



Networking for ATSC 3

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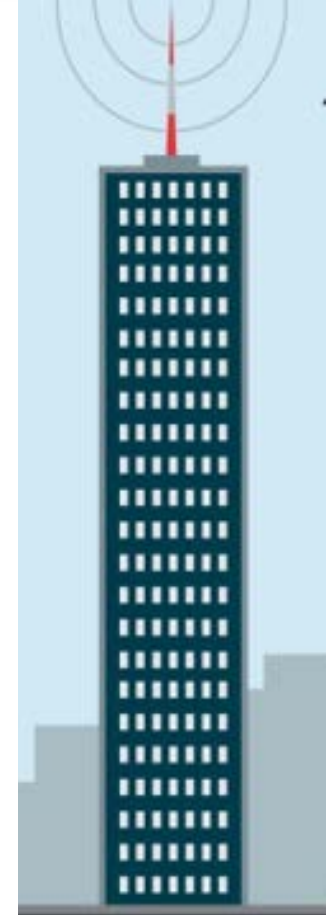


Networking for ATSC 3



Presentation Scope:

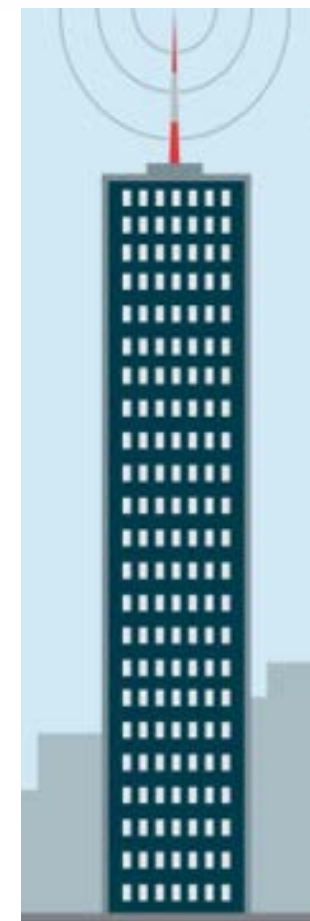
ATSC 3.0 promises to revolutionize the television broadcast industry with integration of traditional over-the-air (OTA) signals and broadband delivered IP content. A key attribute of the ATSC 3.0 standard is the use of the Internet Protocol (IP) as the transport platform. The use of IP as a core transport platform creates the need for the broadcast engineer to have a high competency in networking technology. This presentation will provide a summary of the core competencies required of the broadcast engineer to successfully design, build, and support the ATSC 3.0 infrastructure.



Outline for Today



- Introduction – Why ATSC 3?
- Standards & Model Overview
- Is ATSC 3 Special?
- Network Requirements Overview
- Building the Network
- Cybersecurity
- Closing Thoughts



Introduction – Why ATSC 3?

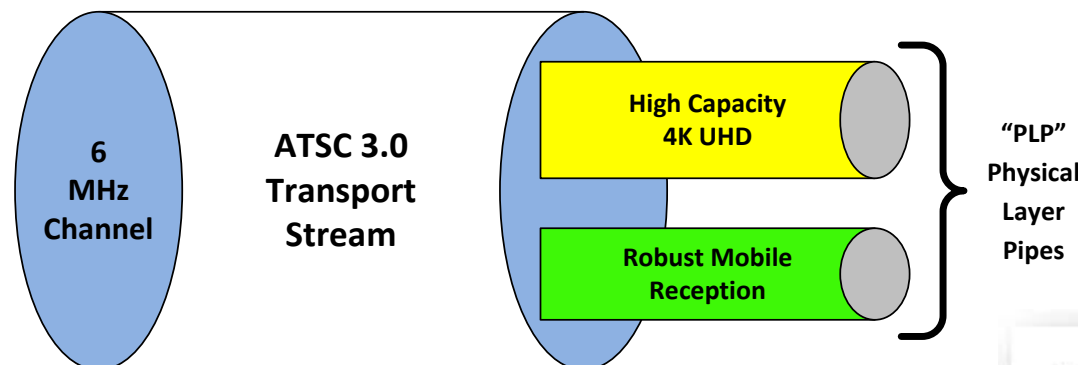


- Configurable, Scalable, Efficient, Interoperable, & Adaptable ¹:
 - Robust Mobile Reception (OFDM)
 - Ultra High-Definition Video (4K, HDR, WCG, HFR)
 - Immersive Audio (AC-4)
 - Internet Protocol Transport Enabled (IP)
 - Advanced Application Support
 - Emergency Alerting
 - Terrestrial / Broadband Integration
 - Interactive Applications



