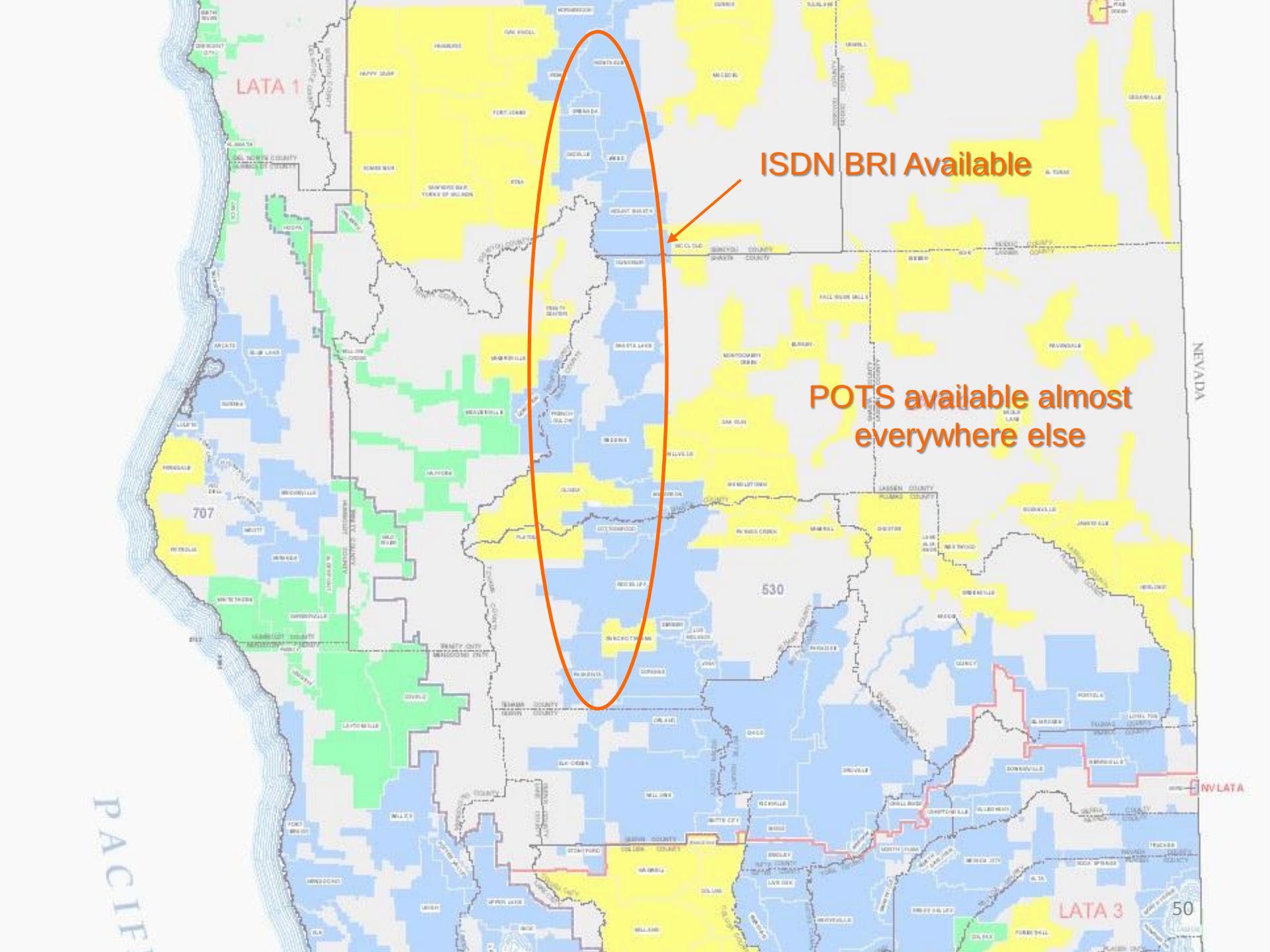
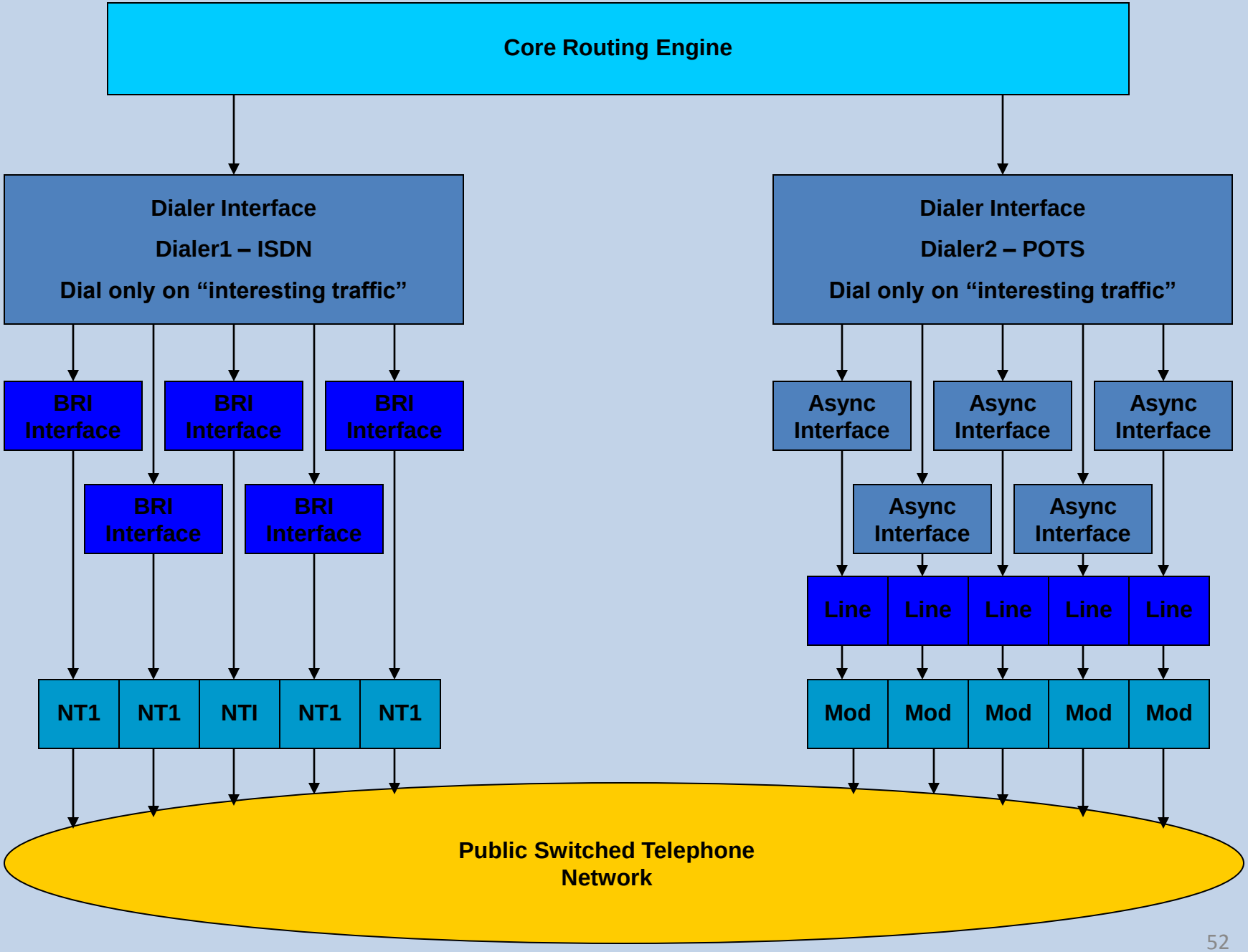

LATA 1
ISDN BRI Available
POTS available almost everywhere else
707
530
NEVADA
NV LATA
LATA 3
PACIFIC

What is the logical process that initiates a connection?

- Traffic that is routed to a network that is defined in the dialer map as being reachable through the Dialer Interface is tested to see if it is "interesting"


Core Routing Engine
Dialer Interface
Dialer1 – ISDN
Dial only on “interesting traffic”
Dialer Interface
Dialer2 – POTS
Dial only on “interesting traffic”
BRI Interface
BRI Interface
BRI Interface
BRI Interface
BRI Interface
Async Interface
Async Interface
Async Interface
Async Interface
Async Interface
Line
Line
Line
Line
Line
NT1
NT1
NTI
NT1
NT1
Mod
Mod
Mod
Mod
Mod
Public Switched Telephone Network

What is the logical process that initiates a connection?

- Traffic that is routed to a network that is defined in the dialer map as being reachable through the Dialer Interface is tested to see if it is "interesting"
- Interesting traffic is buffered and the dialer proceeds to dial the appropriate telephone number defined in the dialer map

What is the logical process that initiates a connection?

- The distant end answers and a PPP connection is established and authenticated

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What is the logical process that initiates a connection?

- The distant end answers and a PPP connection is established and authenticated
- The buffered interesting traffic is passed and any other interesting traffic is immediately passed since the connection is established
- This continues until there is no more interesting traffic for a period exceeding the dialer idle-timeout and the connection is dropped

How is Dial-on-Demand Routing configured in Cisco IOS?

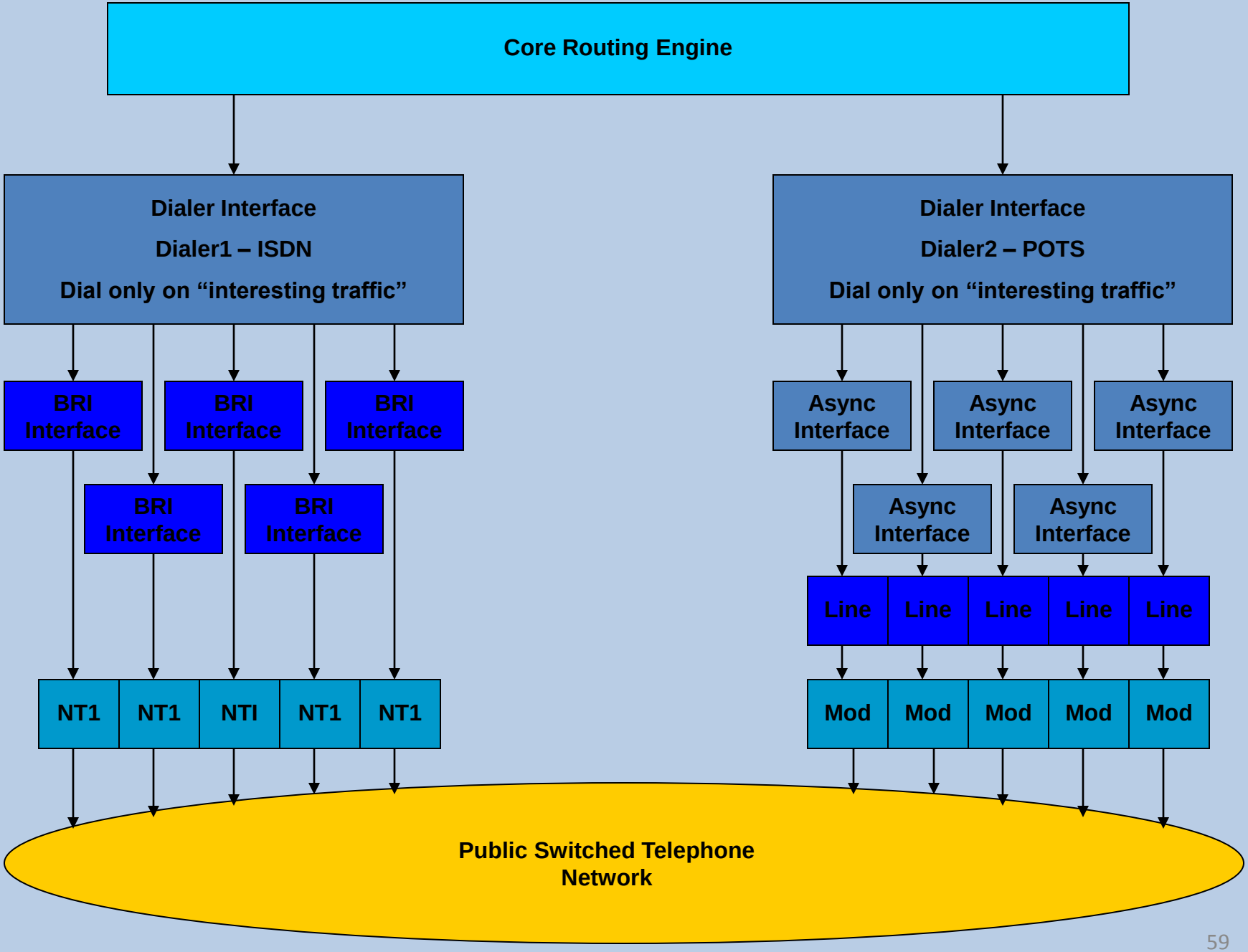
- Define a Dialer Interface that acts as the “front end” interface to the routing process

```
!
interface Dialer2
 ip address 10.XX.XX.XX 255.255.255.0
 no ip proxy-arp
 encapsulation ppp
 no ip route-cache
 no ip mroute-cache
 dialer in-band
 dialer idle-timeout 90
 dialer map ip 10.XX.XX.XX name CedarPassCCTV broadcast 9,123-4567
 dialer map ip 10.XX.XX.XX name DorrisCCTV broadcast 9,910-1112
 dialer map ip 10.XX.XX.XX name SnowmanCCTV broadcast 9,131-4151
 dialer map ip 10.XX.XX.XX name SR70-SR89CCTV broadcast 9,617-1819
 dialer-group 1
 fair-queue
 no cdp enable
 ppp authentication chap
!
```

The Dialer is a logical interface with no associated physical hardware

It has its own IP address – so as far as the routing process is concerned it is a true interface

Core Router Configuration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Async Interface
Async Interface
Async Interface
Async Interface
Line
Line
Line
Line
Line
NT1
NT1
NTI
NT1
NT1
Mod
Mod
Mod
Mod
Mod
Public Switched Telephone Network

How is Dial-on-Demand Routing configured in Cisco IOS?

- Define a Dialer Interface that acts as the “front end” interface to the routing process
- Define a Dialer Map that binds the destination network to an actual telephone number

The Dialer also contains the dialer map that binds the distant end network interface with a telephone number to connect to it

```
!
interface Dialer2
 ip address 10.XX.XX.XX 255.255.255.0
 no ip proxy-arp
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 no ip route-cache
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 ppp authentication chap
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Core Router Configuration

How is Dial-on-Demand Routing configured in Cisco IOS?

- Define a Dialer Interface that acts as the “front end” interface to the routing process
- Define a Dialer Map that binds the destination network to an actual telephone number
- Bind the Dialer Interface to a particular Dialer Group – i.e., the pointer to an access list that defines what kind of “interesting traffic” the dialer will dial on

```
!
interface Dialer2
 ip address 10.XX.XX.XX 255.255.255.0
 no ip proxy-arp
 encapsulation ppp
 no ip route-cache
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 dialer in-band
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 dialer map ip 10.XX.XX.XX name CedarPassCCTV broadcast 9,123-4567
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 dialer-group 1
 fair-queue
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 ppp authentication chap
!
```

The Dialer Group points to the access list that defines what is "interesting traffic" – it has nothing to do with the Dialer Number (Dialer2)

Core Router Configuration

How is Dial-on-Demand Routing configured in Cisco IOS?

- Define what constitutes “interesting traffic” for the Dialer Interface – the interface acts like the connection is always up and ready to pass traffic but “interesting traffic” is what actually initiates a dial connection

```
ip route 10.XX.XX.XX 255.255.255.248 10.XX.XX.XX
ip route 10.XX.XX.XX 255.255.255.248 10.XX.XX.XX
ip route 10.XX.XX.XX 255.255.255.248 10.XX.XX.XX
ip route 10.XX.XX.XX 255.255.255.248 10.XX.XX.XX
ip route 10.XX.XX.XX 255.255.255.248 10.XX.XX.XX
no ip http server
!
dialer-list 1 protocol ip permit
!
snmp-server community XXXX RO
snmp-server chassis-id D02-Central
snmp-server enable traps tty
!
dial-peer cor custom
!
```

The Dialer List is the access list that the Dialer Group points to – they associate because of the identical number (1)

In this case, the access list is simple – dial on all IP traffic

Core Router Configuration

How is Dial-on-Demand Routing configured in Cisco IOS?

- Define what constitutes “interesting traffic” for the Dialer Interface – the interface acts like the connection is always up and ready to pass traffic but “interesting traffic” is what actually initiates a dial connection
- Also define the type of connection (PPP), the type of authentication (CHAP) and how long it will stay up after there is no more “interesting traffic”

```
!
interface Dialer2
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 no cdp enable
 ppp authentication chap
!
```

The encapsulation defines the type of Layer 2 protocol the connection will use

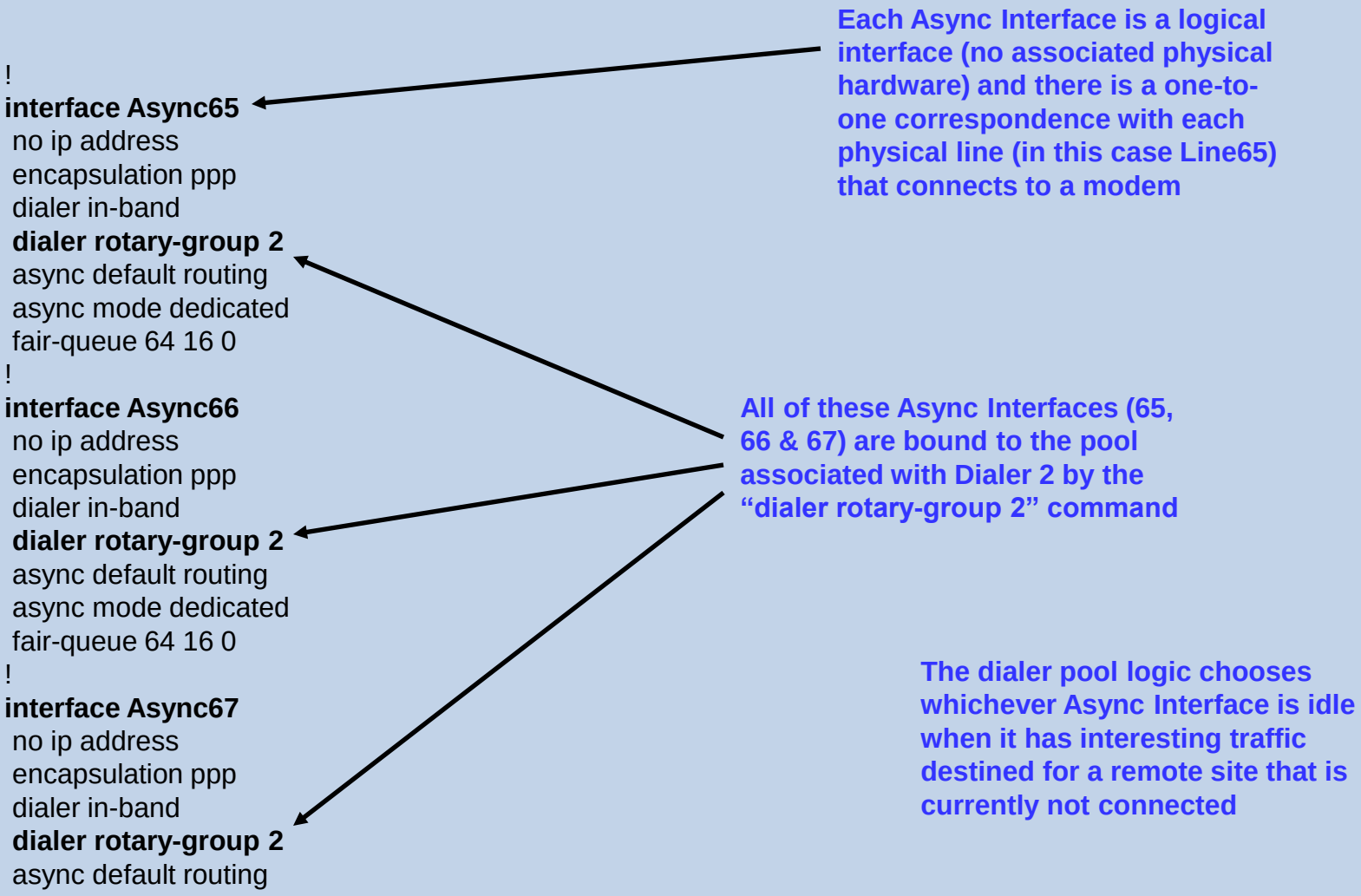
The amount of time (in seconds) that the dial connection stays up without a new burst if "interesting traffic" is also defined in the Dialer Interface

This command configures CHAP as the authentication for the link

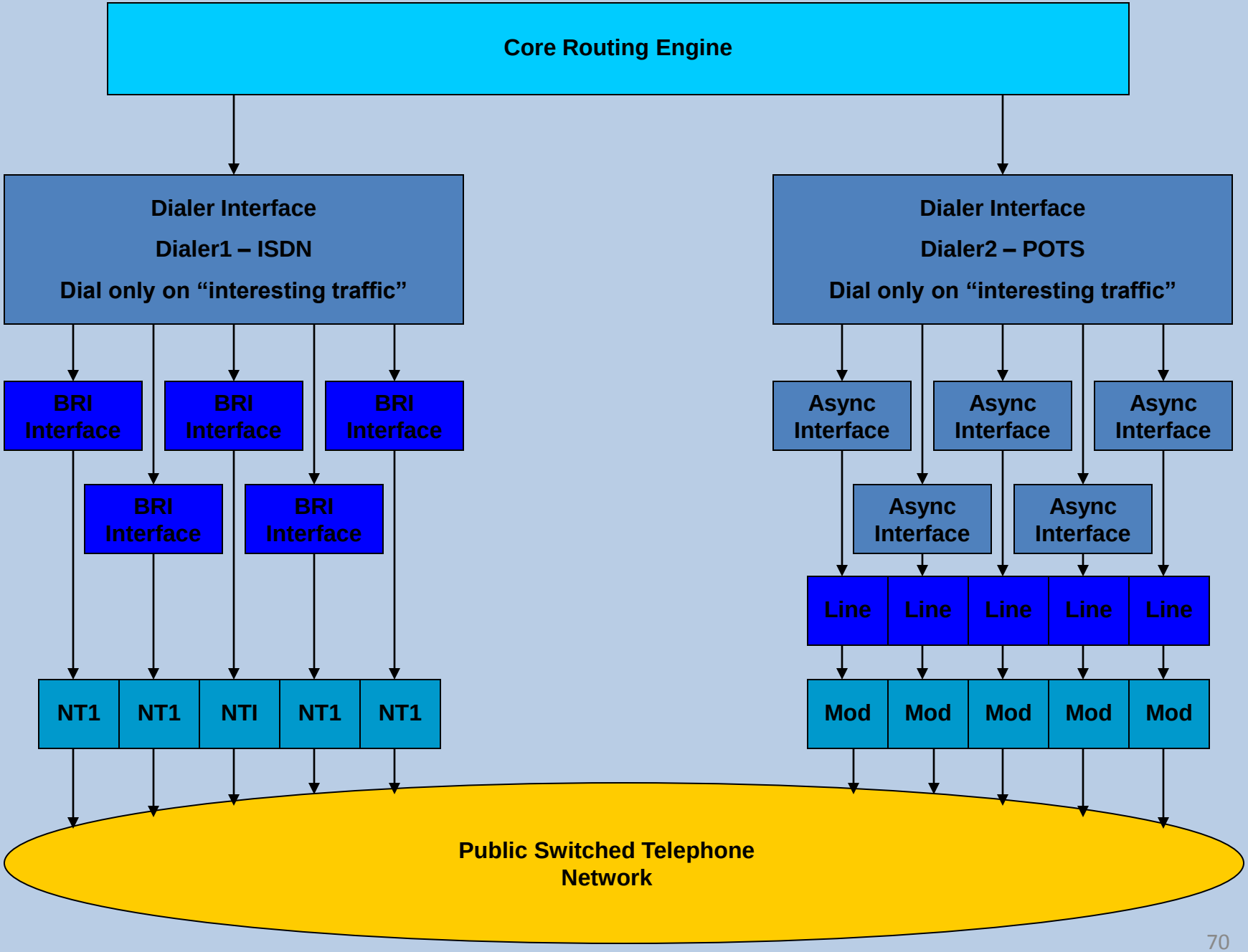
Core Router Configuration

How is Dial-on-Demand Routing configured in Cisco IOS?

- Next define the type of lower layer formatting that will be used (ASYNC) and the number of outgoing modems that will be used in the dialer pool



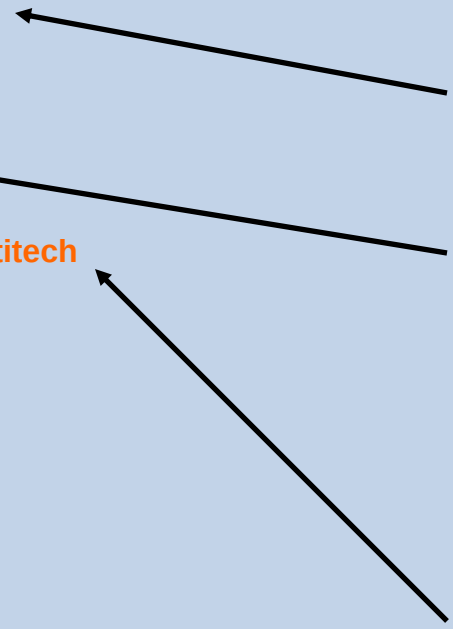
Core Router Configuration


Core Routing Engine
Dialer Interface
Dialer1 – ISDN
Dial only on “interesting traffic”
Dialer Interface
Dialer2 – POTS
Dial only on “interesting traffic”
BRI Interface
BRI Interface
BRI Interface
BRI Interface
BRI Interface
Async Interface
Async Interface
Async Interface
Async Interface
Async Interface
Line
Line
Line
Line
Line
NT1
NT1
NTI
NT1
NT1
Mod
Mod
Mod
Mod
Mod
Public Switched Telephone Network

How is Dial-on-Demand Routing configured in Cisco IOS?

- Next define the type of lower layer formatting that will be used (ASYNC) and the number of outgoing modems that will be used in the dialer pool
- Now define the physical Line Interface that is associated with each Async Interface and each modem