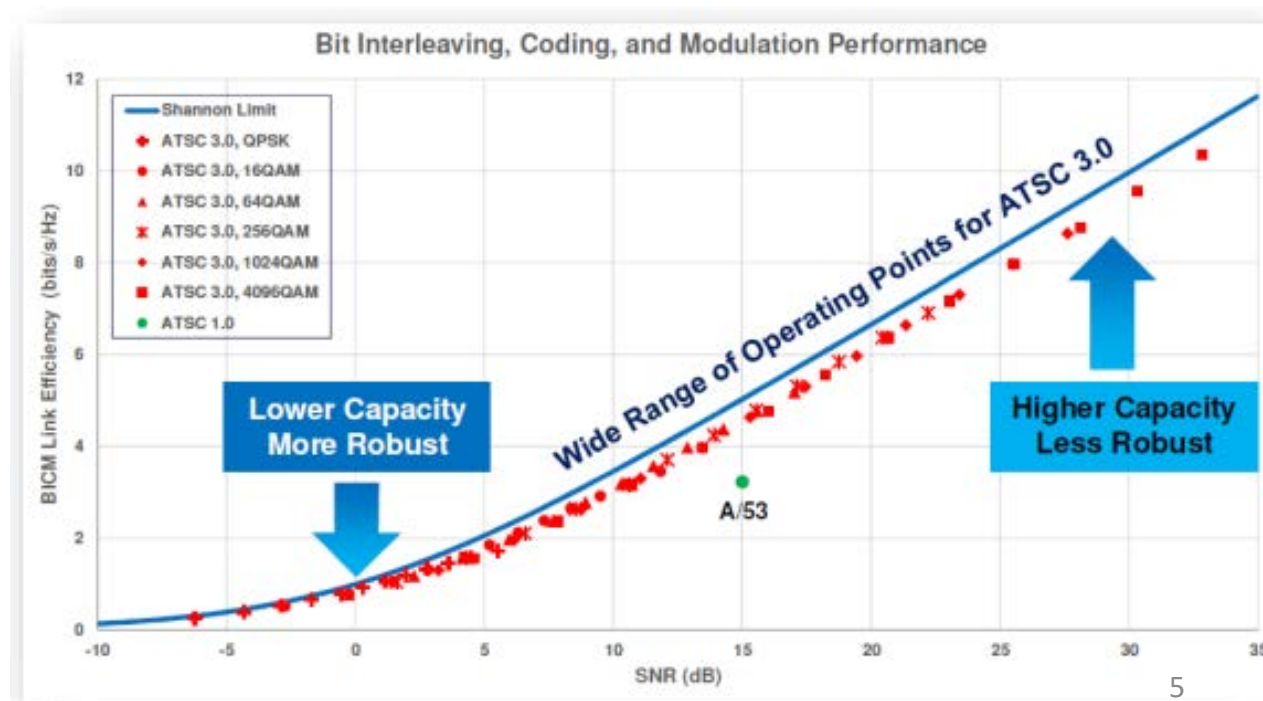
¹ Rich Chernock, ATSC TG3 Chairman

ATSC 3 Physical Layer Pipes - PLP's



PLP Config:

- Modulation
- Coding
- Interleaving



ATSC 3 Standards



<https://www.atsc.org/standards/atsc-3-0-standards/>

Layer 2 Standards:

IEEE- Institute of Electrical & Electronic Engineers

- Project 802 Ethernet Standards:

- 802.1 Bridging
- 802.3 Ethernet
- 802.11 Wireless



<http://standards.ieee.org/about/get/>

IEEE 802 standards are included in the program after they have been published in PDF for a period of six months. To download these documents, you must first agree to our Terms of Use. Please select a category below for a full listing of available standards.

[IEEE 802@: Overview & Architecture](#)

[IEEE 802.1™: Bridging & Management](#)

[IEEE 802.2™: Logical Link Control](#)

[IEEE 802.3™: Ethernet](#)

[IEEE 802.11™: Wireless LANs](#)

[IEEE 802.15™: Wireless PANs](#)

[IEEE 802.16™: Broadband Wireless MANs](#)

[IEEE 802.17™: Resilient Packet Rings](#)

[IEEE 802.20™: Mobile Broadband Wireless Access](#)

[IEEE 802.21™: Media Independent Handover Services](#)

[IEEE 802.22™: Wireless Regional Area Networks](#)

Layer 3 Standards:

IETF – Internet Engineering Task Force

- **Request for Comments – RFC's**
 - The “Standards Bible” of the Internet
 - Used to Explain All Aspects of IP Networking
 - Nomenclature “**RFC xxxx**”
- **Requirement Levels:**
 - Required
 - Recommended
 - Elective
 - Limited Use
 - Not Recommended