```
no ip domain-lookup
ip domain-name d2its.org
!
modemcap entry multitech:MSC=&FS0=1&C1&D3$SB115200$MB14400
!
line con 0
 exec-timeout 2 30
line 65 74
 flush-at-activation
 modem InOut
 modem autoconfigure type multitech
 transport input all
 stopbits 1
 speed 115200
 flowcontrol hardware
line 75 80
 flush-at-activation
 transport input all
 stopbits 1
line aux 0
line vty 0 4
 password xxXXxx
 login
!
end
```

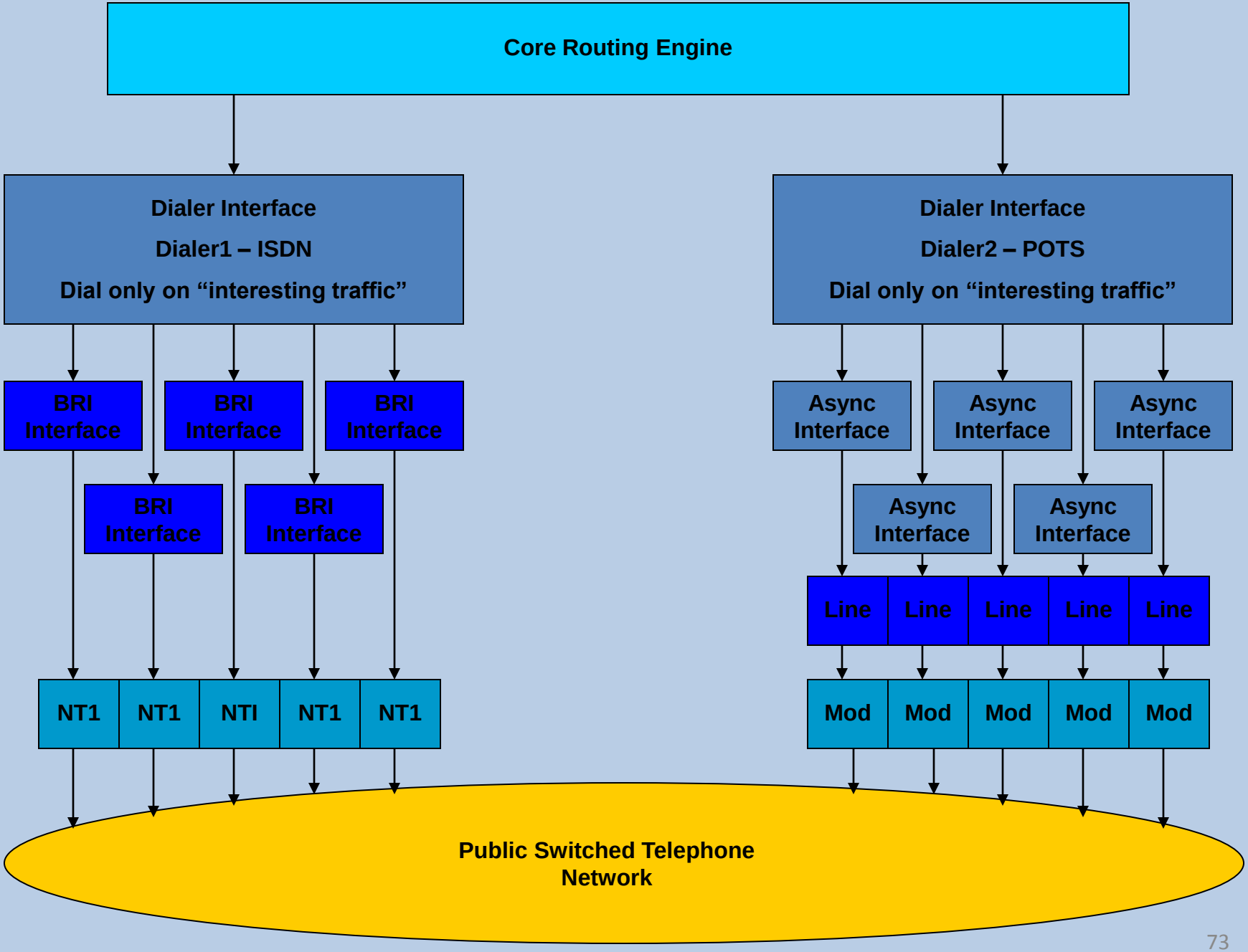


The "AT" command configuration for the particular type of modem used is also defined

The "line" command defines the physical interface characteristics for a group of lines – in this case Line65 through Line74, which correspond to Async65 through Async74

This command defines the particular type of modem used

Core Router Configuration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Line
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Line
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NT1
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NT1
NT1
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Mod
Mod
Mod
Mod
Public Switched Telephone Network

How can I expand this to also do Dial-on-Demand Routing with ISDN?

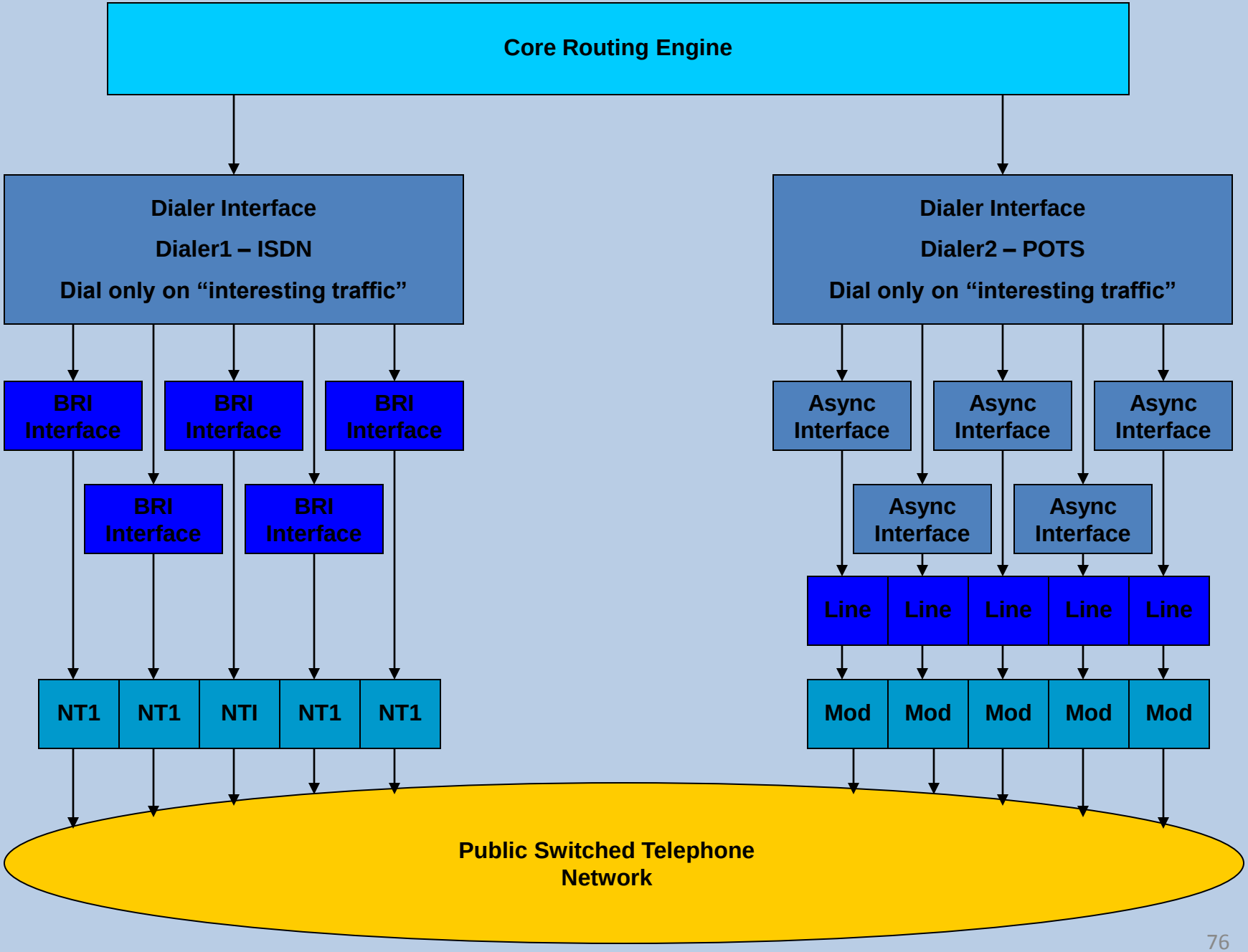
- You can define a different Dialer Interface that is for ISDN

```
!
interface Dialer1
 bandwidth 128
 ip address 10.XX.XX.XX 255.255.255.0
 no ip proxy-arp
 encapsulation ppp
 no ip route-cache
 no ip mroute-cache
 dialer in-band
 dialer idle-timeout 45
 dialer map ip 10.XX.XX.XX name AbramsLakeCCTV broadcast 123-4567
 dialer map ip 10.XX.XX.XX name AbramsLakeCCTV broadcast 123-4568
 dialer map ip 10.XX.XX.XX name WeedAirportCCTV broadcast 568-1234
 dialer map ip 10.XX.XX.XX name WeedAirportCCTV broadcast 568-1235
 dialer map ip 10.XX.XX.XX name NorthWeedCCTV broadcast 899-3456
 dialer map ip 10.XX.XX.XX name NorthWeedCCTV broadcast 899-3459
 dialer load-threshold 20 either
 dialer-group 1
 fair-queue 64 16 0
 no cdp enable
 ppp authentication chap
 ppp multilink
 multilink max-links 2
!
```

Dialer1 is defined as the Dialer Interface associated with an ISDN BRI dialer pool – there is nothing that specifically says this is an ISDN dialer except that there are only BRI Interfaces in the dialer pool that it points to

Note that the Dialer Group points to the same access list as Dialer2 did, so this dialer activates on the same "interesting traffic" – any IP traffic- as Dialer 2 does

Core Router Configuration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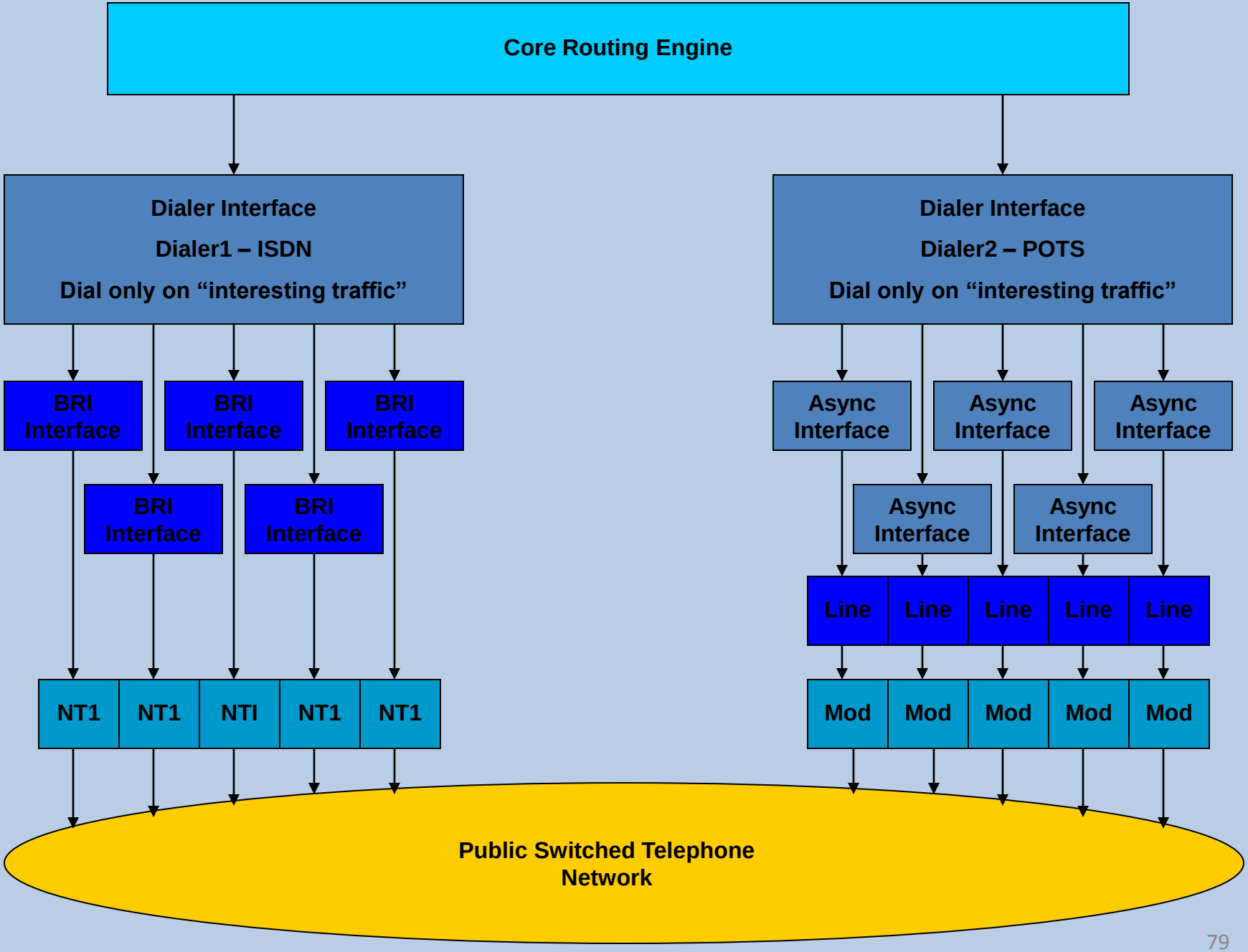
How can I expand this to also do Dial-on-Demand Routing with ISDN?

- You can define a different Dialer Interface that is for ISDN
- The ISDN BRI Interfaces must then be bound to the new Dialer Interface as was done with the Async Interfaces to the analog dialer

```
!
interface BRI3/0
 no ip address
 no ip proxy-arp
 encapsulation ppp
 no ip route-cache
 no ip mroute-cache
 dialer rotary-group 1
 isdn switch-type basic-5ess
 isdn spid1 0112345670 [1234567]
 isdn spid2 0112345680 [1234568]
 fair-queue
 no cdp enable
!
interface BRI3/1
 no ip address
 no ip proxy-arp
 encapsulation ppp
 no ip route-cache
 no ip mroute-cache
 dialer rotary-group 1
 isdn switch-type basic-ni
 isdn spid1 53012345690101 [1234569]
 isdn spid2 53012345620101 [1234562]
 fair-queue
 no cdp enable
```

Both of these BRI Interfaces (0 & 1) are bound to the pool associated with Dialer 1 by the "dialer rotary-group 1" command

Core Router Configuration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Public Switched Telephone Network

How can I expand this to also do Dial-on-Demand Routing with ISDN?

- You can define a different Dialer Interface that is for ISDN
- The ISDN BRI Interfaces must then be bound to the new Dialer Interface as was done with the Async Interfaces to the analog dialer
- The BRI contains two “B” channels, they must be bound together as one pipe – or multilinked – in order to transport 128 kbps

```
!
interface Dialer1
 bandwidth 128
 ip address 10.XX.XX.XX 255.255.255.0
 no ip proxy-arp
 encapsulation ppp
 no ip route-cache
 no ip mroute-cache
 dialer in-band
 dialer idle-timeout 45
 dialer map ip 10.XX.XX.XX name AbramsLakeCCTV broadcast 123-4567
 dialer map ip 10.XX.XX.XX name AbramsLakeCCTV broadcast 123-4568
 dialer map ip 10.XX.XX.XX name WeedAirportCCTV broadcast 568-1234
 dialer map ip 10.XX.XX.XX name WeedAirportCCTV broadcast 568-1235
 dialer map ip 10.XX.XX.XX name NorthWeedCCTV broadcast 899-3456
 dialer map ip 10.XX.XX.XX name NorthWeedCCTV broadcast 899-3459
 dialer load-threshold 20 either
 dialer-group 1
 fair-queue 64 16 0
 no cdp enable
 ppp authentication chap
 ppp multilink
 multilink max-links 2
!
```

The "multilink" command is what binds each individual "B" channel to a particular field site into a single logical data pipe

The "multilink max-links" command prevents the dialer from trying to put up more connections to a site than what exists

Core Router Configuration

```
!
interface Dialer1
 bandwidth 128
 ip address 10.XX.XX.XX 255.255.255.0
 no ip proxy-arp
 encapsulation ppp
 no ip route-cache
 no ip mroute-cache
 dialer in-band
 dialer idle-timeout 45
 dialer map ip 10.XX.XX.XX name AbramsLakeCCTV broadcast 123-4567
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 dialer map ip 10.XX.XX.XX name WeedAirportCCTV broadcast 568-1235
 dialer map ip 10.XX.XX.XX name NorthWeedCCTV broadcast 899-3456
 dialer map ip 10.XX.XX.XX name NorthWeedCCTV broadcast 899-3459
 dialer load-threshold 20 either
 dialer-group 1
 fair-queue 64 16 0
 no cdp enable
 ppp authentication chap
 ppp multilink
 multilink max-links 2
!
```

Dialer1 defines all of the same parameters as Dialer2

Note that there are two telephone numbers in the dialer map for each ISDN field site – each number corresponds to an individual "B" channel

Core Router Configuration

How can I expand this to also do Dial-on-Demand Routing with ISDN?

- The Dialer Interface will first connect to a field site with a single “B” channel – this is good for grabbing a small amount of data (like RWIS data or a still jpeg)

How can I expand this to also do Dial-on-Demand Routing with ISDN?

- The Dialer Interface will first connect to a field site with a single “B” channel – this is good for grabbing a small amount of data (like RWIS data or a still jpeg)
- Initiating the multilinking of both “B” channels is configured in the Dialer Interface

```
!
interface Dialer1
 bandwidth 128
 ip address 10.XX.XX.XX 255.255.255.0
 no ip proxy-arp
 encapsulation ppp
 no ip route-cache
 no ip mroute-cache
 dialer in-band
 dialer idle-timeout 45
 dialer map ip 10.XX.XX.XX name AbramsLakeCCTV broadcast 123-4567
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 dialer map ip 10.XX.XX.XX name NorthWeedCCTV broadcast 899-3459
 dialer load-threshold 20 either
 dialer-group 1
 fair-queue 64 16 0
 no cdp enable
 ppp authentication chap
 ppp multilink
 multilink max-links 2
!
```

The "load" or amount of traffic the router is trying to send over a connection is used to determine if another channel is needed

The "dialer load-threshold" command is what defines under what conditions the second "B" channel is brought up and multilinked, this is known as Bandwidth on Demand or BOD

Core Router Configuration

DDR Things to Consider

- Lines into the TMC are limited

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- Because the number of outgoing lines are limited, the TMC must also limit the number of sites displayed on the wall

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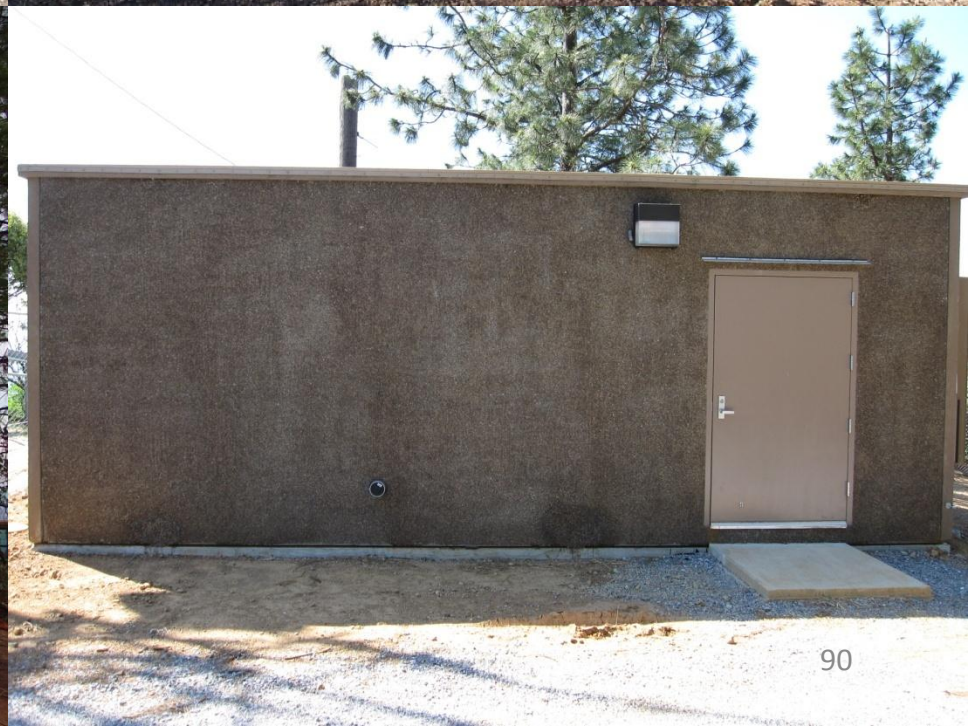
DDR Things to Consider

- Lines into the TMC are limited
- Because the number of outgoing lines are limited, the TMC must also limit the number of sites displayed on the wall
- JPEG update frequency also ties-up phone lines causing contention, and should be considered when restricting number of sites for TMC display
- Channel limitation – If you're using DDR, services are limited to lower bandwidth connections

Point-to-Point Microwave Network



Point-to-Point Microwave Network

- Currently microwave system built with T1 radios, capacity for 8 T1's north and 4 T1's south

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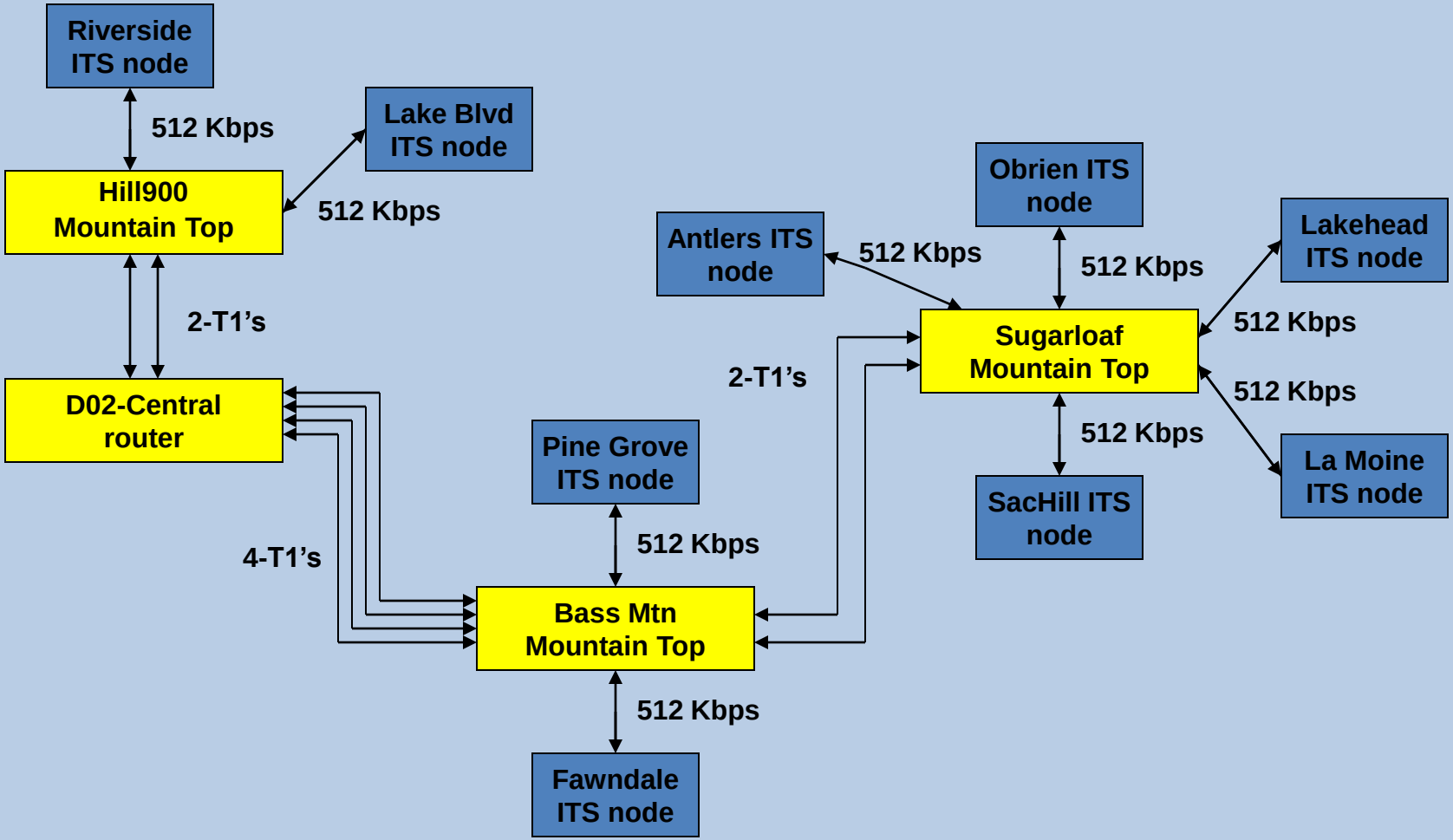


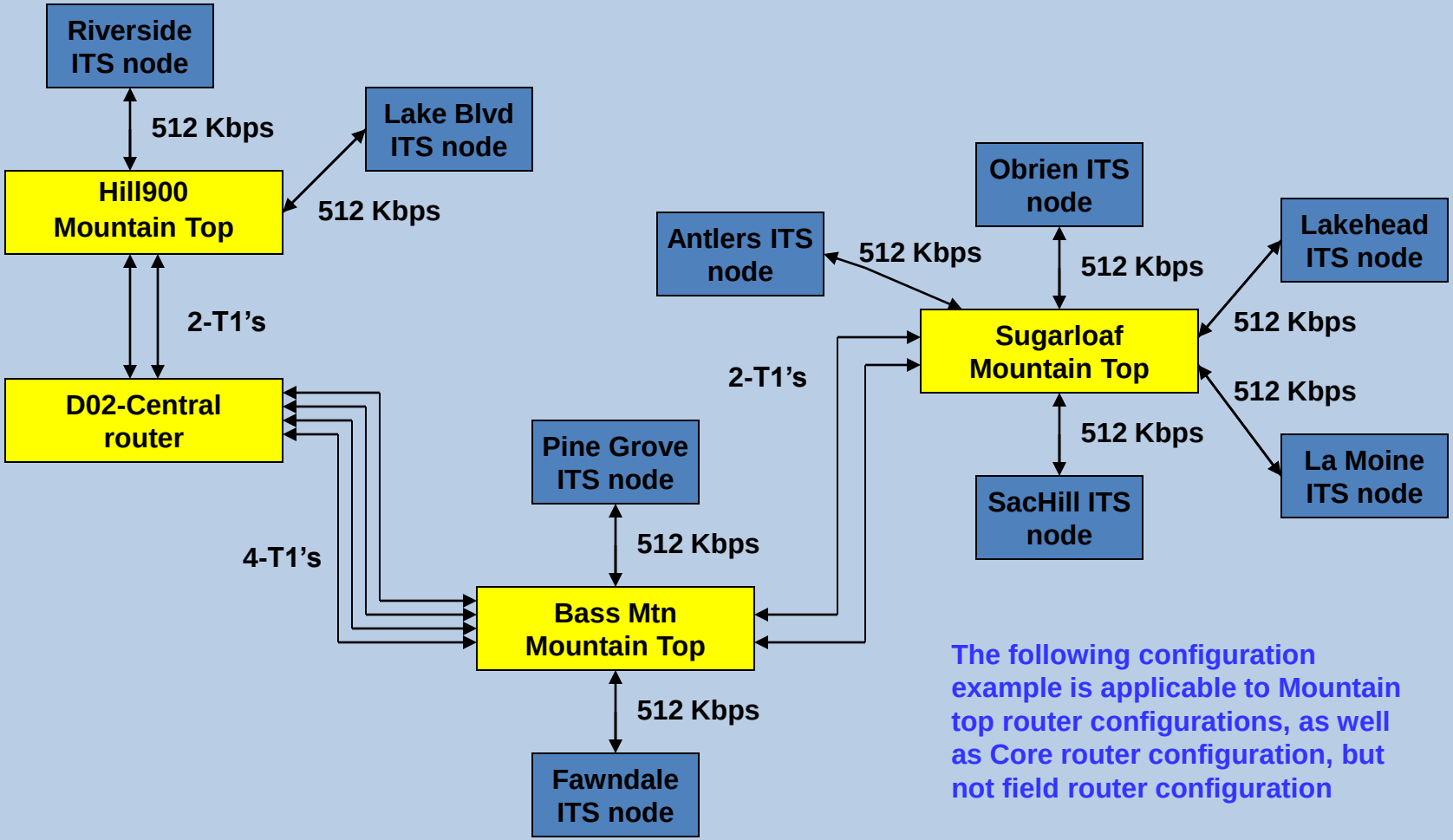
Point-to-Point Microwave Network

- Currently microwave system built with T1 radios, capacity for 8 T1's north and 4 T1's south
- Remember that the microwave network is an extended star
- Traffic from the core will pass through several mountain top sites before reaching a remote router at the far end of the network

Point-to-Point Microwave Network

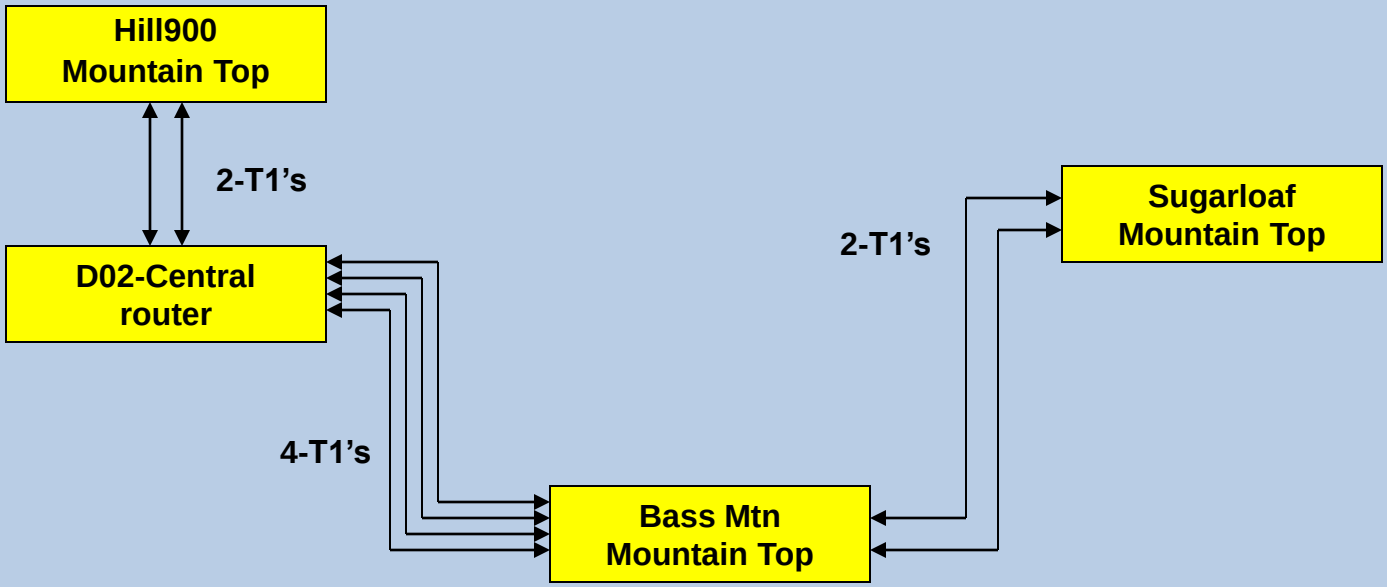
- Currently microwave system built with T1 radios, capacity for 8 T1's north and 4 T1's south
- Remember that the microwave network is an extended star
- Traffic from the core will pass through several mountain top sites before reaching a remote router at the far end of the network
- These mountain top links are backbone links

Point-to-Point Microwave Network



The following configuration example is applicable to Mountain top router configurations, as well as Core router configuration, but not field router configuration

Point-to-Point Microwave Network



```
!
interface Multilink3
 bandwidth 3072
 ip address 10.xx.xx.xx 255.255.255.252
 no ip proxy-arp
 no ip route-cache
 no ip mroute-cache
 no cdp enable
 ppp multilink
 ppp multilink group 3
!
interface Serial1/0
 bandwidth 1536
 no ip address
 no ip proxy-arp
 encapsulation ppp
 no ip route-cache
 no ip mroute-cache
 serial restart-delay 0
 no dce-terminal-timing-enable
 no fair-queue
 no cdp enable
 ppp authentication chap
 ppp multilink
 ppp multilink group 3
!
```

The multilink is a logical interface that bundles multiple physical circuits, such as a T1's, into one channelized link

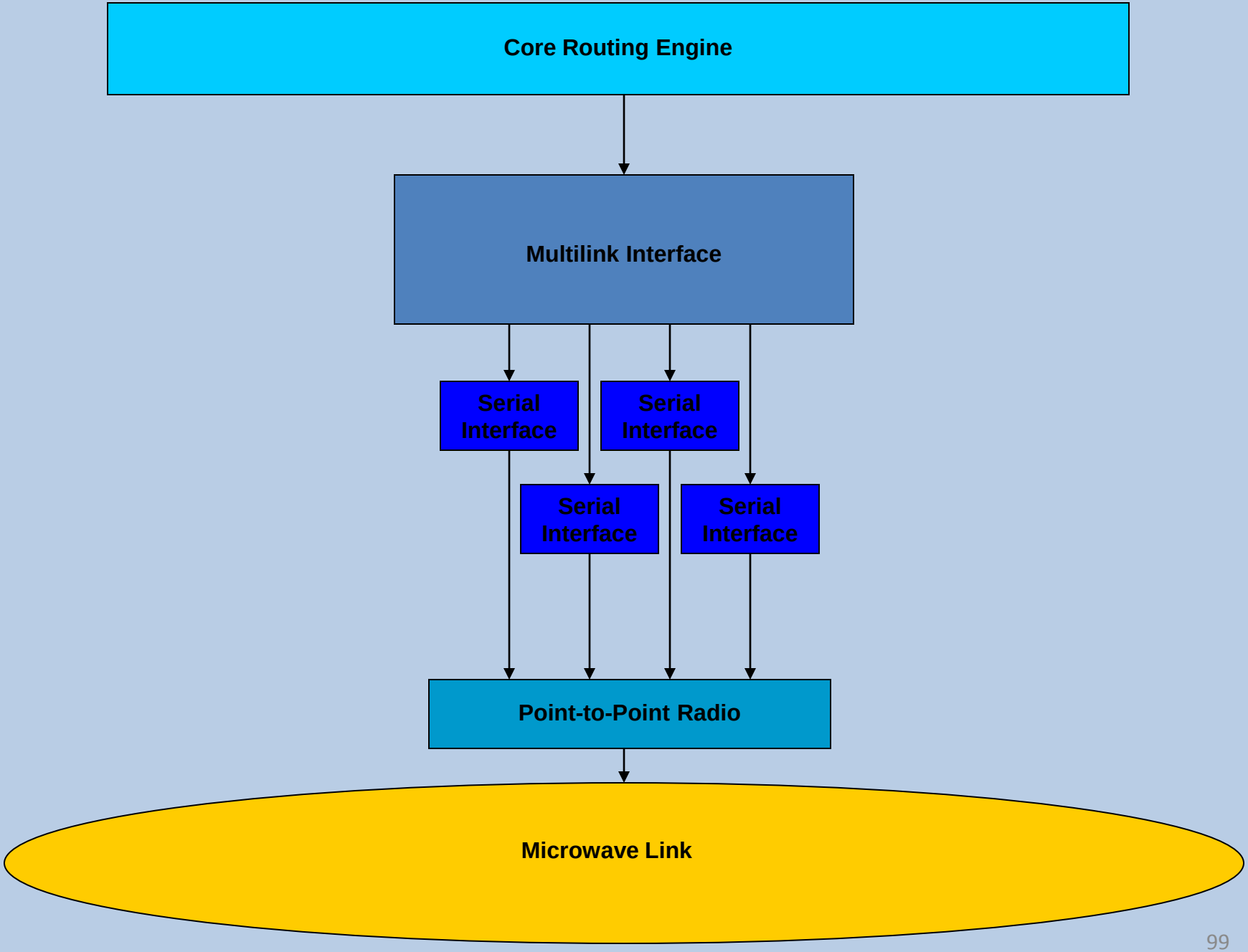
Each multilink represents a multi-T1 connection to the mountain top, shown is a 2-T1 connection

Multilink encapsulated as a PPP connection

The multilink group name binds individual circuits to the this group of circuits

Note the connection is always on, there is no timeout, etc, as in the dialer configuration

Core Router Configuration


Core Routing Engine
Multilink Interface
Serial Interface
Serial Interface
Serial Interface
Serial Interface
Point-to-Point Radio
Microwave Link

```
!
interface Multilink3
 bandwidth 3072
 ip address 10.xx.xx.xx 255.255.255.252
 no ip proxy-arp
 no ip route-cache
 no ip mroute-cache
 no cdp enable
 ppp multilink
 ppp multilink group 3
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interface Serial1/0
 bandwidth 1536
 no ip address
 no ip proxy-arp
 encapsulation ppp
 no ip route-cache
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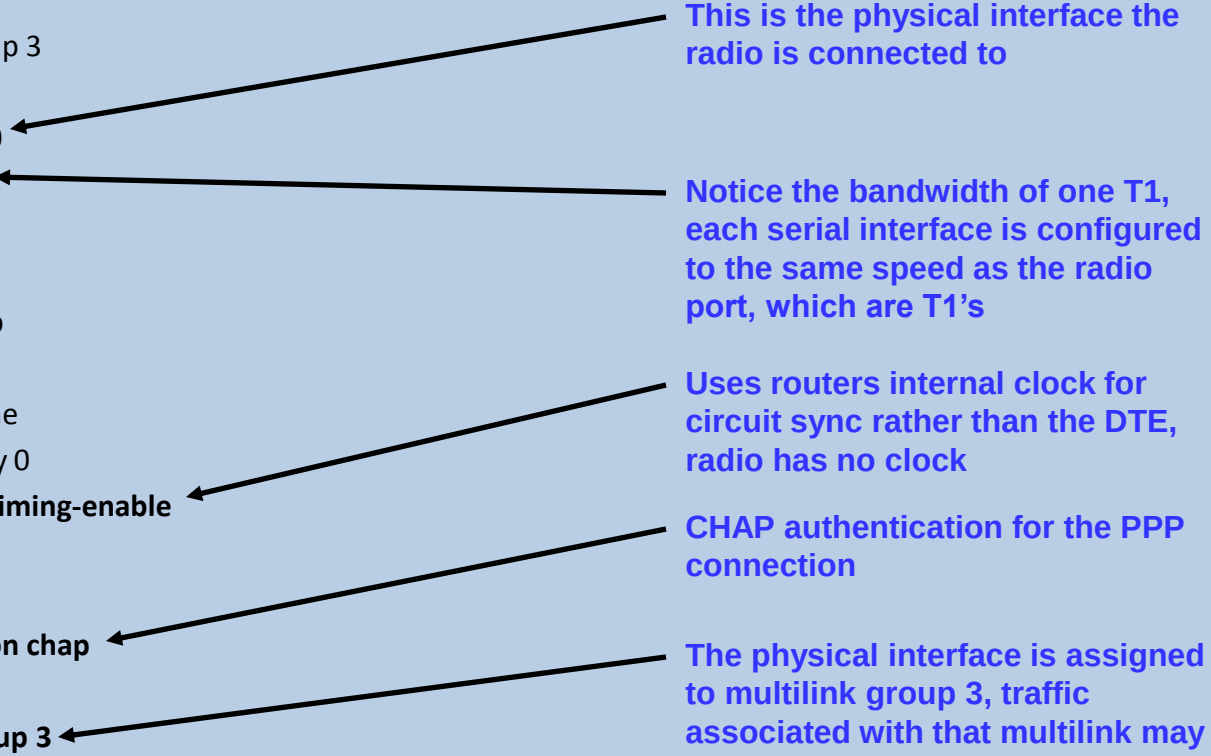


This is the physical interface the radio is connected to

Notice the bandwidth of one T1, each serial interface is configured to the same speed as the radio port, which are T1's

Uses routers internal clock for circuit sync rather than the DTE, radio has no clock

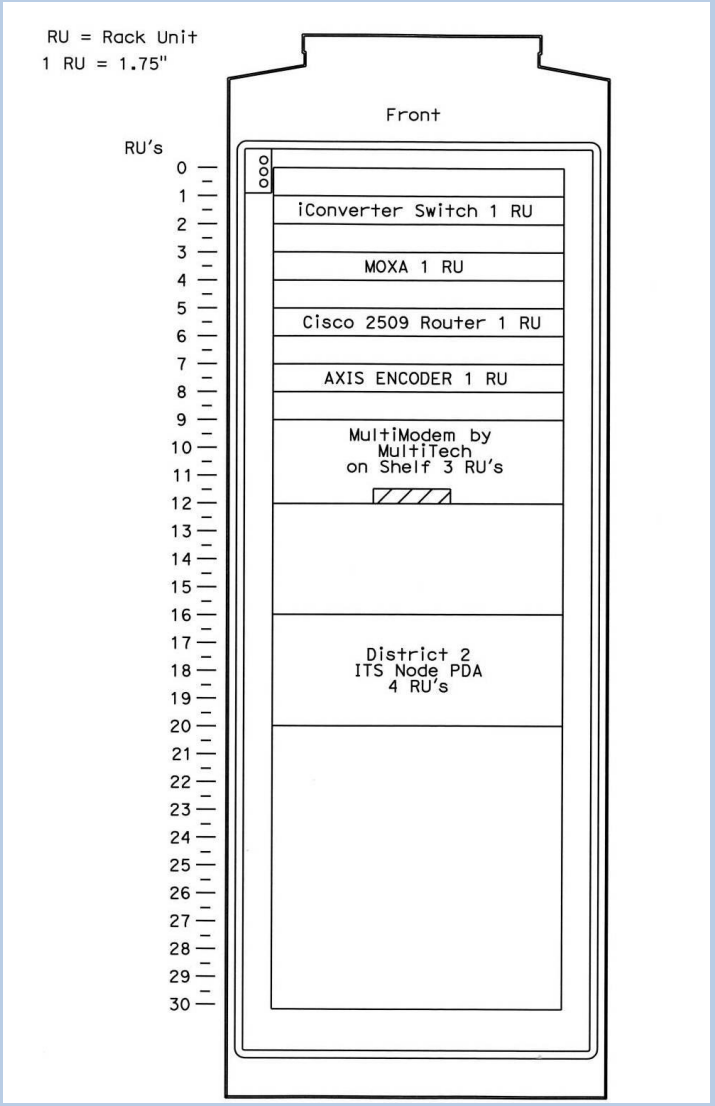
CHAP authentication for the PPP connection

The physical interface is assigned to multilink group 3, traffic associated with that multilink may use this interface (one of two)

Core Router Configuration


ITS Node
Design

ITS Node – POTS Site



Port Key

(Port type, Port number, Connector Type) IP Address if Applicable

E = Ethernet Port
S = Serial Port
V = Video Port
A = Asynch Port
R = RJ-45 Connector (following T568B standard)
RC = RJ-45 w/ custom connector
T = Terminal Connector
B = BNC connector
C = Cisco Asynch Port