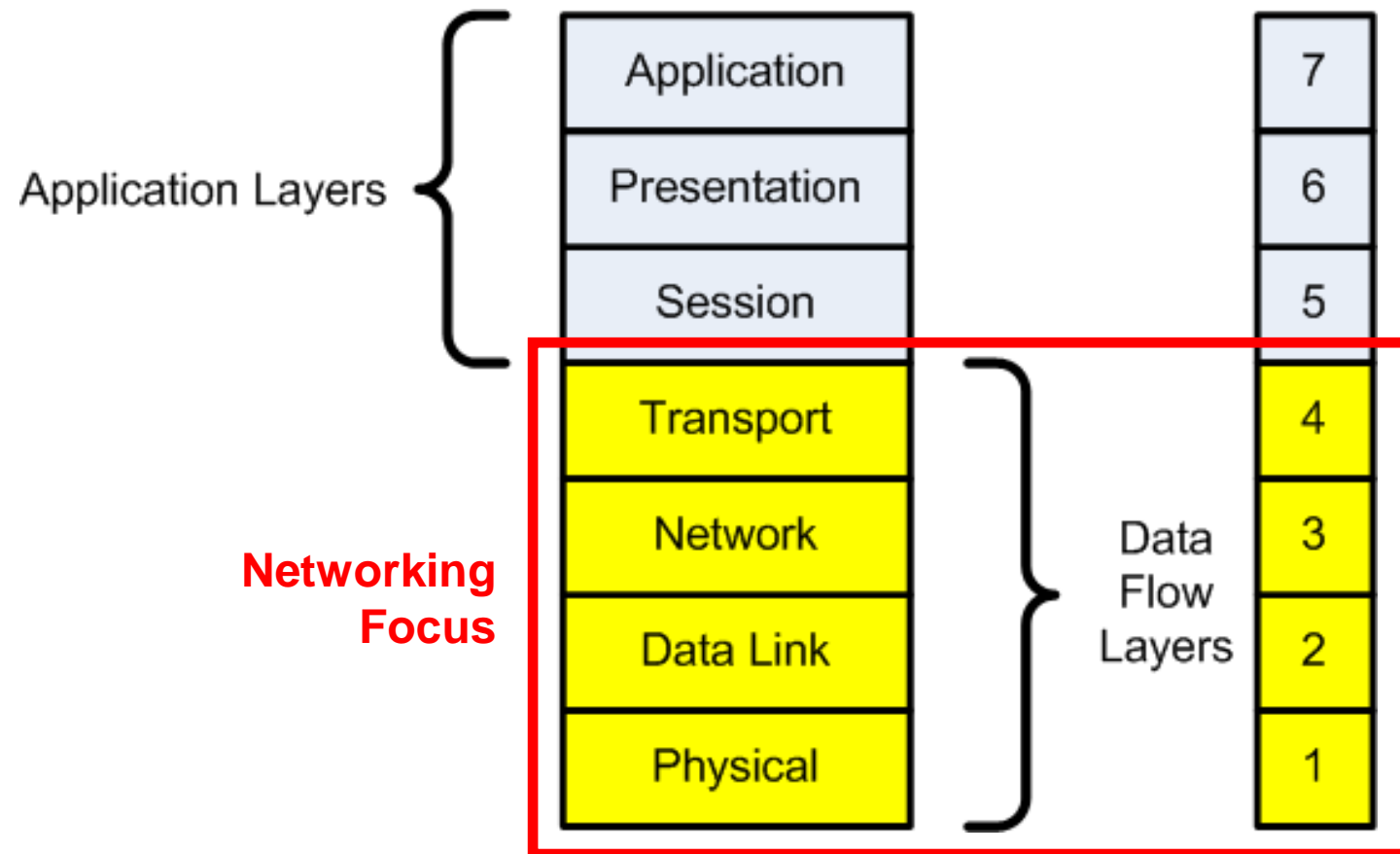
www.rfc-editor.org/rfc.html

The OSI Model

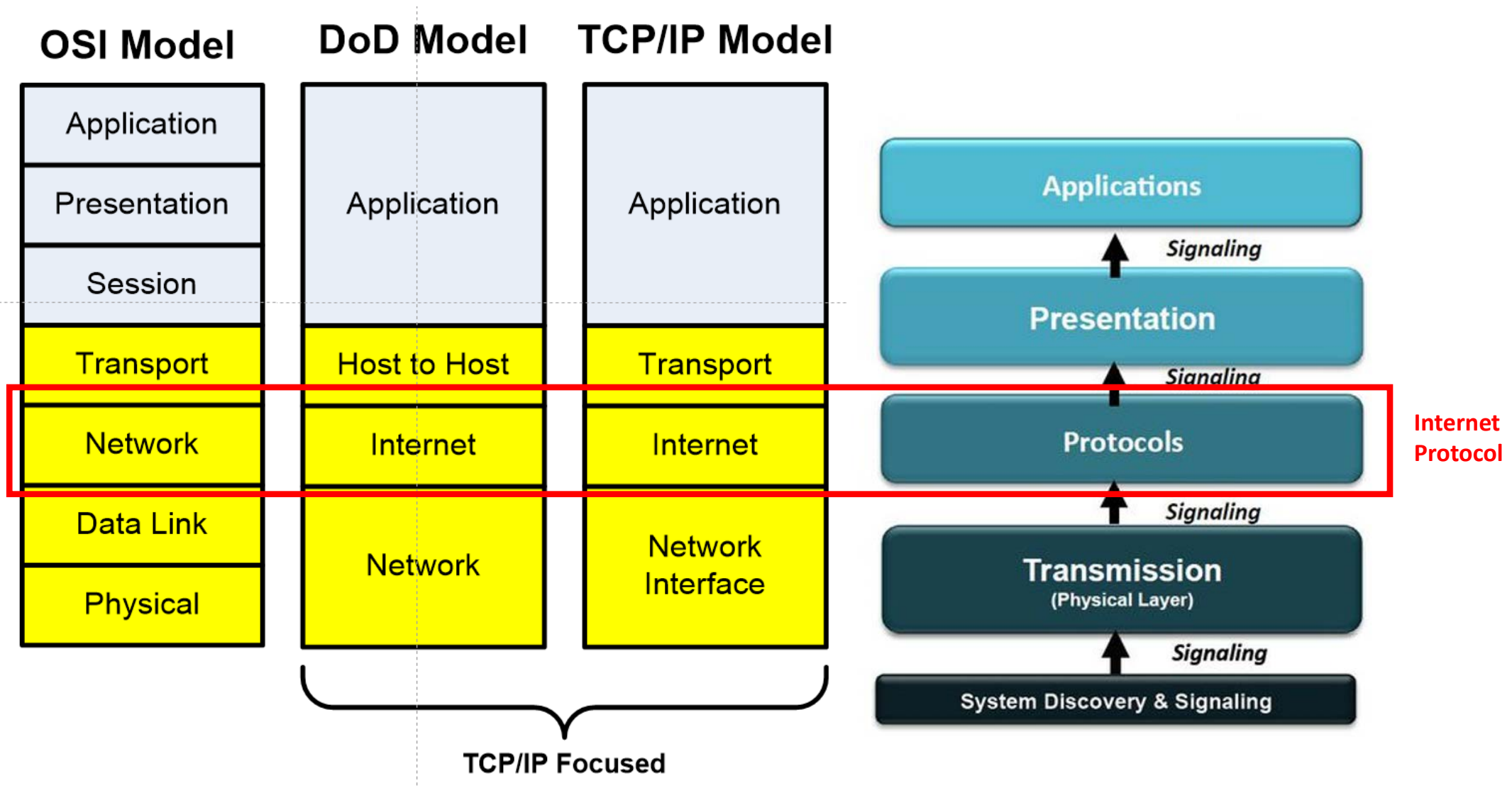
Open Systems Interconnection (OSI) Model

Developed by the International Organization for Standardization (ISO)

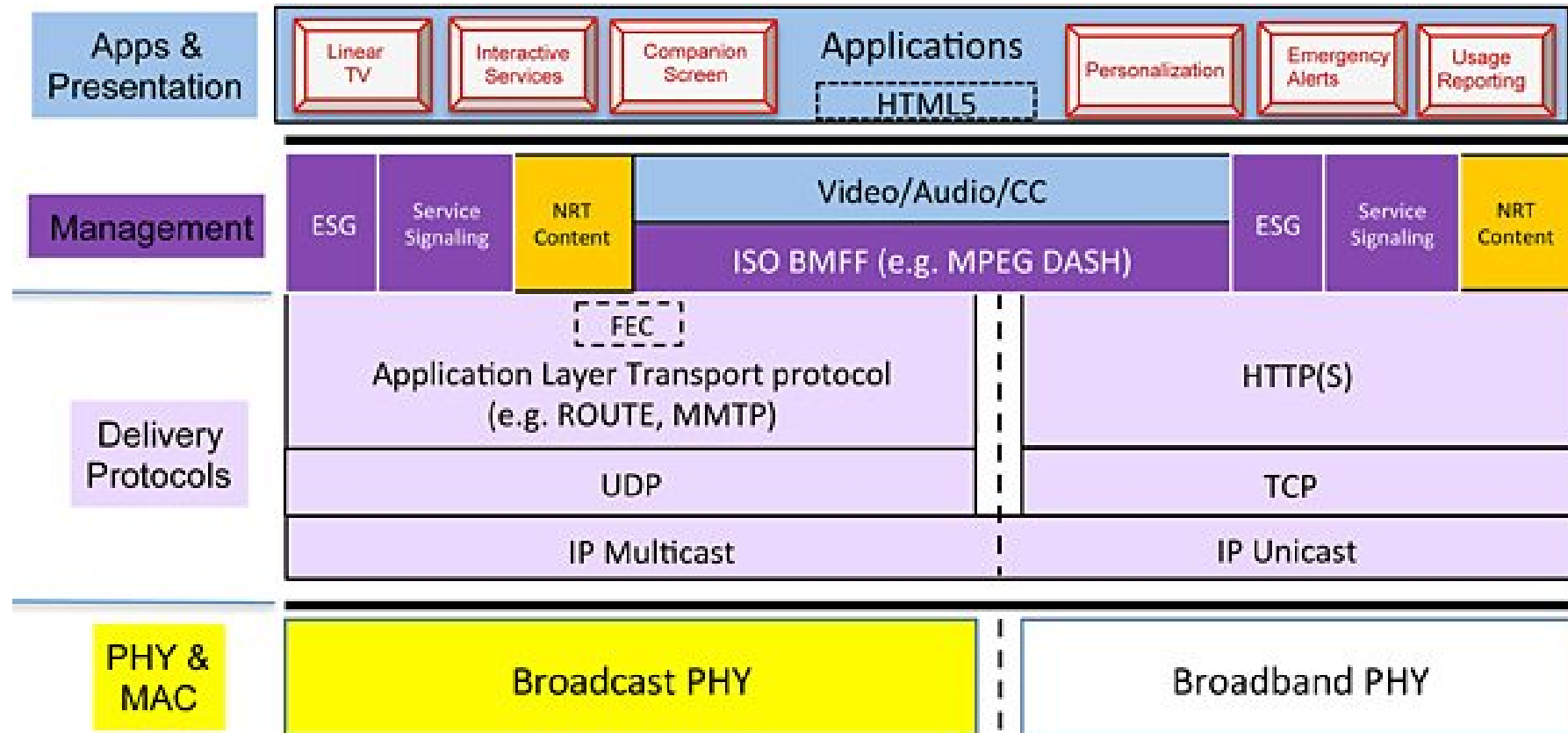
Defines How Data Traverses From An Application to the Network



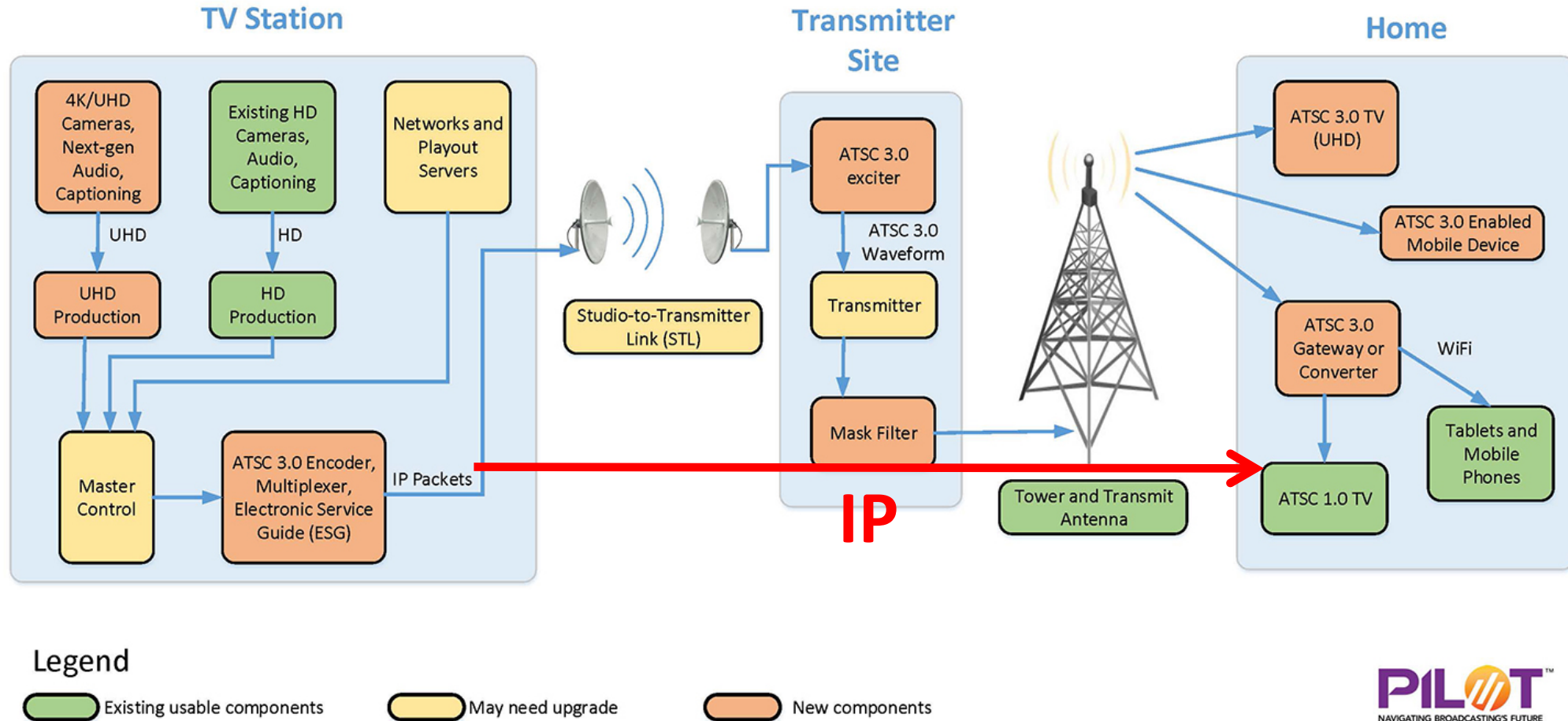
Network Models & ATSC 3 Layer Architecture