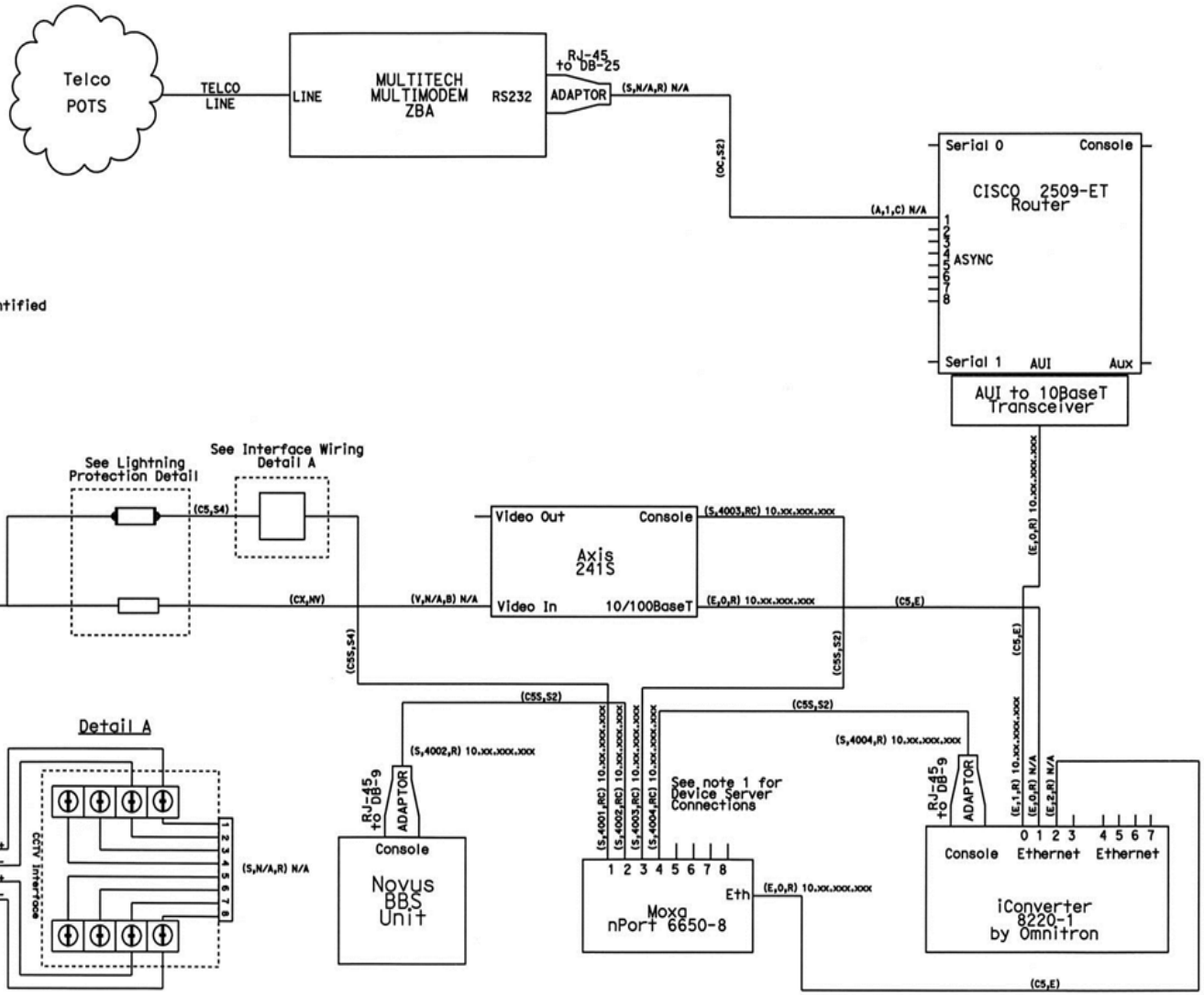
Cabling Key

(Cable, Signal)

C5 = Cat5e Straightthrough cable (Blue Cable)
C5S = Cat5e D2 Standard Serial Cable (Green Cable)
CX = RG6u Coaxial Cable
OC = Octopus Cable (Cisco part #72 0845 01)
S2 = RS-232
R4 = RS-422
E = Ethernet
NV = NTSC Video

ITS NODE WITH CCTV

POTS LINE



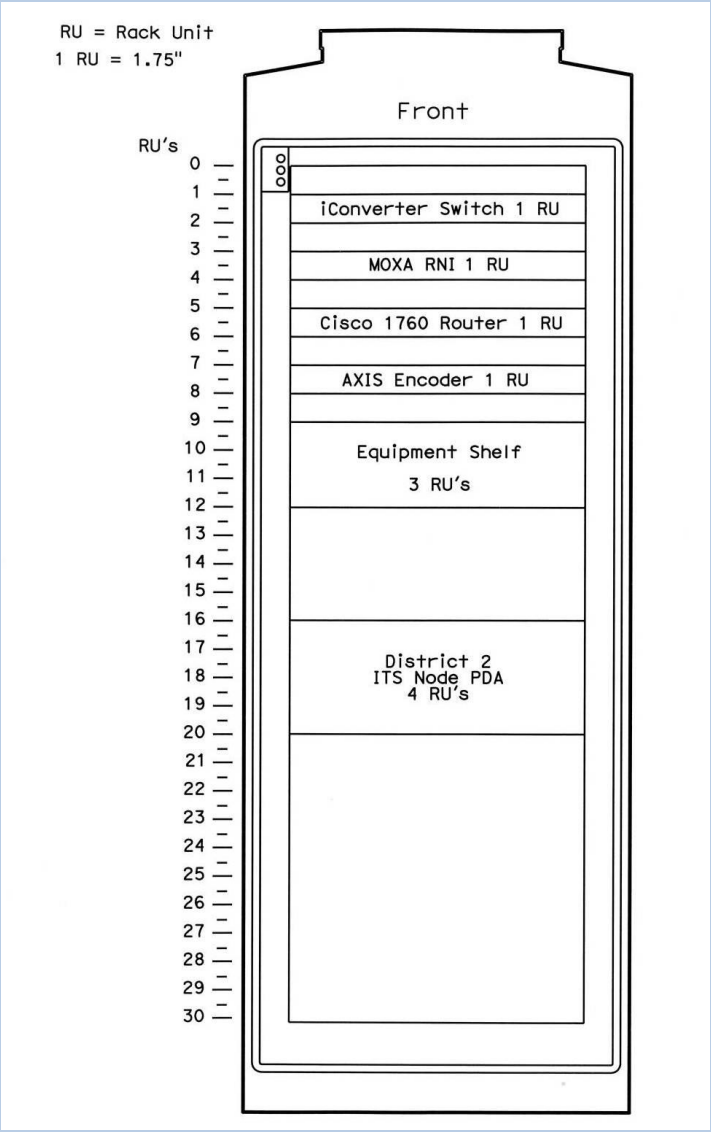
Note:

1. Serial Devices connected to Moxa Device Server are identified by color coded shrink tube at the Moxa device server according to table 1,

Table 1

Port	Color	Device
1	Yellow	PTZ Controls
2	Red	BBS Console
3	Green	Encoder Console
4	Blue	Switch Console

ITS Node – ISDN Site



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ITS NODE WITH CCTV

ISDN SITE

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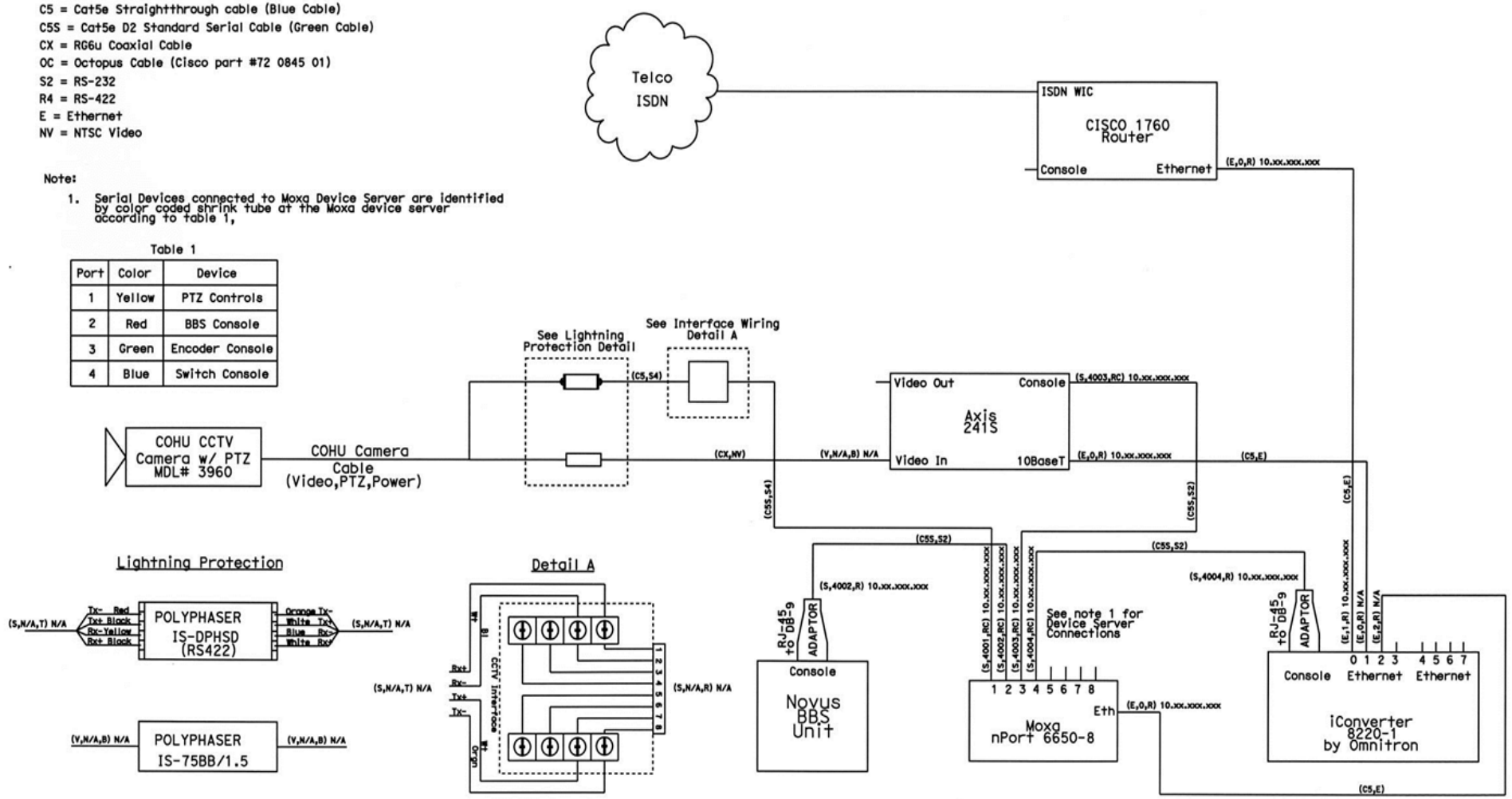

DDR Field Site Configuration Considerations

- The field router configured similar to core

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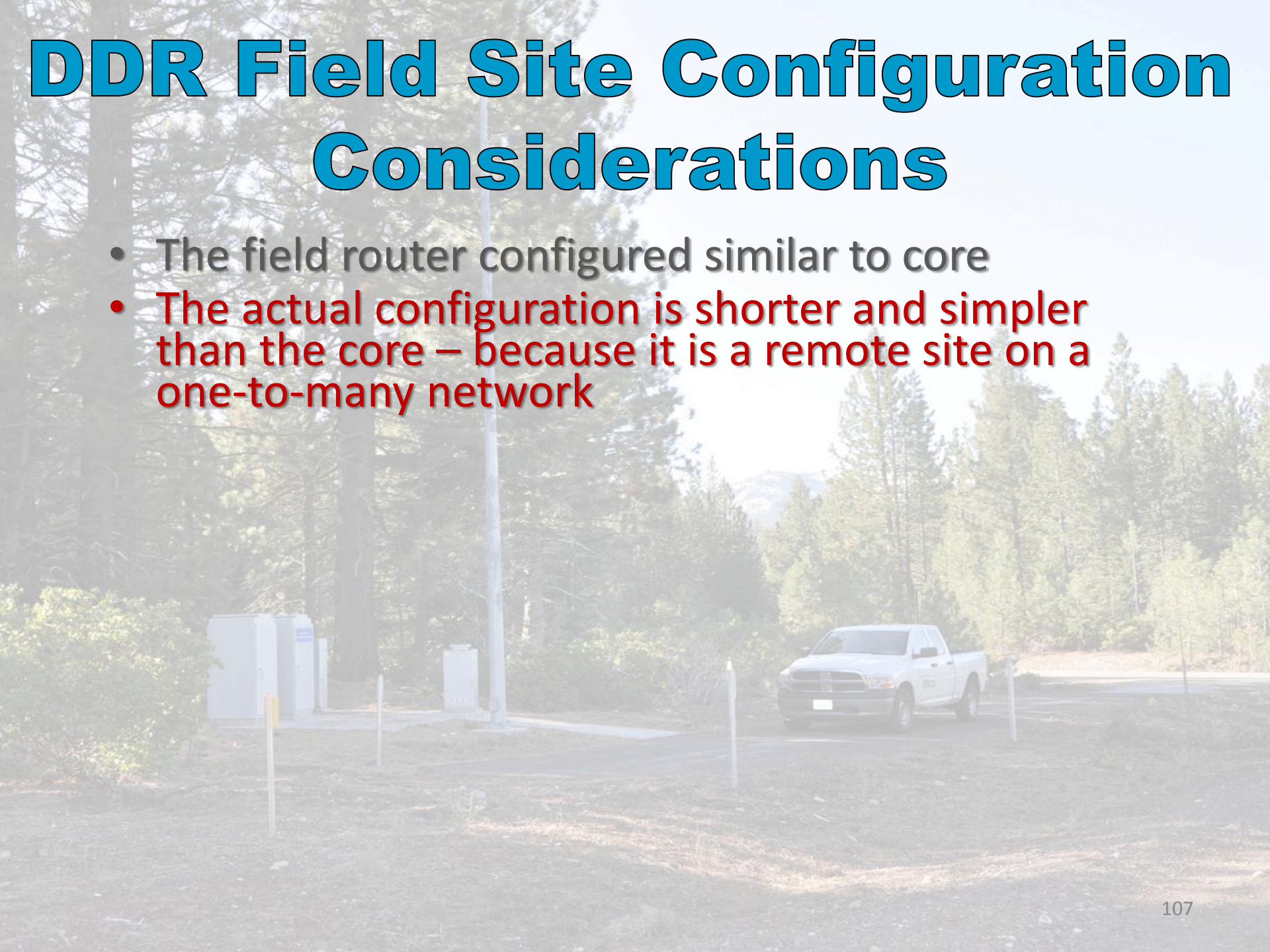
- The actual configuration is shorter and simpler than the core – because it is a remote site on a one-to-many network



ITS Node Router Configuration for DDR

```
interface Async1
 no ip address
 encapsulation ppp
 dialer in-band
 dialer rotary-group 2
 async default routing
 async mode dedicated
 no fair-queue
!
interface Dialer2
 ip address 10.XX.XX.XX 255.255.255.0
 no ip proxy-arp
 encapsulation ppp
 no ip route-cache
 no ip mroute-cache
 dialer in-band
 dialer idle-timeout 90
 dialer map ip 10.XX.XX.XX name D02-Central broadcast 5551234
 dialer-group 1
 no fair-queue
 no cdp enable
 ppp authentication chap
!
dialer-list 1 protocol ip permit
```

All of the same logical bindings that are present at the core are present in the field router – just fewer in number because there is only one interface in the "pool"

Note that there is only one "dialer map" entry – the connection back to the default route (the core)

POTS

ITS Node Router Configuration for DDR

```
interface BRI0/0
 no ip address
 encapsulation ppp
 no ip mroute-cache
 dialer rotary-group 1
 dialer-group 1
 isdn switch-type basic-ni
 isdn spid1 530XXXXXXX0101
 isdn spid2 530XXXXXXX0101
 no fair-queue
 no cdp enable
!
interface Dialer1
 ip address 10.XX.XX.XXX 255.255.255.0
 no ip proxy-arp
 encapsulation ppp
 dialer in-band
 dialer idle-timeout 45
 dialer map ip 10.XX.XX.X name D02-Central broadcast 5551234
 dialer map ip 10.XX.XX.X name D02-Central broadcast 5555678
 dialer load-threshold 20 either
 dialer-group 1
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 no cdp enable
 ppp authentication chap
 ppp multilink
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```

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ISDN

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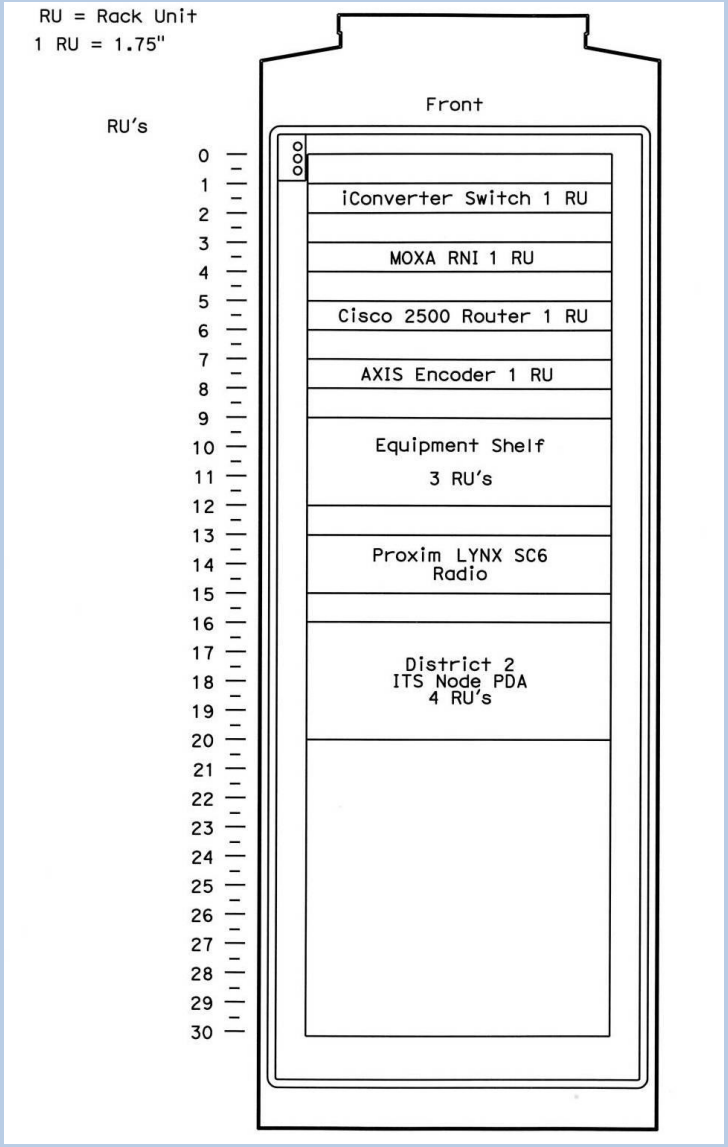
- Use of a limited incoming dialer pool at the core (not implemented here) can make testing much more convenient

DDR Field Site Configuration Considerations

- The field router configured similar to core
- The actual configuration is shorter and simpler than the core – because it is a remote site on a one-to-many network
- You can allow the field site router to initiate a connection to the core for troubleshooting and testing, but devices running on the network must not be able to dial in to the core; turn off default discovery features, such as Cisco CDP
- Use of a limited incoming dialer pool at the core (not implemented here) can make testing much more convenient
- However, dialing in from the field could be security issue

ITS Node - Microwave



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V = Video Port
A = Asynch Port
R = RJ-45 Connector (following T568B standard)
RC = RJ-45 w/ custom connector
T = Terminal Connector
B = BNC connector
C = Cisco Serial Port
VR = V.35 Port

Cabling Key

(Cable, Signal)

C5 = Cat5e Straightthrough cable (Blue Cable)
C5S = Cat5e D2 Standard Serial Cable (Green Cable)
CX = RG6u Coaxial Cable
OC = Octopus Cable (Cisco part #72 0845 01)
CV = Cisco V.36 Serial Cable
S2 = RS-232
R4 = RS-422
E = Ethernet
NV = NTSC Video

Note:

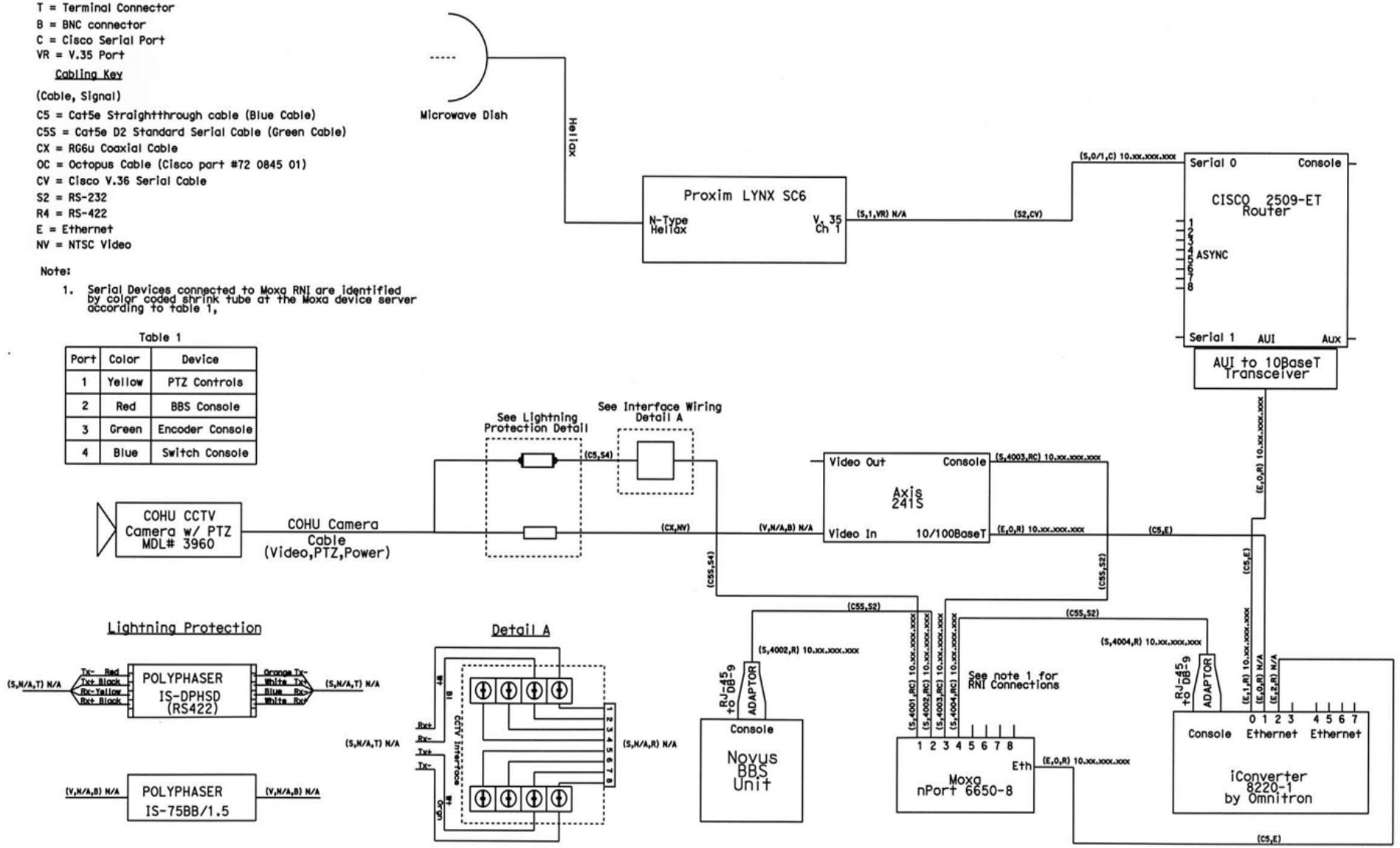
1. Serial Devices connected to Moxa RNI are identified by color coded shrink tube at the Moxa device server according to table 1,

Table 1

Port	Color	Device
1	Yellow	PTZ Controls
2	Red	BBS Console
3	Green	Encoder Console
4	Blue	Switch Console

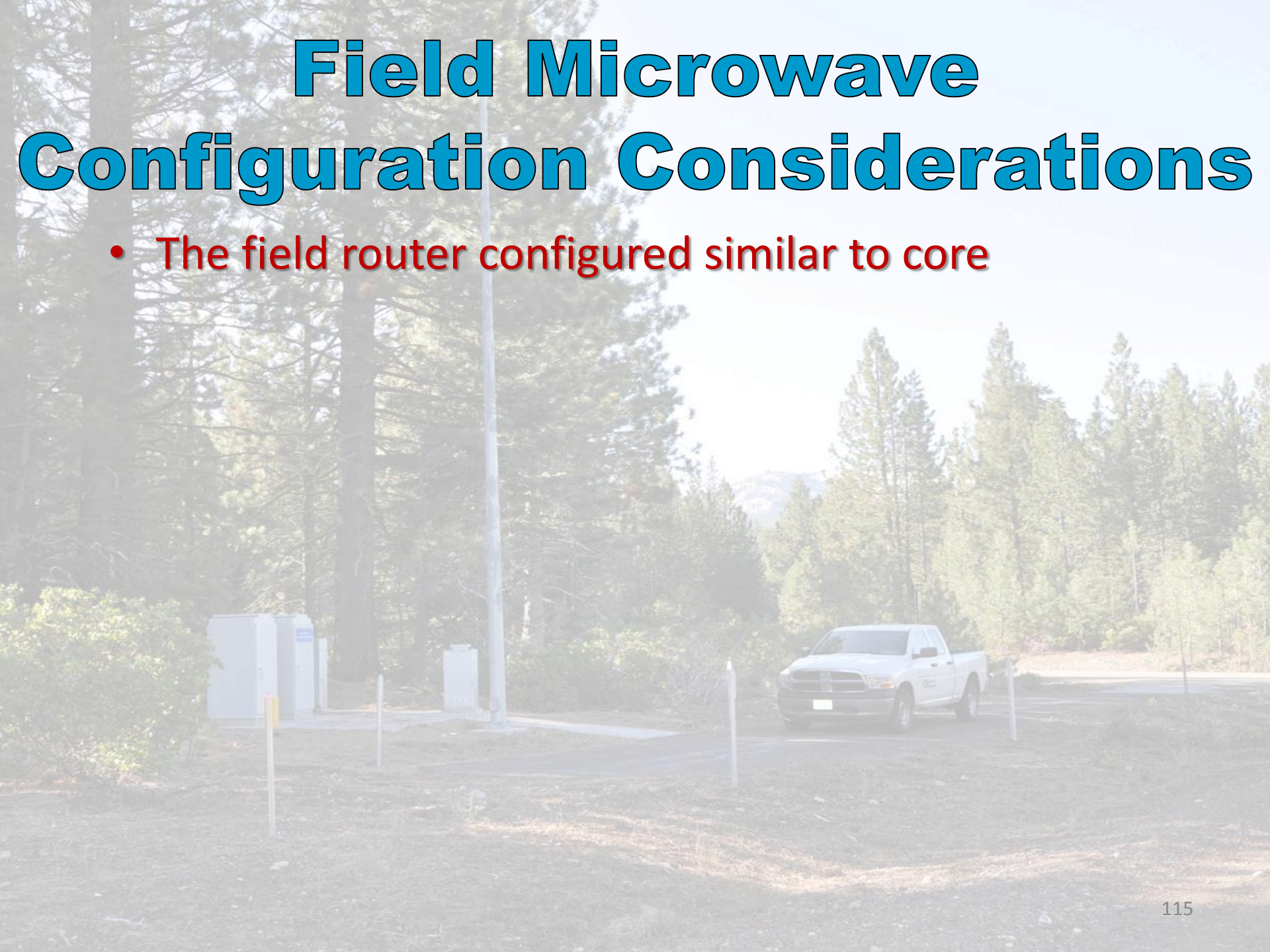
ITS NODE WITH CCTV

RADIO SITE



Field Microwave Configuration Considerations

- The field router configured similar to core



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- The actual configuration is shorter and simpler than the core – because it is a remote site on a one-to-many network
- Connection always on (unless link goes down)
- Linked to mountain top and routed from there to the DO via microwave backbone

```
no ip domain-lookup
ip domain-name d2its.org
!
crypto key generate rsa
!
interface Loopback0
 ip address 1.1.1.1 255.255.255.255
!
interface Ethernet0
 ip address 10.xx.xx.xxx 255.255.255.240
 no cdp enable
!
interface Serial0
 bandwidth 512
 ip address 10.xx.xx.xx 255.255.255.252
 no ip proxy-arp
 encapsulation ppp
 no ip route-cache
 no ip mroute-cache
 no fair-queue
 no cdp enable
 ppp authentication chap
!
ip classless
ip route 0.0.0.0 0.0.0.0 10.xx.xx.xx
no ip http server
```

Notice there is no multilink configuration as in the core, multilinking is not needed, as only one interface is connected to the radio

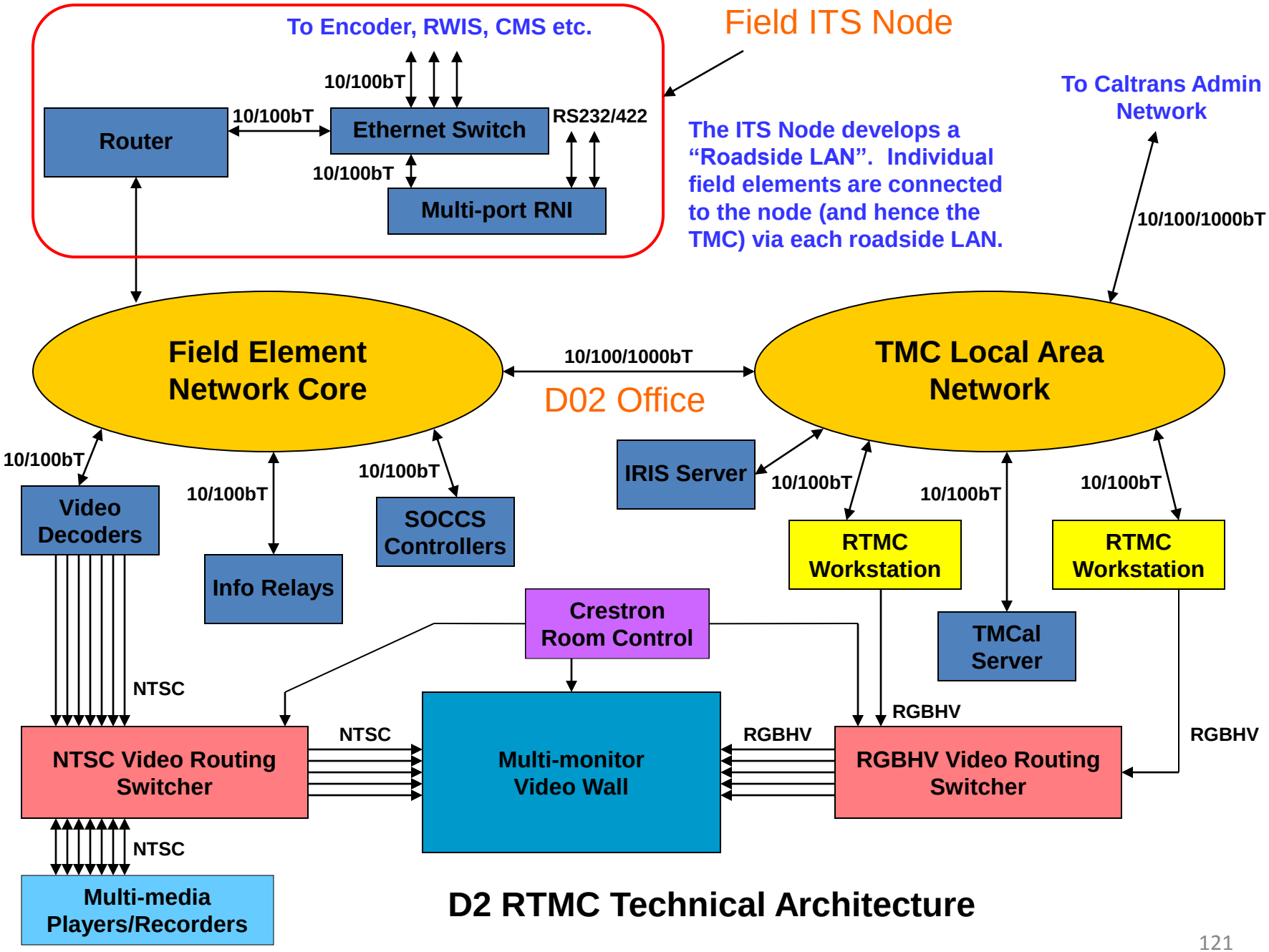
This is the interface the radio is connected to, no need for logical interfaces

PPP encapsulation and CHAP authentication

Note the connection is always on, there is no timeout

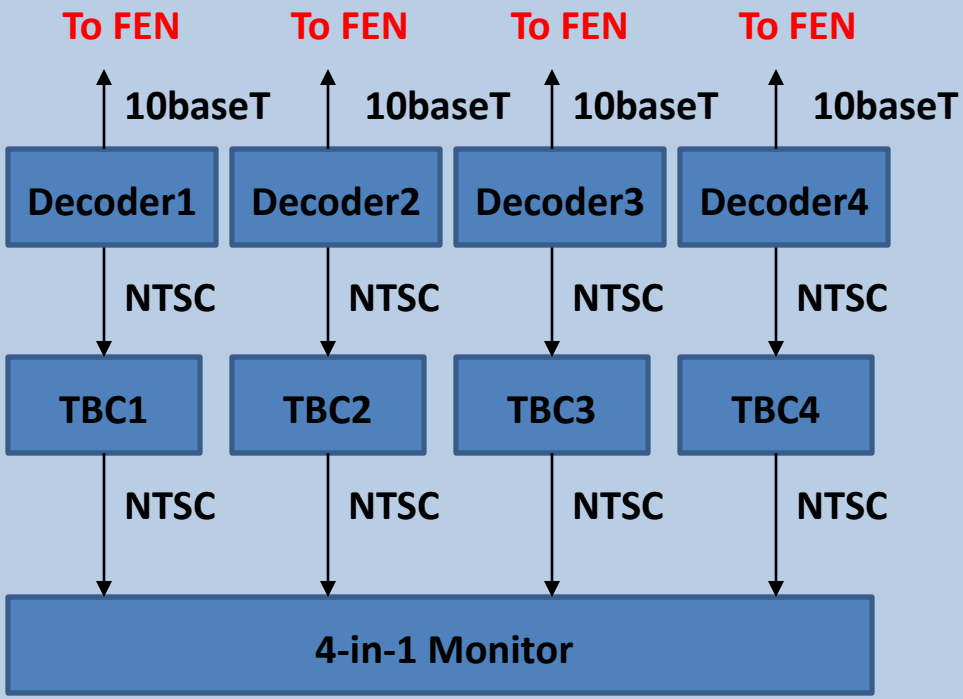
Field Router Configuration

Video Distribution



D2 RTMC Technical Architecture

Video Distribution

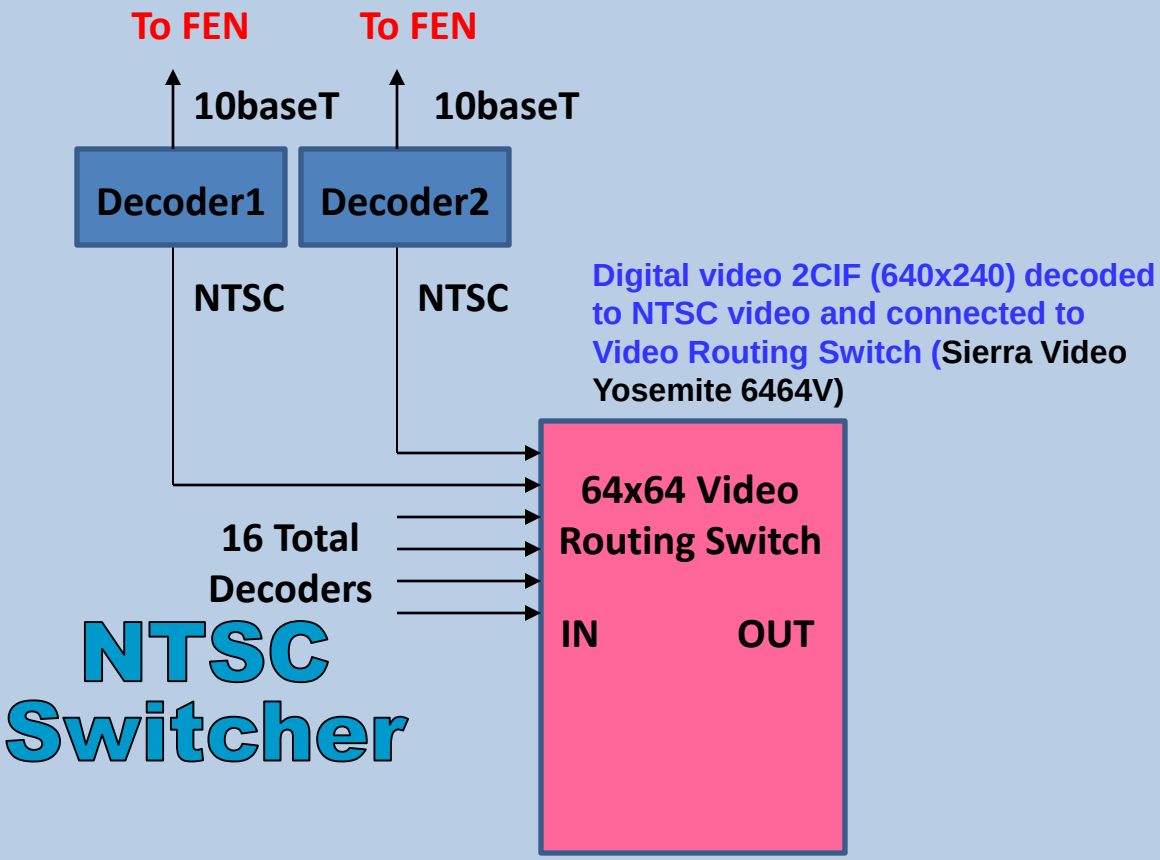


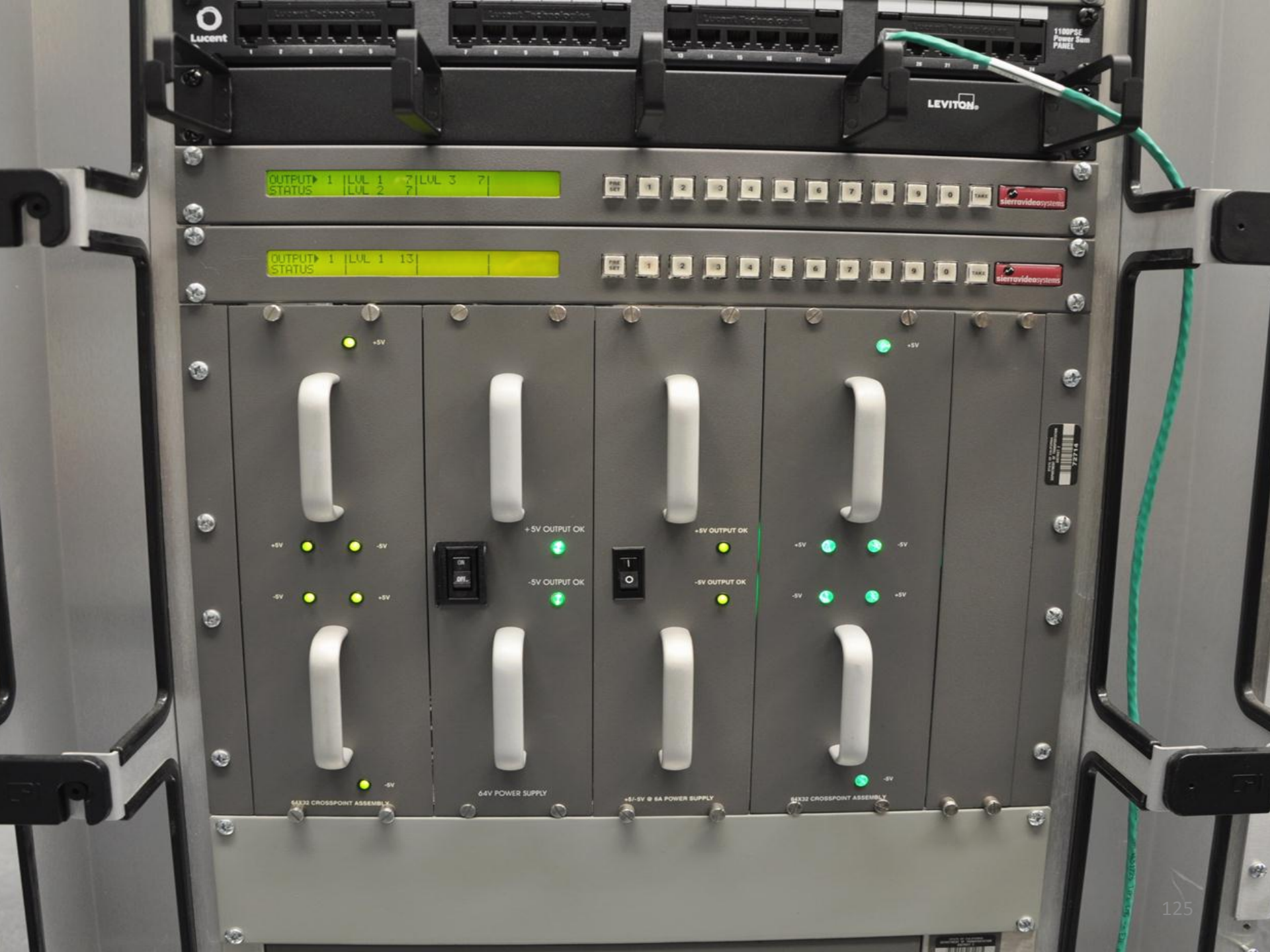
NTSC video sources in field encoded and routed over FEN to sixteen total Decoders (Axis 292) at District Office

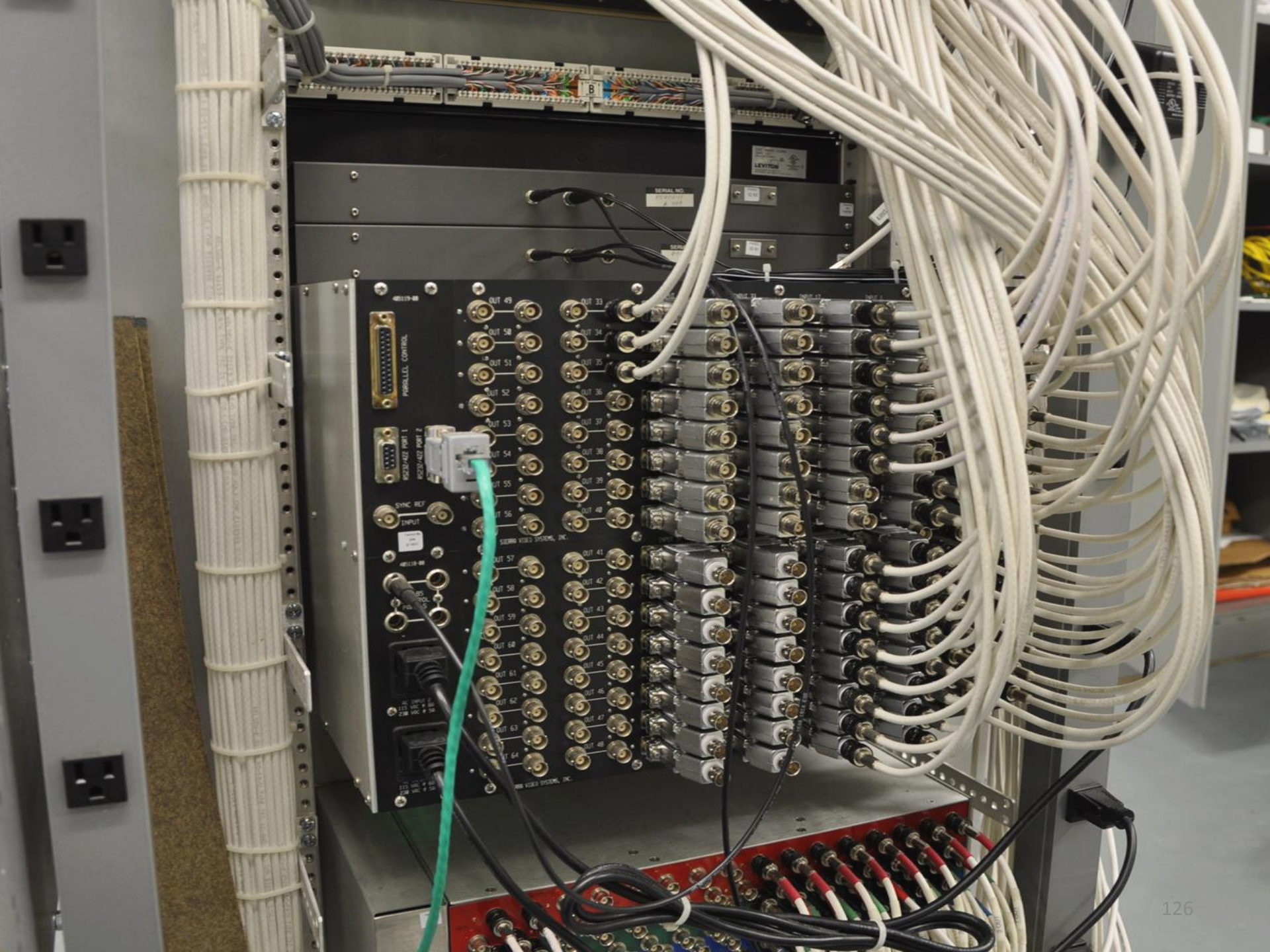
TBC – Time Base Corrector, prevents video from "tearing" mid-frame when switched, connects to video system sync signal (FOR-A Electronics FA-115)

Rack mount 4-in-1 NTSC video monitor for local troubleshooting and monitoring (Marshall Electronics V-R44P)

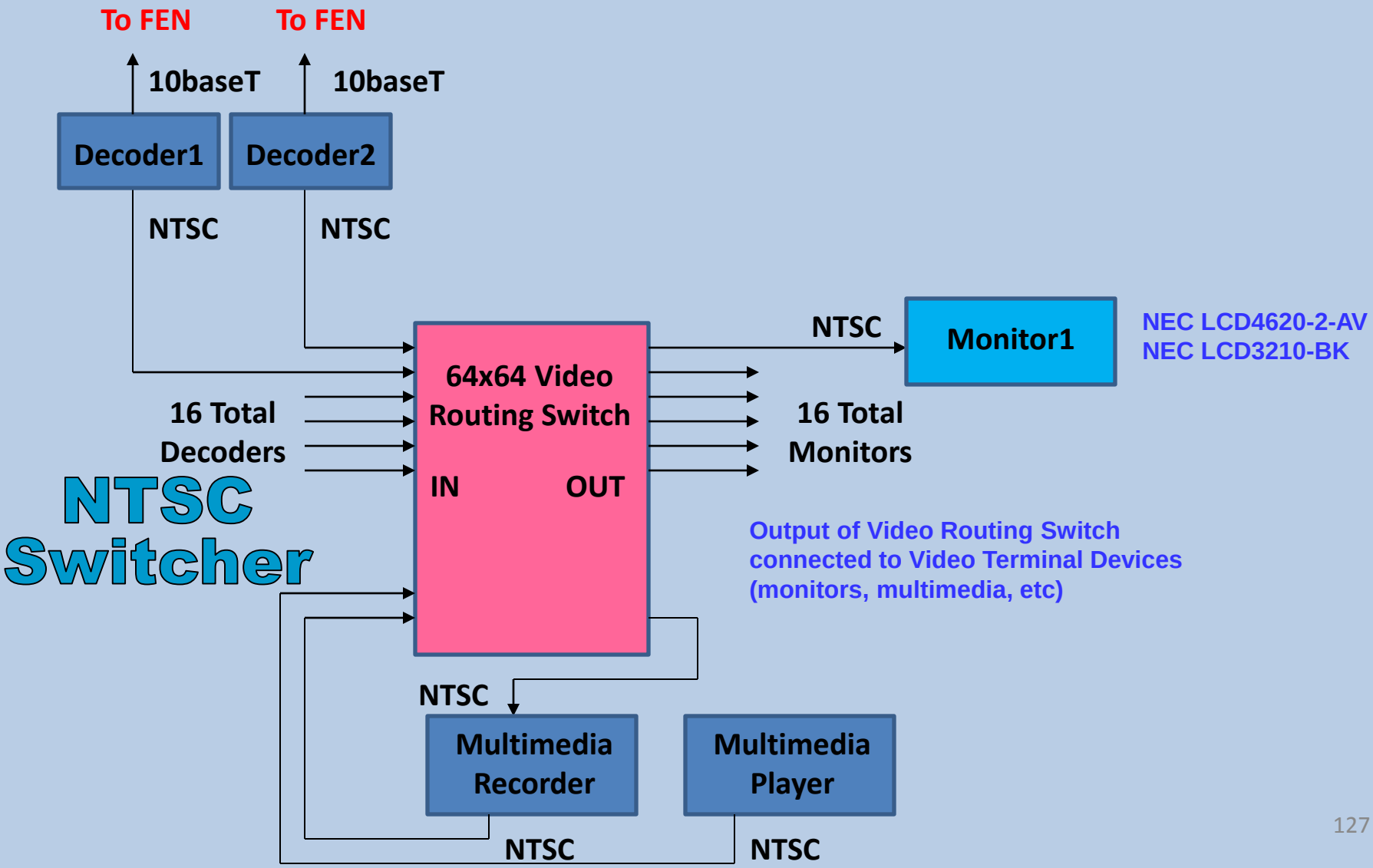
Video Distribution




Lucent
LEVITON
OUTPUT 1 LVL 1 7 LVL 3 7
STATUS LVL 2 7
OUTPUT 1 LVL 1 13
STATUS
sierravideosystems
+5V OUTPUT OK
-5V OUTPUT OK
64V POWER SUPPLY

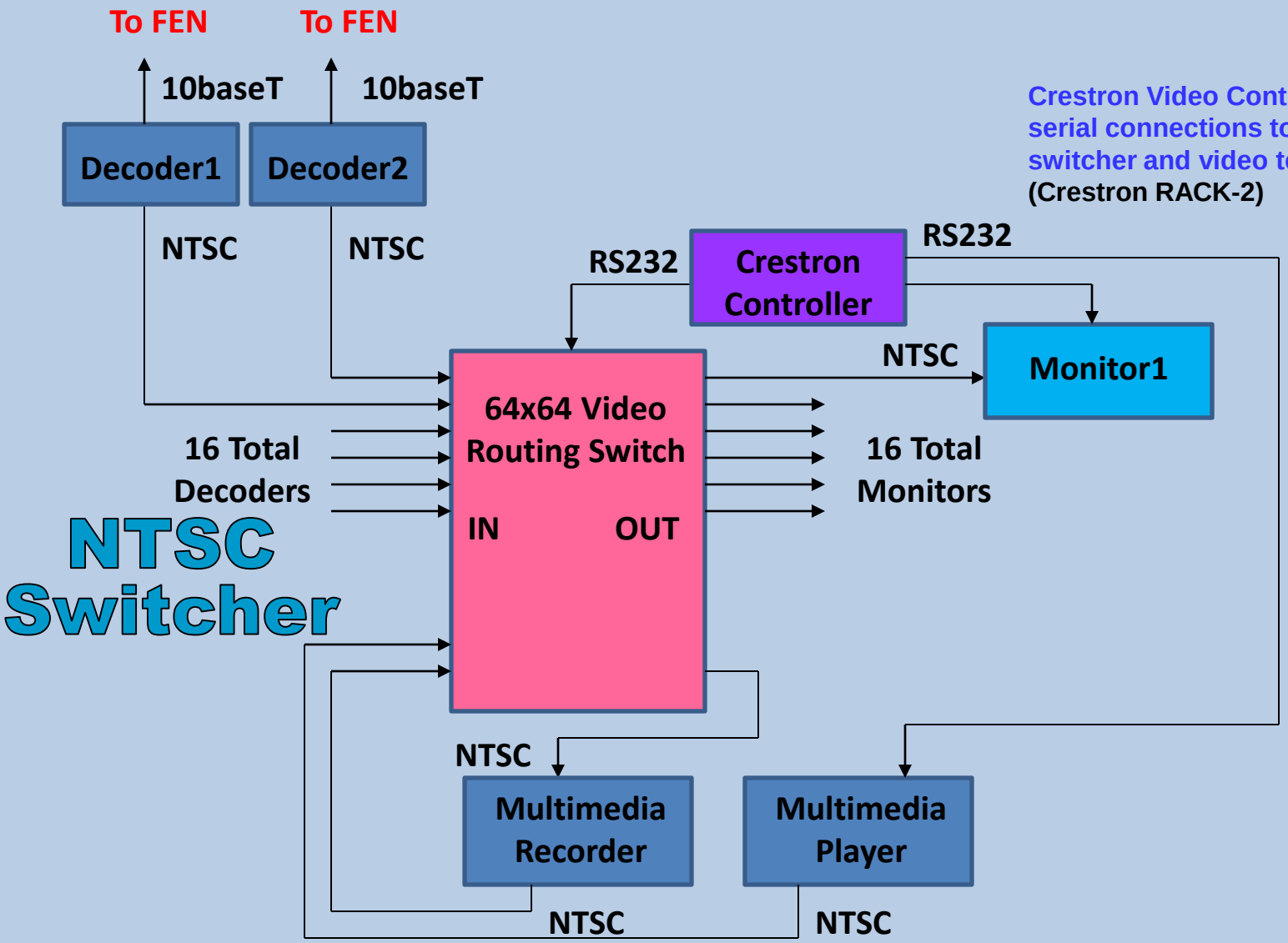

PARALLEL CONTROL
RS232/422 PORT 1
RS232/422 PORT 2
SYNC REF
INPUT
SIERRA VIDEO SYSTEMS, INC.

Video Distribution



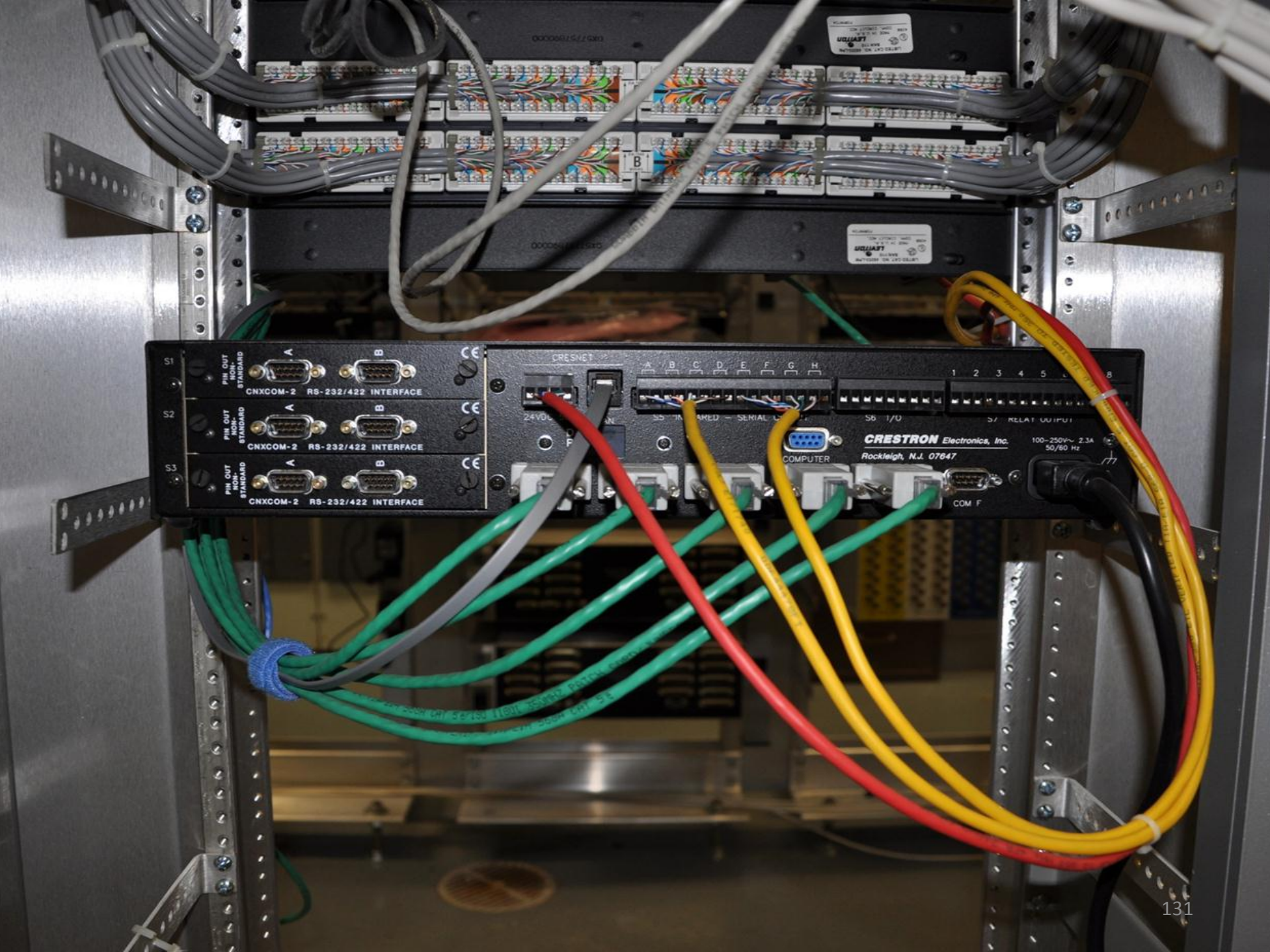

SACRAMENTO HILL
PRESET 1
LAKE BLVD
PRESET 2
RIVERSIDE AVE
PRESET 1
SUNDIAL BRIDGE DR
PRESET 2
ANTLERS BRIDGE
PRESET 3
PIT RIVER BRIDGE
PINE GROVE
PRESET 1
SALT CREEK
PRESET 3

Video Distribution

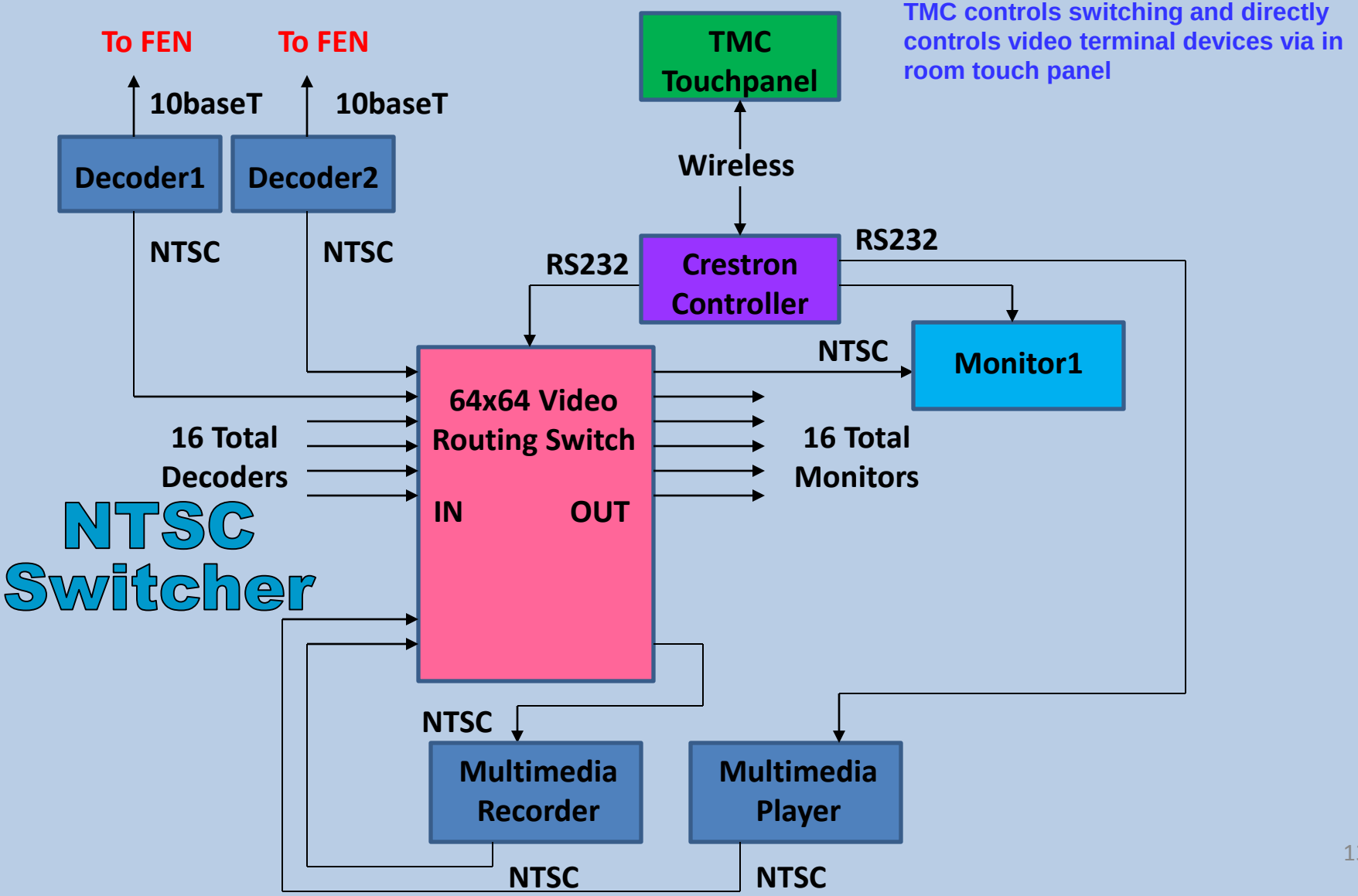


Crestron Video Control system uses serial connections to control video switcher and video terminal devices (Crestron RACK-2)

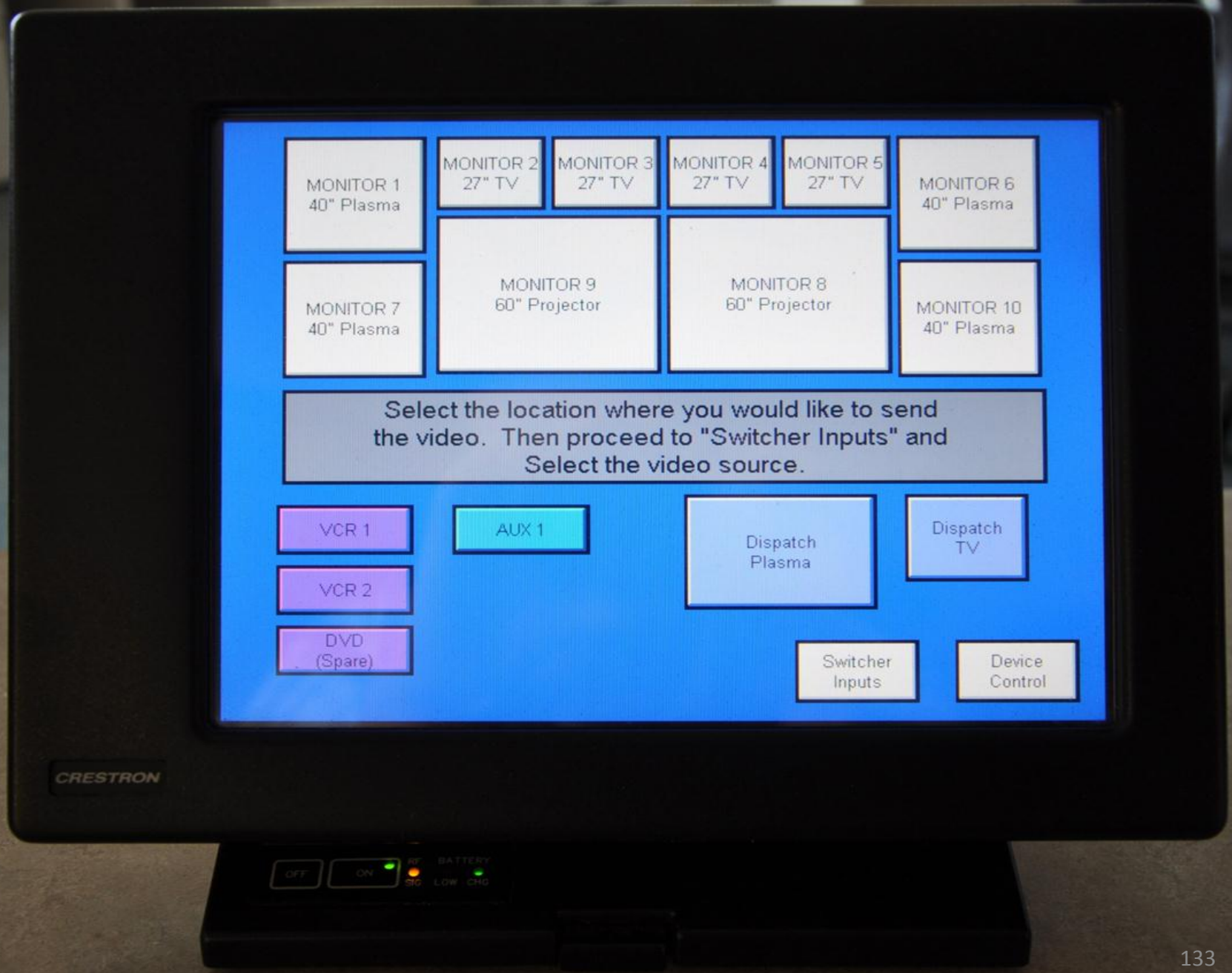

Lucent
PROFESSIONAL CONTROL PROCESSOR
Main Menu
PANEL INFO
05/15/12 11:59:38am
MSG TIME COM
MENU
BKLT
PWR
LAN
NET
ERR
HW-R
SW-R
RXD
TXD
LNK
ENR
CRESTRON
RXD TXD RTS CTS
COM A
COM B
COM C
COM D
COM E
COM F
IR-SERIAL
INPUT-OUTPUT
RELAY
SLOT
CNMSX-PRO

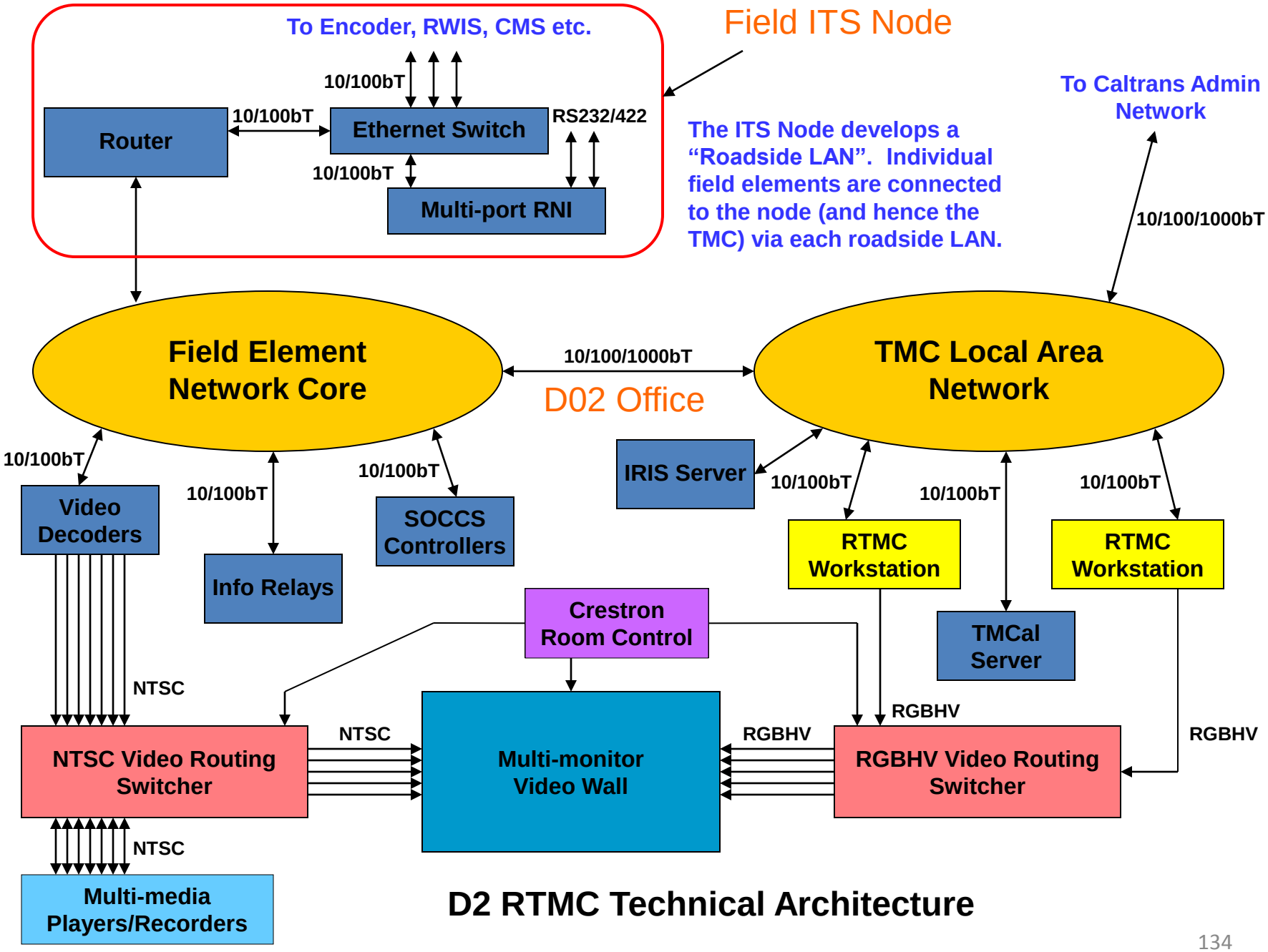

S1
S2
S3
CNXCOM-2 RS-232/422 INTERFACE
CNXCOM-2 RS-232/422 INTERFACE
CNXCOM-2 RS-232/422 INTERFACE
CRESNET
COMPUTER
CRESTRON Electronics, Inc.
Rockleigh, N.J. 07647
COM F