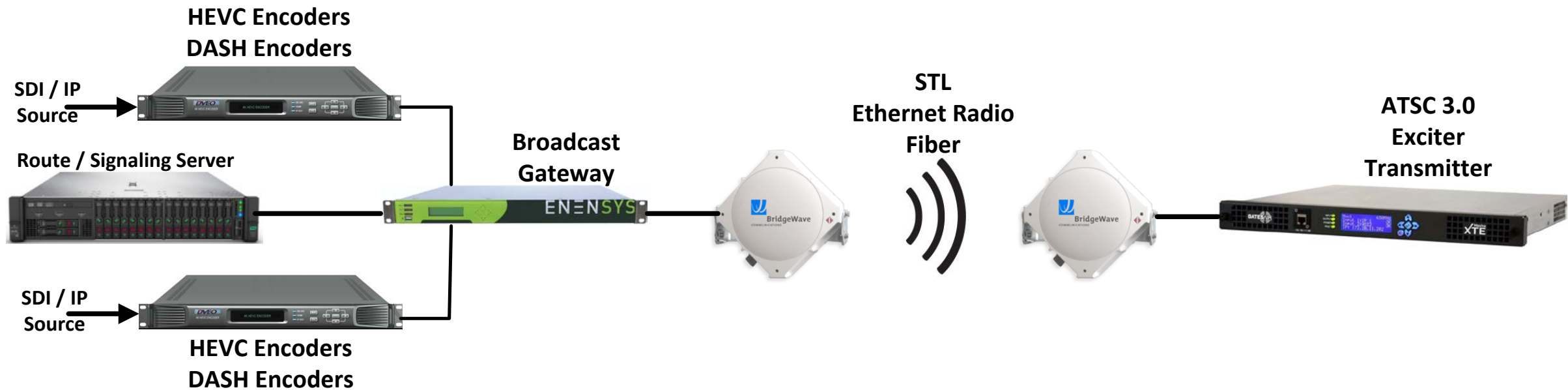
The ATSC 3 Protocol “stack”



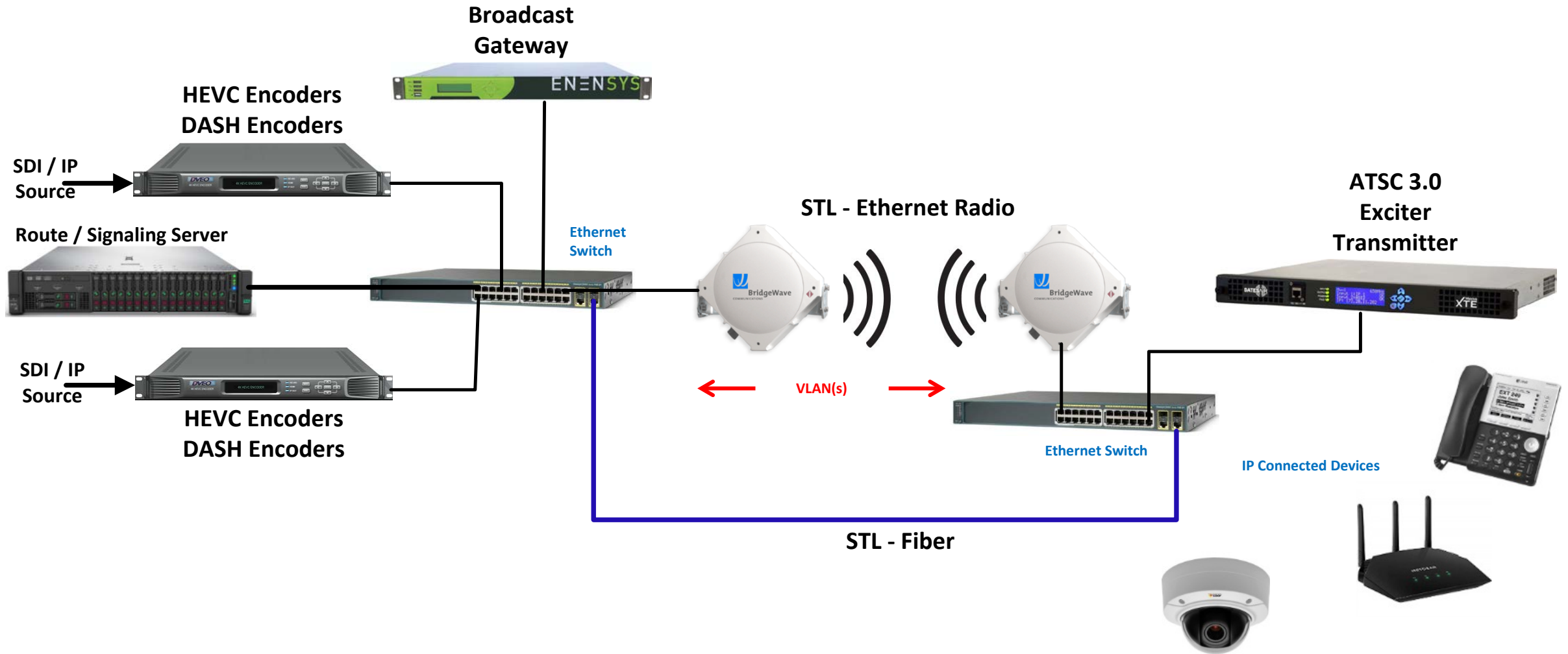
Deploying the ATSC 3.0 Broadcast Ecosystem



My Simplified ATSC 3 Station



A More Practical Version



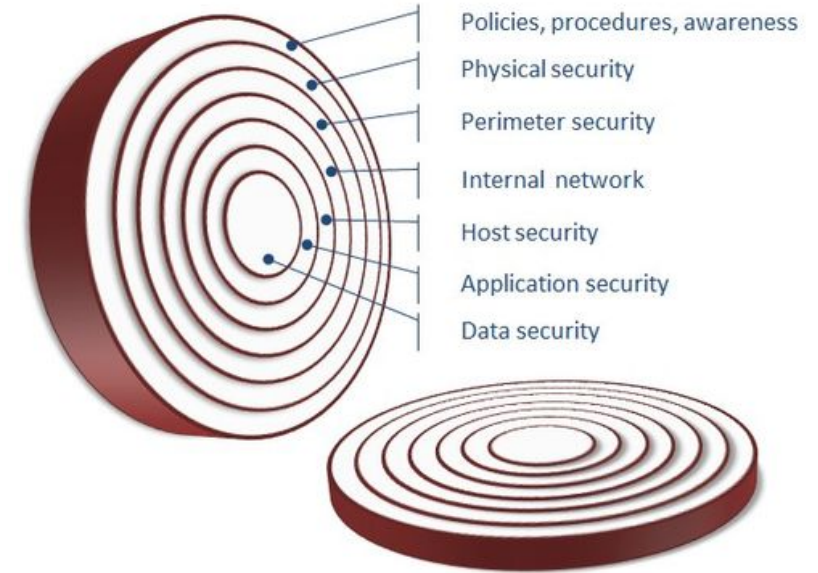
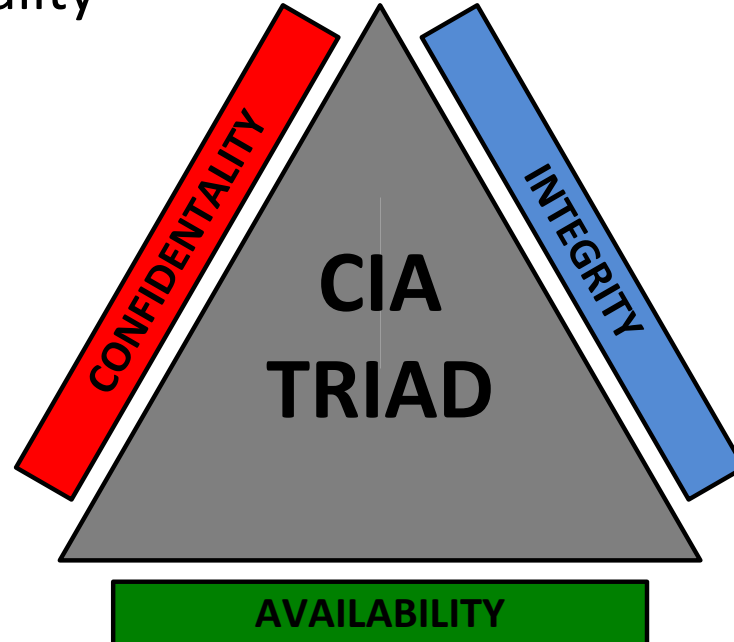


Is ATSC 3 Special?
(network requirement wise)

Well, It Depends!

Network Requirements:

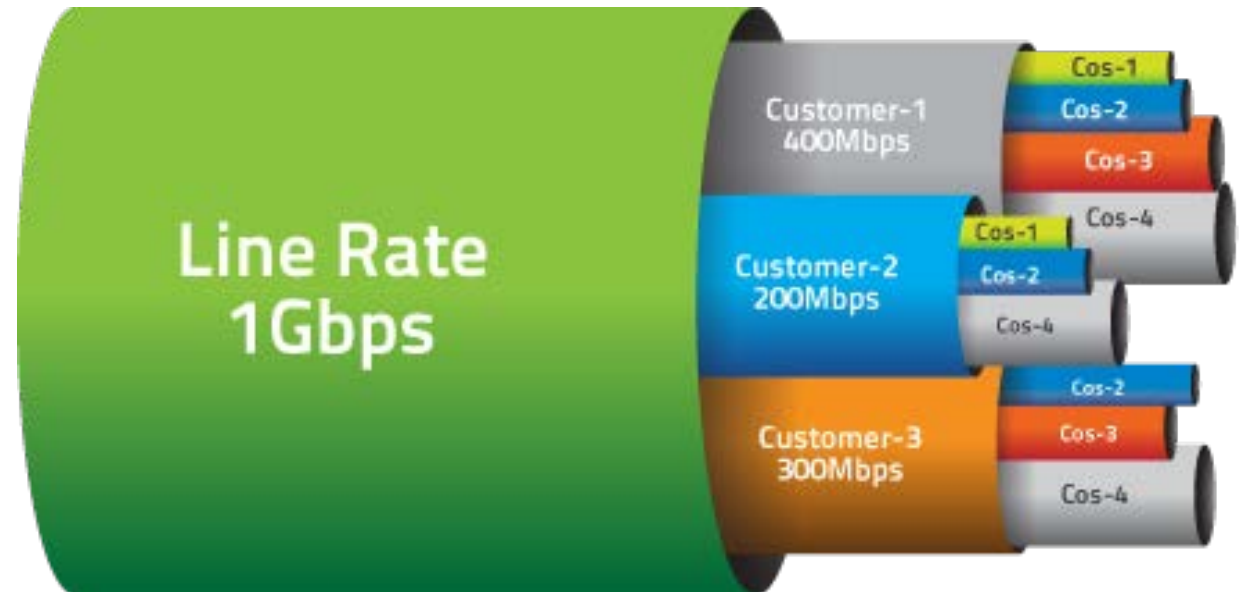
- Design for Performance
 - QoS
- Design for Cybersecurity
 - Confidentiality
 - Integrity
 - Availability



The "Onion" Network
Segmented Network
Layered Network
"Defense in Depth"

Quality of Service – “QoS” Considerations

- Throughput
 - Errors
 - Packet Loss
 - Latency
 - Jitter
 - Delivery Order
- Core QoS Factors



The Collision Domain & The Broadcast Domain

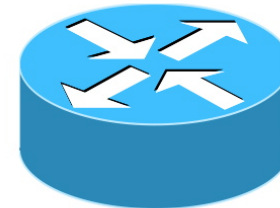
- Collision Domain

- Layer 2 Ethernet Switch Port Controls
- Improve Performance:
 - Eliminate Collisions
 - Allow Host Full-Duplex
 - Isolates Traffic
- Enables Switch Port Security