Video Distribution



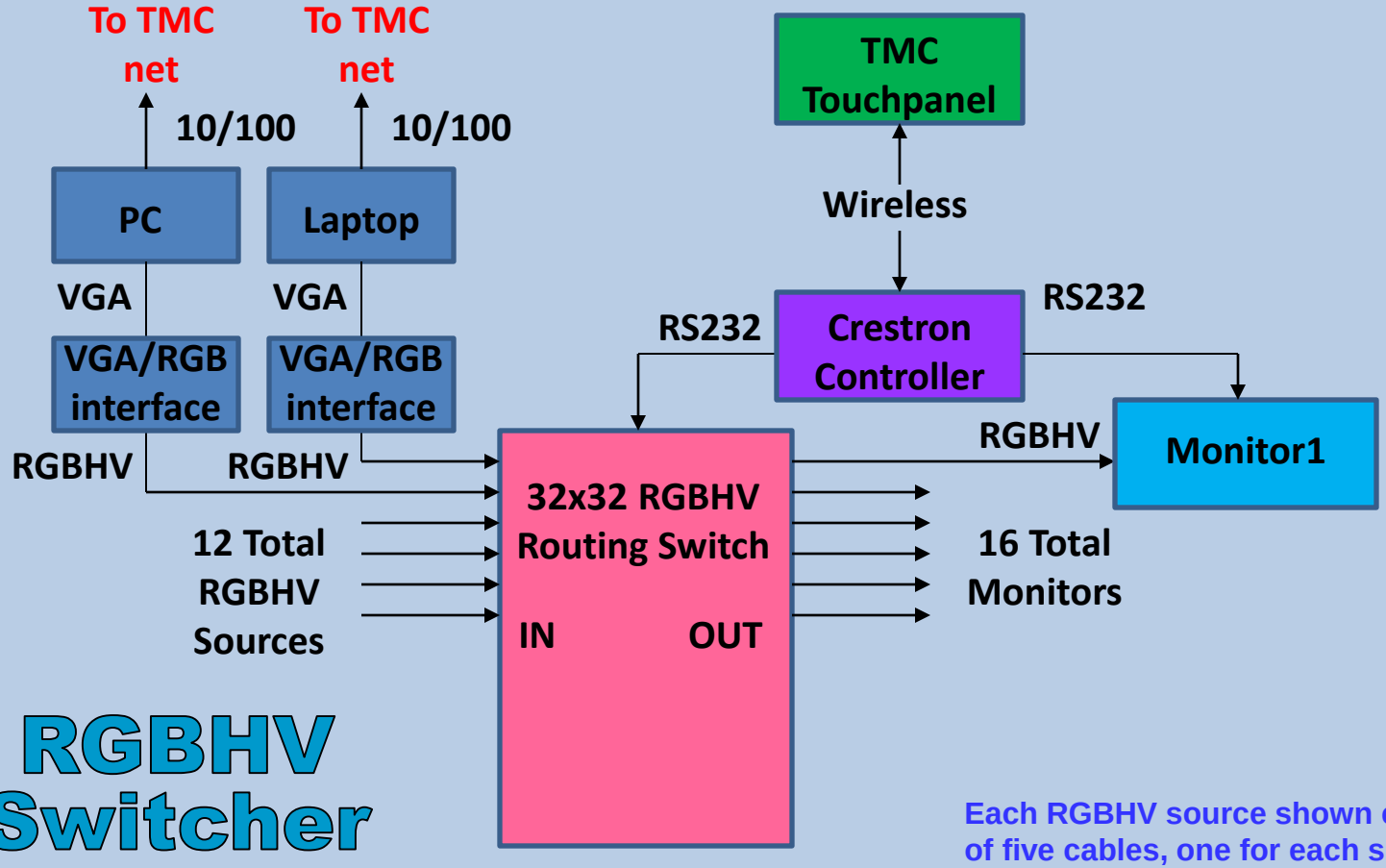
TMC controls switching and directly controls video terminal devices via in room touch panel


MONITOR 1
40" Plasma
MONITOR 2
27" TV
MONITOR 3
27" TV
MONITOR 4
27" TV
MONITOR 5
27" TV
MONITOR 6
40" Plasma
MONITOR 7
40" Plasma
MONITOR 9
60" Projector
MONITOR 8
60" Projector
MONITOR 10
40" Plasma
Select the location where you would like to send the video. Then proceed to "Switcher Inputs" and Select the video source.
VCR 1
AUX 1
Dispatch Plasma
Dispatch TV
VCR 2
DVD (Spare)
Switcher Inputs
Device Control
CRESTRON
OFF
ON
BATTERY
LOW
CHG



D2 RTMC Technical Architecture

Video Distribution



RGBHV Switcher

Each RGBHV source shown consists of five cables, one for each signal (Red, Green, etc)

Technical Considerations

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- Connectivity, and available communications in rural environments

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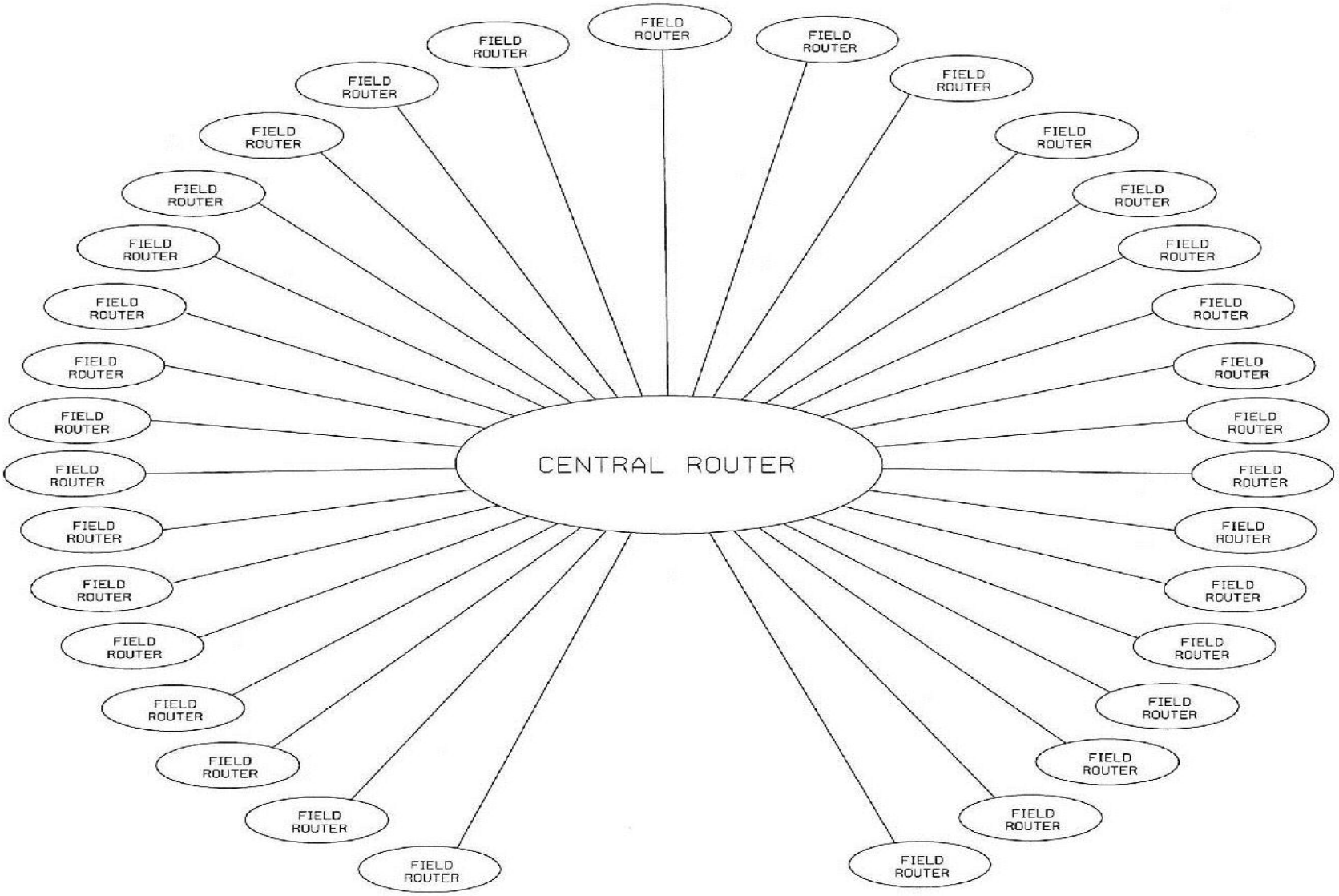
- System growth and the number of outgoing lines



That's a lot of phone lines

Technical Considerations

- Connectivity, and available communications in rural environments
- System growth and the number of outgoing lines
- Channel limitations – Video bandwidth and frame-rate, think about remote POTS sites

Technical Considerations

- "Streaming" video on a POTS line is not full motion video (24+ frames/sec)

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- On slow POTS lines our operators experience streaming rate of 1 frame every 20-40 seconds, that’s 0.025 f/s
- Because of this effect our operators experience significant latency for camera control
- Most out of the box encoders will not support link bandwidths low enough to support the low frame rate

Channel Limitations

Technical Considerations

- Using an Axis encoder we were able to change a script in the /etc/conf.d/bandwidth file and “throttle” down the Ethernet connection

Channel Limitations

Technical Considerations

TC_RATE=400Kbit
TC_BURST=30k
LOWER_LIMIT_KBIT=30
UPPER_LIMIT_KBIT=102400
LOWER_LIMIT_MBIT=1
UPPER_LIMIT_MBIT=100

Rate and queue (burst) size of a CCTV site with Radio link

TC_RATE=10Kbit
TC_BURST=5k
LOWER_LIMIT_KBIT=5
UPPER_LIMIT_KBIT=102400
LOWER_LIMIT_MBIT=1
UPPER_LIMIT_MBIT=100

Rate and queue (burst) size of a CCTV site with POTS link

Channel Limitations

Technical Considerations

- Using an Axis encoder we were able to change a script in the /etc/conf.d/bandwidth file and “throttle” down the Ethernet connection
- In addition we “benchmarked” the POTS line speeds and setup a connection speed in the router, so that sites with bad phone lines (highly variable) would stop dropping in and out

Channel Limitations

Technical Considerations

```
!
boot system flash
enable secret 5 $1$.D3G$8YDrF3PMlz6hkcgXMhG2S0
!
username D02-Central-A password 7 124B550411031E0B2E222A2F36277045
username EELab_2509 password 7 15405B090D2438302D3A3B7246
ip subnet-zero
no ip domain-lookup
ip domain-name d2its.org
!
modemcap entry multitech:MSC=&FS0=1&C1&D3$SB115200$MB14400
!
```

The $MBn portion of the command sets the maximum transmission speed the modem can connect across the phone line

Channel Limitations

Technical Considerations

- Connectivity, and available communications in rural environments
- System growth and the number of outgoing lines
- Channel limitations – Video bandwidth and frame-rate, think about remote POTS sites
- Cabling issues – Poor cabling design and installation increases likelihood of crosstalk, very difficult to troubleshoot

Technical Considerations

- Reduces cross talk potential, noise introduced from random EMI sources (in the room or other pairs in the same cable)

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Structured Cabling

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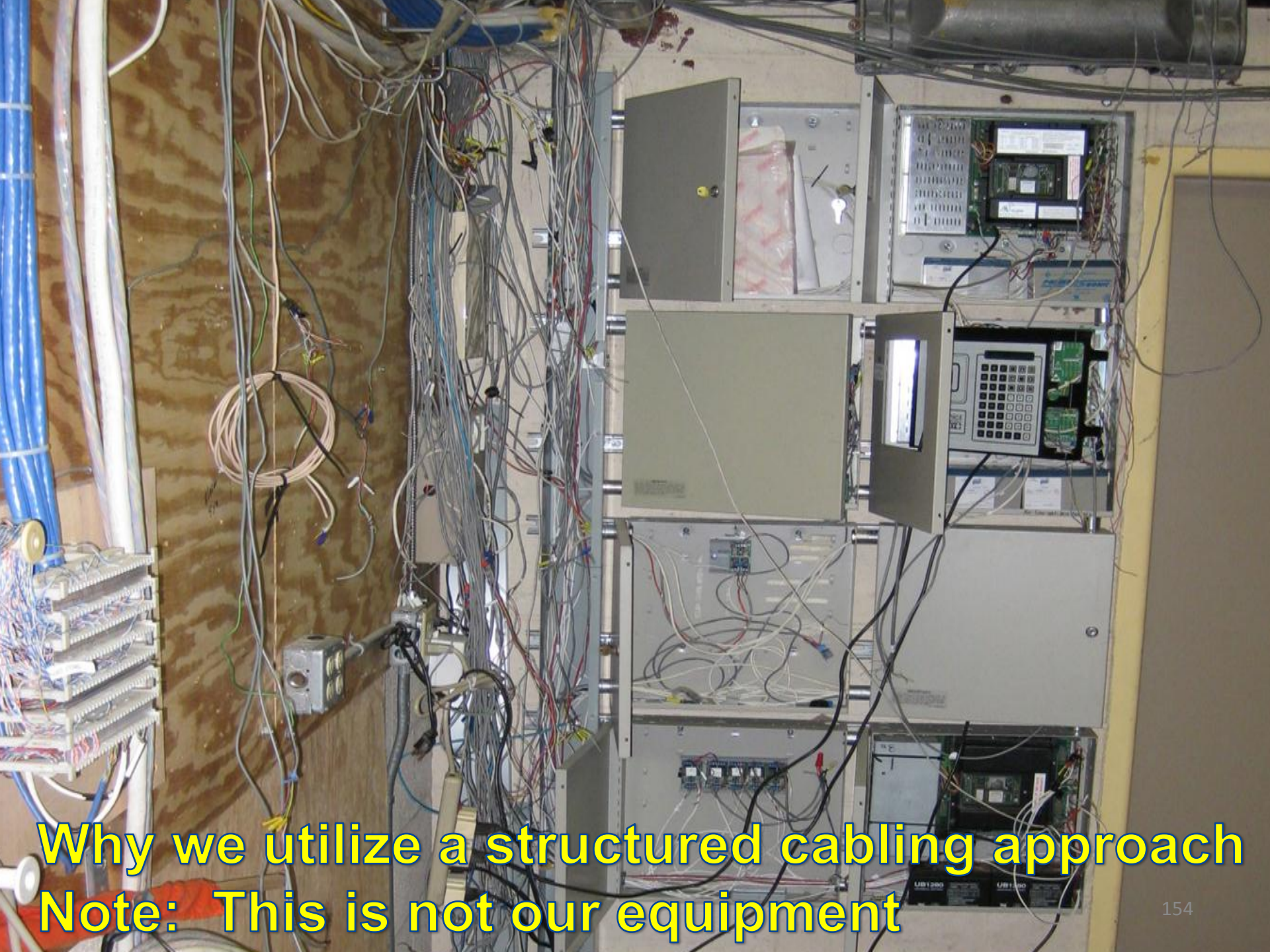
- Twisted pair cables reduce effect of cross talk by equalizing the distance of each conductor to nearby EMI sources
- Follows Telco industry standards, District 2 utilizes EIA/TIA 568 standards
- Looks professional and good practice

Structured Cabling



Why we utilize a structured cabling approach

Note: This is not our equipment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Structured Cabling Approach

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- Channel limitations – Video bandwidth and frame-rate, think about remote POTS sites
- Cabling issues – Poor cabling design and installation increases likelihood of crosstalk, very difficult to troubleshoot
- Network Security – Following industry accepted best practices is critical

Technical Considerations

- Video distribution and control

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- Grounding

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- TMC operations
  - CMS
  - HAR
  - CCTV usage and JPEG updates

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- Video distribution and control
- Grounding
- TMC operations
  - CMS
  - HAR
  - CCTV usage and JPEG updates
- Network traffic directions and flow will dictate interface spec and placement in network.

Other Design Considerations

- Market availability of products and lifecycles

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- Market availability of products and lifecycles
- Internal issues (IT policies and requirements, etc)
- Procurement
- What differentiates us from IT
  - Machine to machine network
  - Not a bunch of Admin users on the network

Other Design Considerations

- The Enterprise market is geared toward administrative networks

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  - Complexity (software and configuration) of course this can be good and bad

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  - Generally offer environmentally hardened products
  - Limited interface options, this is the biggest issue we face
  - Security has not been incorporated well on devices in the industrial market when compared to the enterprise market; think RuggedCom

Recent Core Upgrade

- Our legacy core router, Cisco 3660, became unsupported by Cisco 12/31/2008, we want all core and backbone network equipment on a support contract

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- The 3660 router was a “one-to-many” core router, served as interface for the POTS, ISDN, and radio networks, as well as the local TMC and Caltrans networks

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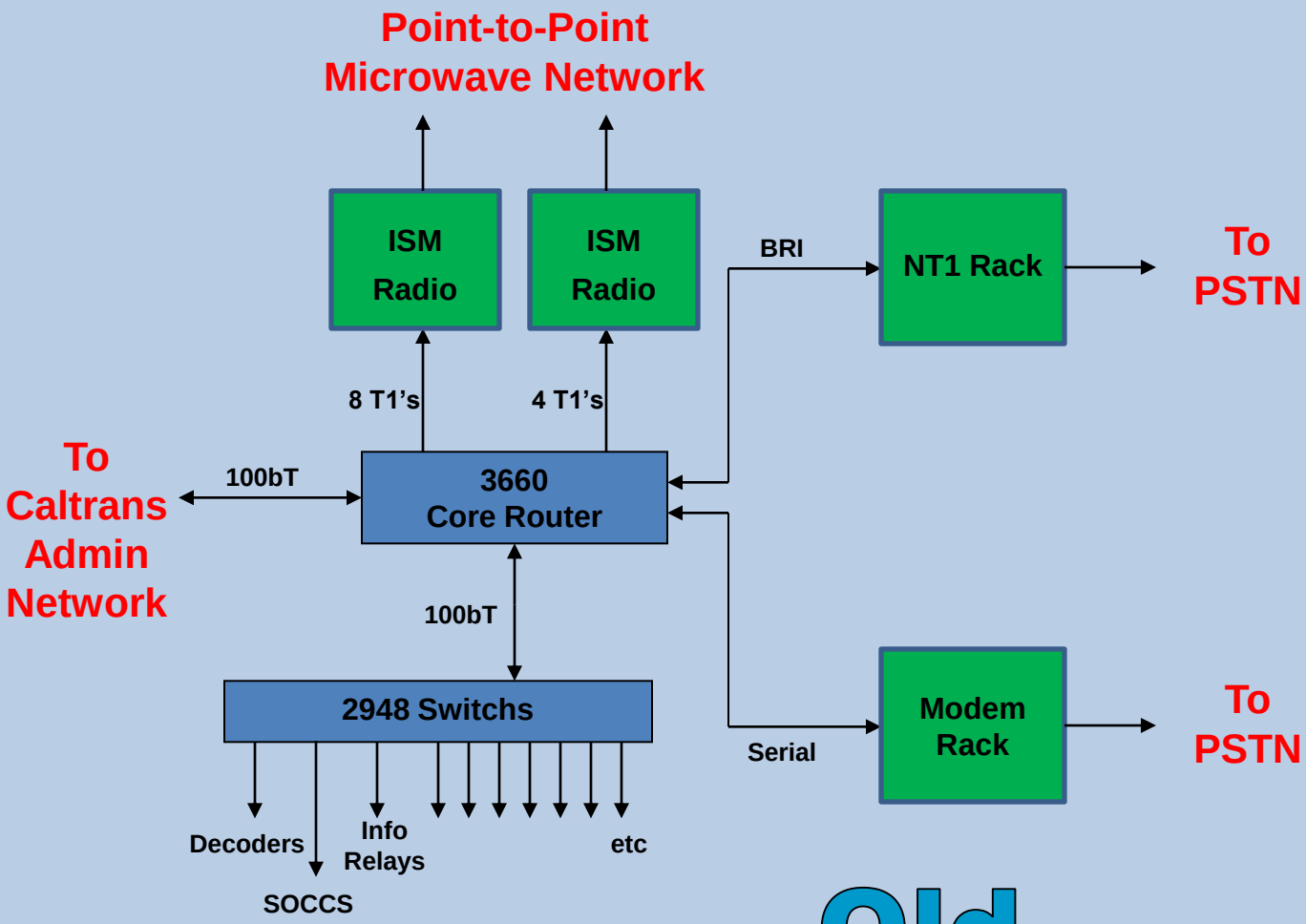
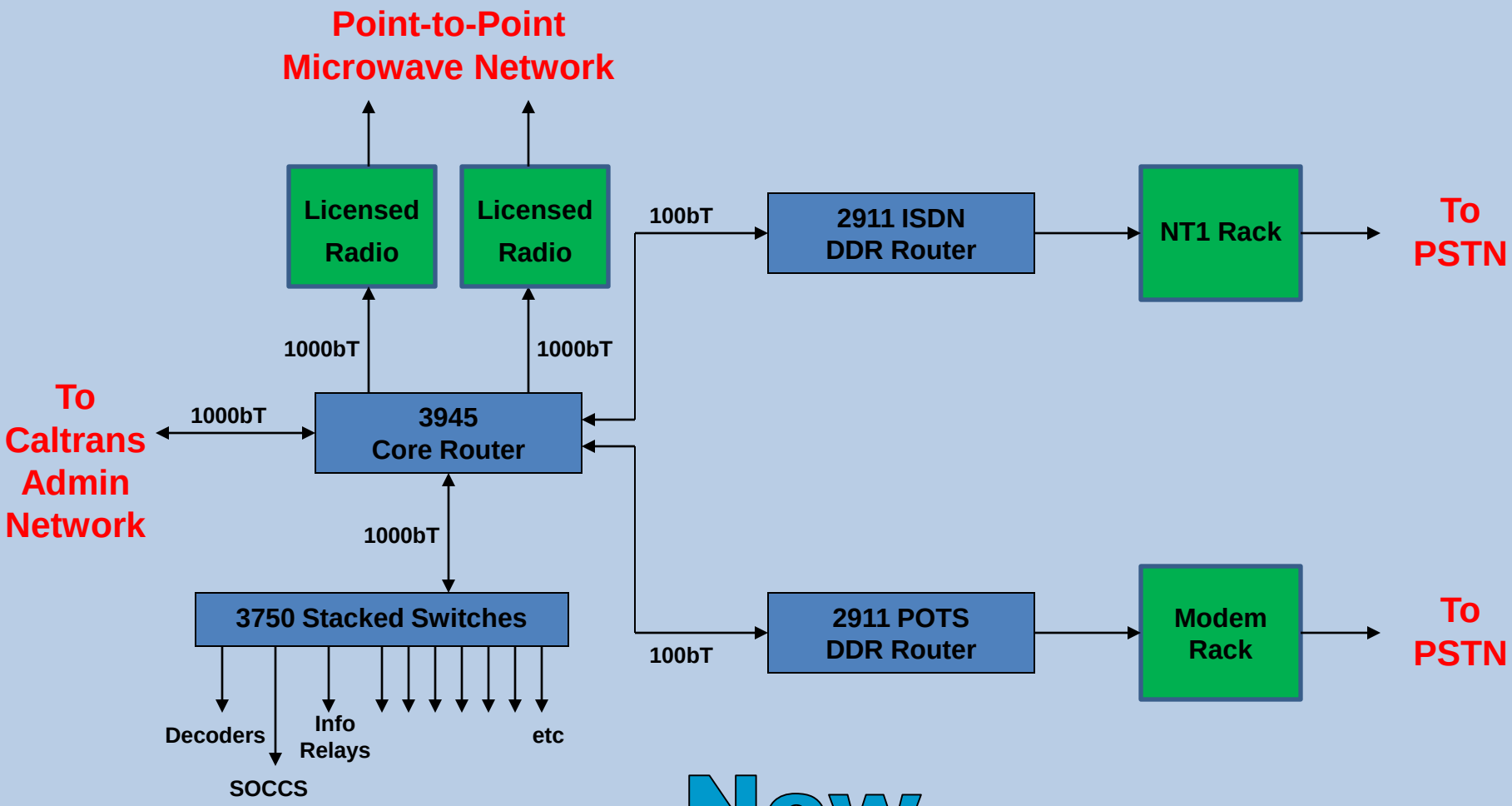
- We came up with the idea to use a router for each communications subtype

Recent Core Upgrade



Old

Recent Core Upgrade



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- This layered approach to the network allowed the upgrade to appear virtually seamless to the operators in the TMC as we didn't have to take down all communications subtypes at once to install equipment, instead incrementally one at a time and came down to logistics
- Due to the new routers added to the network, as well as a software and server push from HQ we re-assigned equipment to new racks and developed a new layout in our equipment room and dedicated a rack for uncertainty in HQ projects