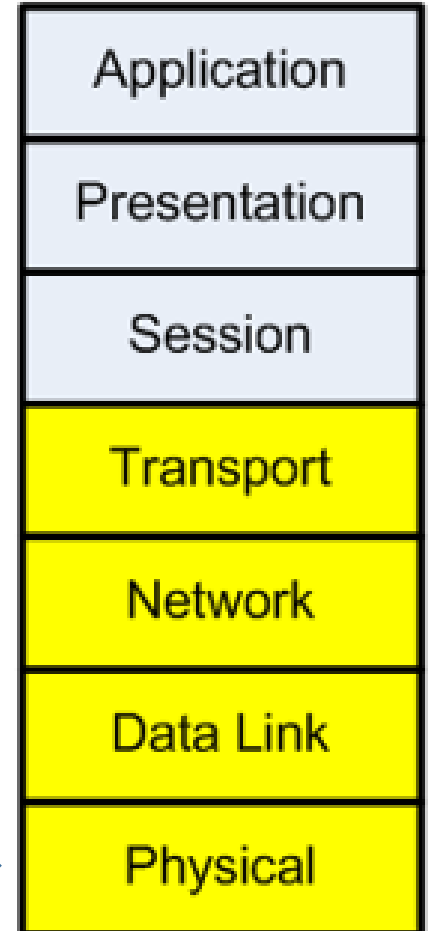


- Broadcast Domain

- Layer 3 Router Interface Defines
- Improve Performance:
 - Limits Reach of a Layer 2 Broadcast
 - Superset of a Collision Domain – Multiple Collision Domains Within Broadcast Domain
- Segments Network Hosts



The Physical Layer



Too Many Types of Ethernet 😊

| Ethernet Standard | | Ethernet Standard Cable Length & Speed | | | | |
|------------------------|------|--|--|----------|-----------------------|-------------------------|
| Experimental Ethernet | 1985 | | | | | |
| Ethernet II (DIX v2.0) | 1982 | | | | | |
| IEEE 802.3 standard | 1985 | | | | | |
| 802.3a | 1990 | 10Base-T | 100 meters | 10 Mbps | Twisted Pair | Copper CAT 3 |
| 802.3b | 1990 | 100Base-T | 100 meters | 100 Mbps | Twisted Pair | Copper CAT 5 |
| 802.3c | 1995 | 1000Base-T | 100 meters | 1 Gbps | Twisted Pair | Copper CAT 5e |
| 802.3d | 1998 | 1000Base-T | 55 meters | 1 Gbps | Twisted Pair | Copper CAT 6 |
| 802.3e | 1998 | 10GBase-T | 100 meters | 10 Gbps | Twisted Pair | Copper CAT 6a |
| 802.3i | 1998 | Fiber | | | | |
| 802.3j | 1998 | 100Base-FX | 2 K | 100 Mbit | Fiber Pair | Fiber Optic Muti-mode |
| 802.3u | 1998 | 1000Base-X | Used to refer to Gigabit Ethernet transmission over fiber, where options include 1000BASE-SX, 1000BASE-LX, 1000BASE-LX10, 1000BASE-BX10 or the non-standard -EX and -ZX. | | | |
| 802.3x | 1998 | 1000Base-LX | 5K or more | 1 Gbit | Long (wavelegth) LX | Fiber Optic Single mode |
| 802.3y | 1998 | 1000Base-SX | 550 meters | 1 Gbit | Short (wavelength) SX | Fiber Optic Muti-mode |
| 802.3z | 1998 | 10 Gigabit Fiber | | | | |
| 802.3-1998 | 1998 | 10GBase-SR | 300 Meters | 10 Gbit | Short Range | Fiber Optic Muti-mode |
| 802.3ab | 1998 | 10GBase-LR | 10K-25K | 10 Gbit | Long Range | Fiber Optic Single Mode |
| 802.3ac | 1998 | 10Gbase-ER | 40K | 10 Gbit | Extended Range | Fiber Optic Single Mode |
| 802.3ad | 2002 | ISPs/Wans Fiber | | | | |
| 802.3-2002 | 2002 | 10GBase-SW | 300 meters | 10 Gbit | Short WANs | Fiber Optic Mutimode |
| 802.3ae | 2002 | 10GBase-LW | 10K-25K | 10 Gbit | Long WANs | Fiber Optic Single Mode |
| 802.3af | 2002 | 10GBase-EW | 40K | 10 Gbit | Extended WANs | Fiber Optic Single Mode |
| Note: | | The above 3 are used to intergrate 10Gig Ethernet into SONET & SDH | | | | |

Ethernet SFP Transceivers

“Single Form-factor Pluggable” – **SFP / SFP+ / XFP** (mini GBIC)
Transceiver - LC Fiber Connector

Copper or Optical Based Transceiver to Provide Flexible
Physical Interface





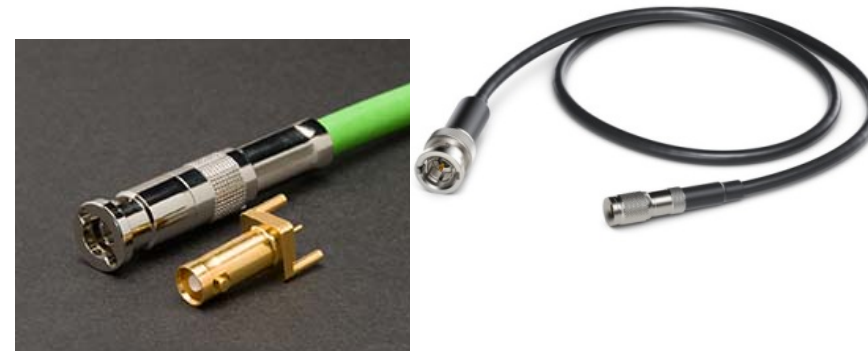
- Data SFP Transceiver (1 Gbps and beyond)

- 1000-Base-T
- SX series
- LX series
- EX series
- ZX series

| Standard | Detailed Description |
|----------|---|
| T | Operates on a standard Cat5 copper cable with links up to 100 m |
| SX | Operates on MMF fiber and supports links up to 550 m |
| LX/LH | Supports links up to 10km over SMF and 550 m over MMF |
| EX | Operates on SMF and supports links up to 40 km |
| ZX | Operates on SMF and supports links up to 70 km |