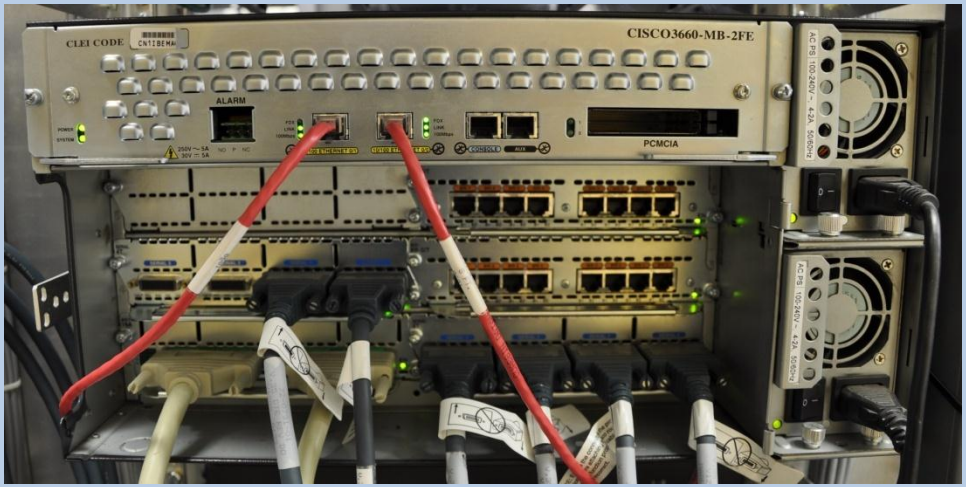
Recent Core Upgrade

- Fixing Grounding issues not address during original installation

Recent Core Upgrade

- Fixing Grounding issues not address during original installation
- Cabling issues
  - 1000bT patching, our back-board approach not sufficient for 1000bT
  - 25-pair cables and NT1 rack, replacement equipment was not compatible with old cabling infrastructure

Recent Core Upgrade



Old Router

3660 SPEC

- 2 FE ports
- 1 Aux and 1 Console port
- 6 NM slots
- NM cards include
  - 8 BRI (unsupported)
  - 4 serial
  - 16 Async (unsupported)
- 61.4 Mbps throughput
- 256 MB SDRAM
- 64 MB Flash

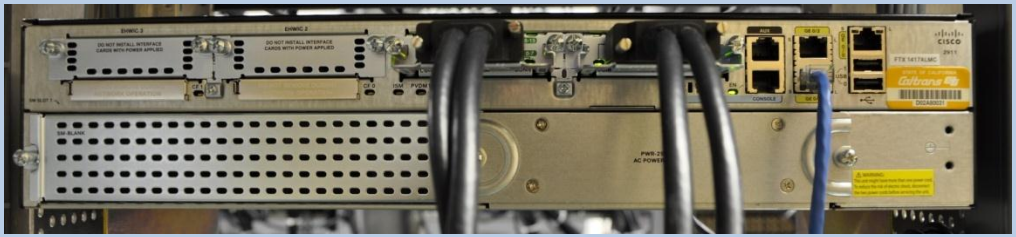
Recent Core Upgrade

New Router

3945 SPEC

- 3 GE ports (2 SFP)
- 1 Aux and 1 Console port
- 4 EHWIC slots
  - 1 GE port card
  - 2 FE port card
- 4 SM slots
- SM – NM adapters
- NM cards include
  - 8 T1's (PRI)
  - DS-3
- 502.8 Mbps throughput
- 2 GB SDRAM
- 1 GB Flash

Recent Core Upgrade



New Router

2911 SPEC

- 3 GE ports
- 1 Aux and 1 Console port
- 4 EHWIC slots
  - 4-port BRI card
  - 16-port ASYNC card
- 1 SM slots
- SM – NM adapters
- SM cards available
- 180.7 Mbps throughput
- 2 GB SDRAM
- 1 GB Flash

Future Communications Subtypes - GPRS

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- Currently looking for external T1 interface (CSU) for additional surge protection

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  - Local Telco offers VOIP, which isn't compatible w/ our POTS system, though they do offer consumer grade DSL
  - Our network currently is not setup to do DSL
  - Currently working on interface w/ DSL at District Office, exploring RLAN and VPN as options for securing the connection at the DO

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- Fiber project currently in construction

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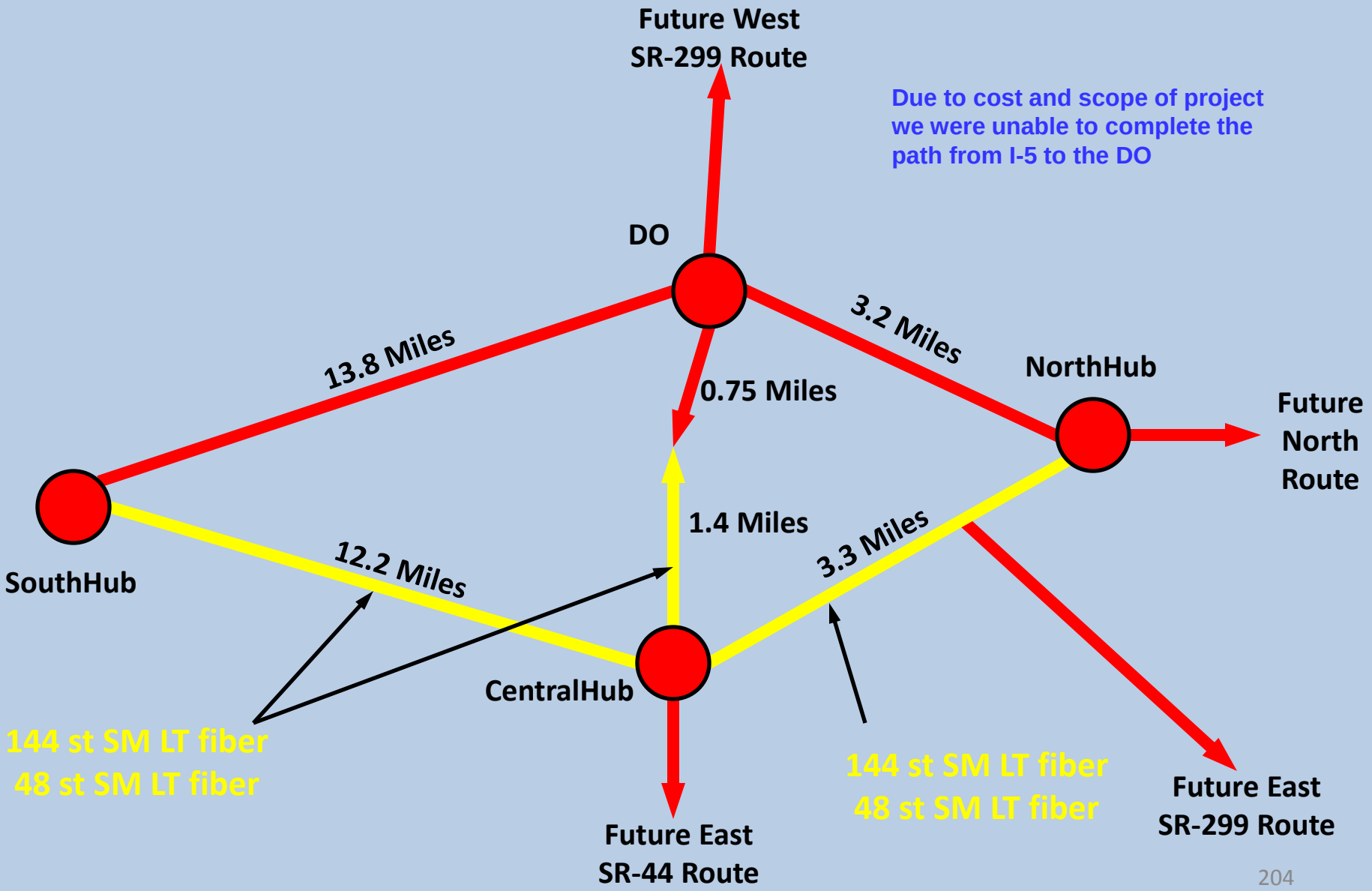
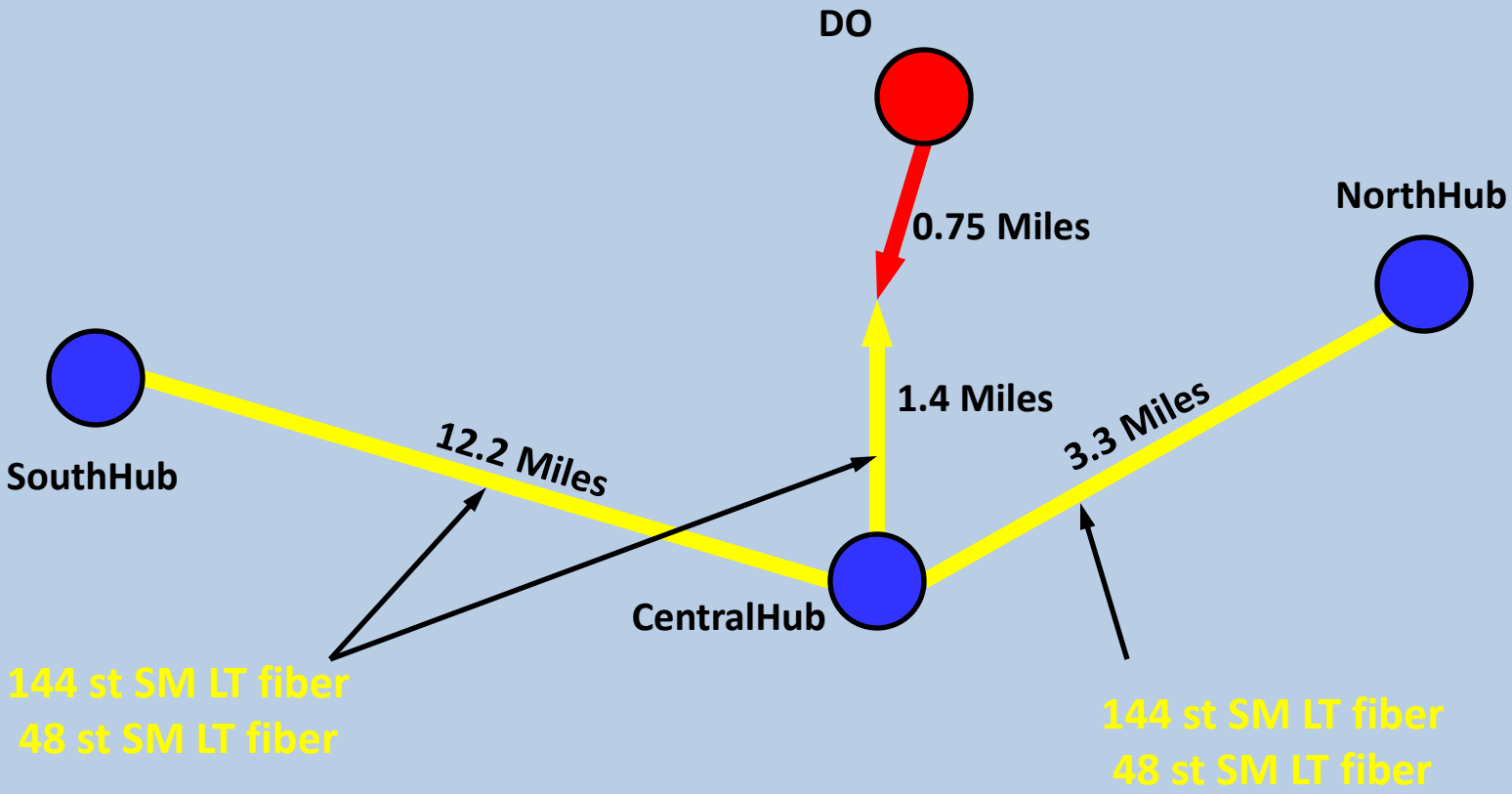
- Project installing 17 miles of fiber along I-5 and 2 miles of fiber along SR-44
- Follow-on project in planning to splice and terminate fiber, install hub buildings and towers
- Won't be running fiber to the District Office in the near term, will ride Microwave backbone back to the DO

Fiber Route

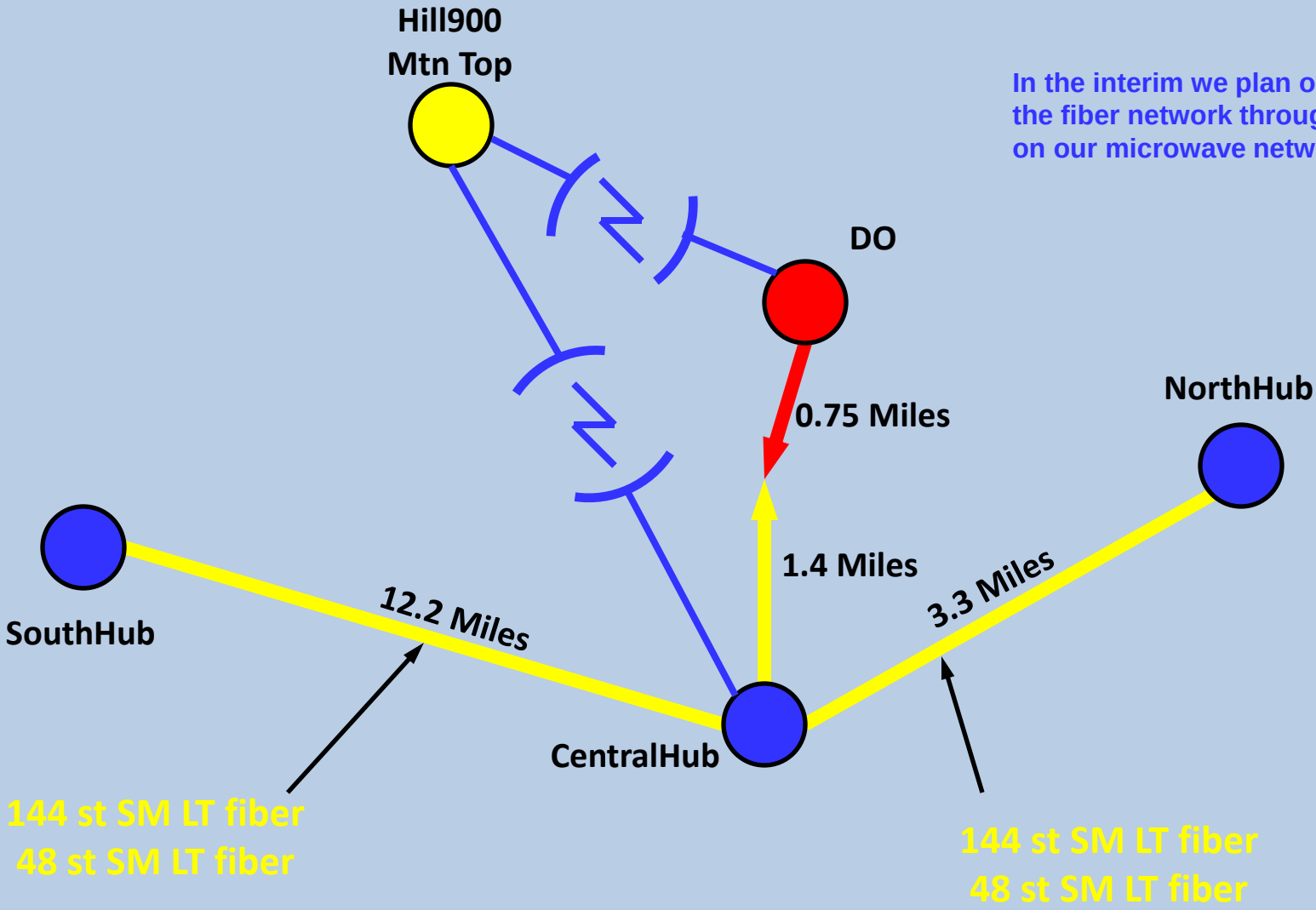

Future West
SR-299 Route
Due to cost and scope of project we were unable to complete the path from I-5 to the DO
DO
13.8 Miles
3.2 Miles
0.75 Miles
NorthHub
Future
North
Route
1.4 Miles
SouthHub
12.2 Miles
3.3 Miles
CentralHub
144 st SM LT fiber
48 st SM LT fiber
144 st SM LT fiber
48 st SM LT fiber
Future East
SR-299 Route
Future East
SR-44 Route

Fiber Route

We hope to complete the 3 hub buildings after the first follow-up project, but will still be unable to bring fiber to the DO due to cost

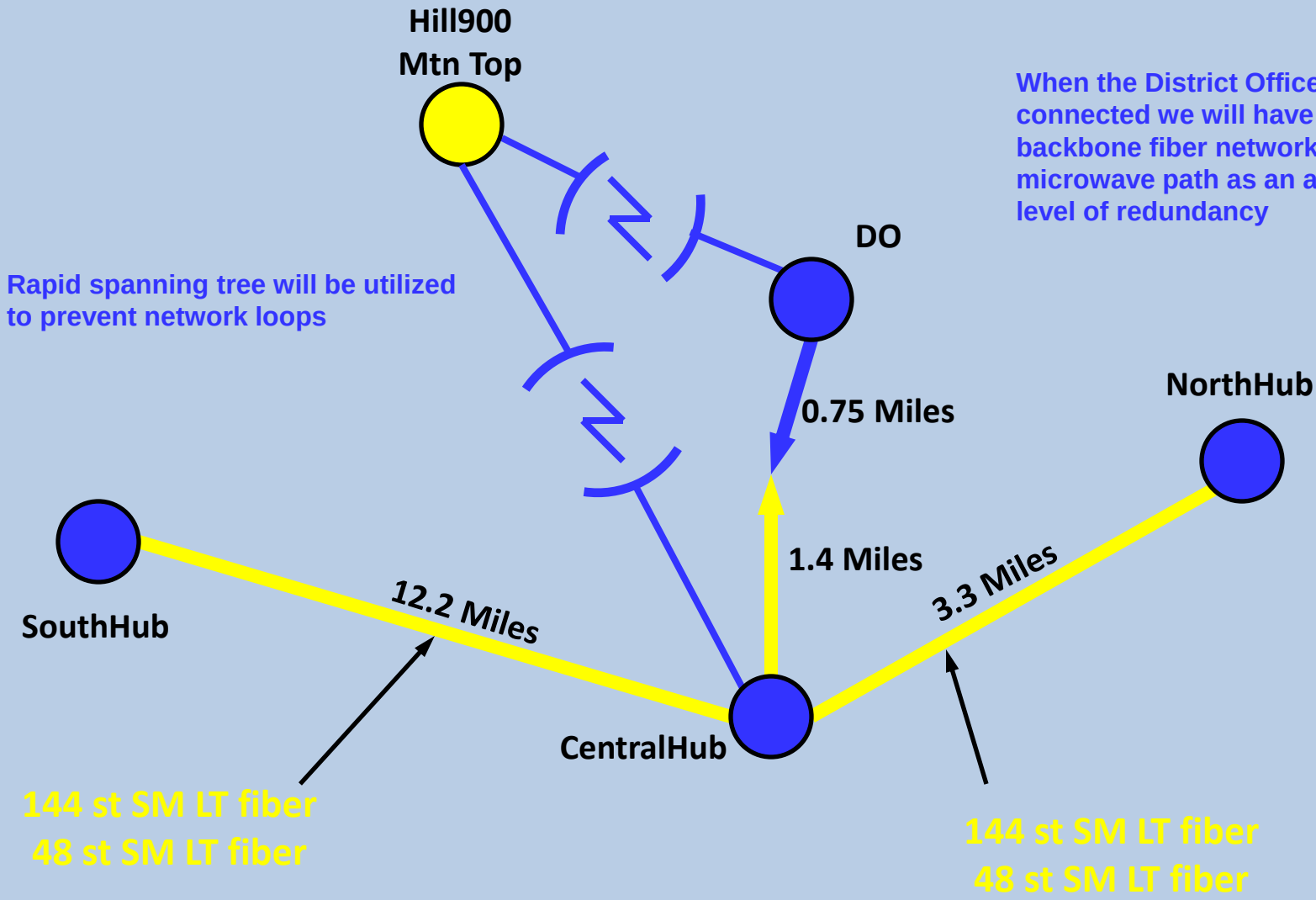


Fiber Route



In the interim we plan on routing the fiber network through Hill900 on our microwave network

Fiber Route


Hill900
Mtn Top
When the District Office is connected we will have a switched backbone fiber network, using the microwave path as an additional level of redundancy
DO
Rapid spanning tree will be utilized to prevent network loops
0.75 Miles
NorthHub
1.4 Miles
SouthHub
12.2 Miles
3.3 Miles
CentralHub
144 st SM LT fiber
48 st SM LT fiber
144 st SM LT fiber
48 st SM LT fiber

Future Communications Subtypes - Fiber

- Some project details
  - Six orange HDPE internally ribbed conduits installed and concrete encased

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  - Six orange HDPE internally ribbed conduits installed and concrete encased
  - 48”x48”x78” SV installed every ¼ mile

Future Communications Subtypes - Fiber

- Some project details
  - Six orange HDPE internally ribbed conduits installed and concrete encased
  - 48”x48”x78” SV installed every ¼ mile
  - Two fiber cables installed
    - 144 strand SM LT distribution fiber cable
    - 48 strand SM LT backbone fiber cable

Areas we're improving and need improvement

- Grounding – Still have hum bars due to inadequate ground system installed during original TMC installation

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- Grounding – Still have hum bars due to inadequate ground system installed during original TMC installation
- Video Control – In the middle of an upgrade
- Fiber to the DO – Need to be able to accommodate routing and termination of fiber cables at the DO
- Audio distribution – We have none but it is desired

Questions