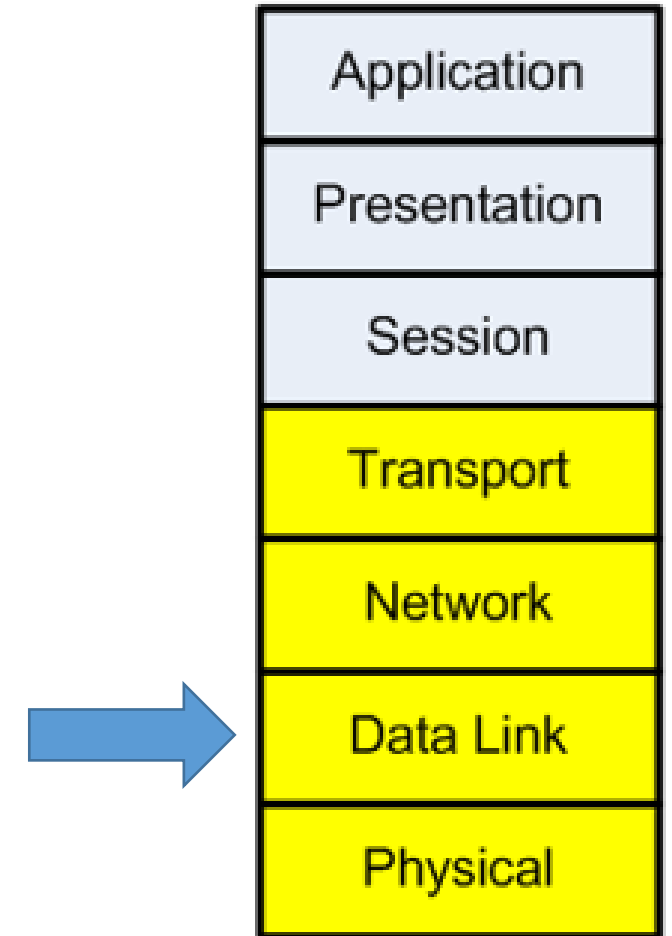
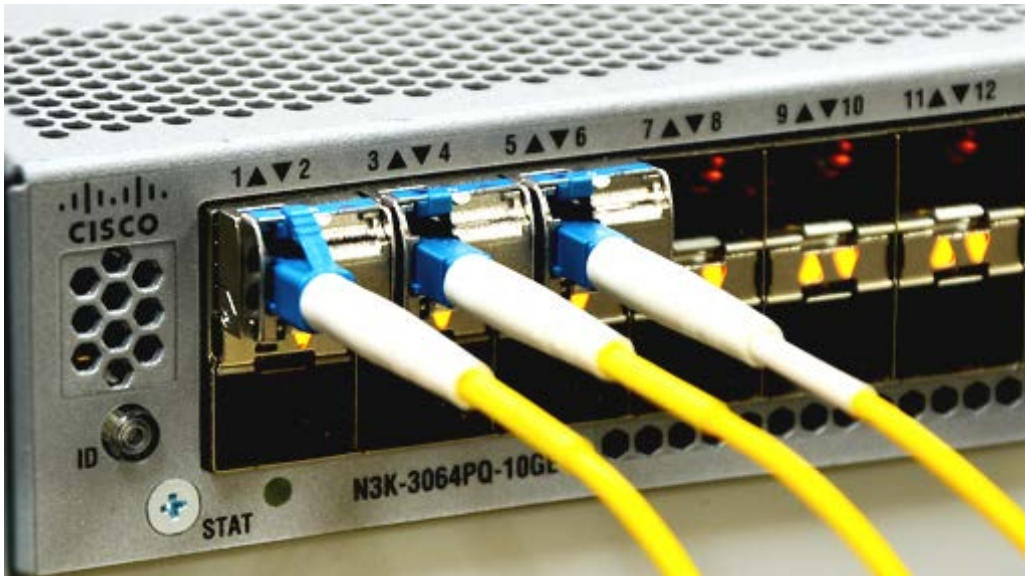
- Video SFP Transceiver (SDI SFP)

- 3G-SDI
- 6G-SDI
- 12G-SDI



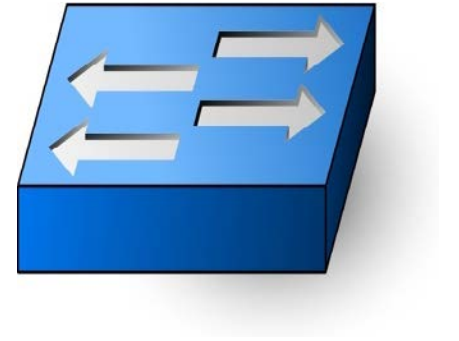
HD-BNC / micro BNC

The Data Link Layer



Ethernet Switching Fundamentals

Originally Known as “Bridging” IEEE 802.1d



- **Ethernet Switching is Transparent**

- Ethernet Frames are Not Modified – “**Transparent Bridging**”
- Bridging or Switching Modes:
 - **Store & Forward** – Dropped if Errored (CRC)
 - **Cut-Through** – Reads Header – Forwards Frame

- **Switches Allow Segmentation of Network**

- Allows Dedicated Bandwidth and Creates Point-Point Communication
- Increased Throughput Due to Zero or Minimal Collisions
- Provides Full-Duplex Operation to Host Device
- Increased Security Capability

- **Switches Selectively Forward Individual “Frames”** from an Ingress Port to a Single Egress Port

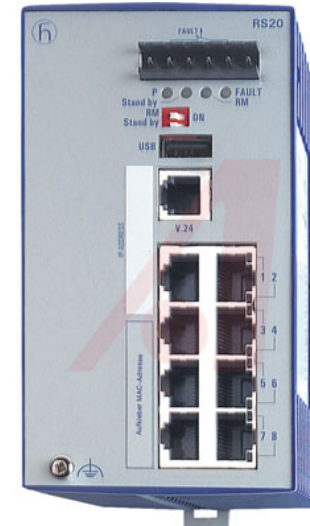
Ethernet Switch Functions



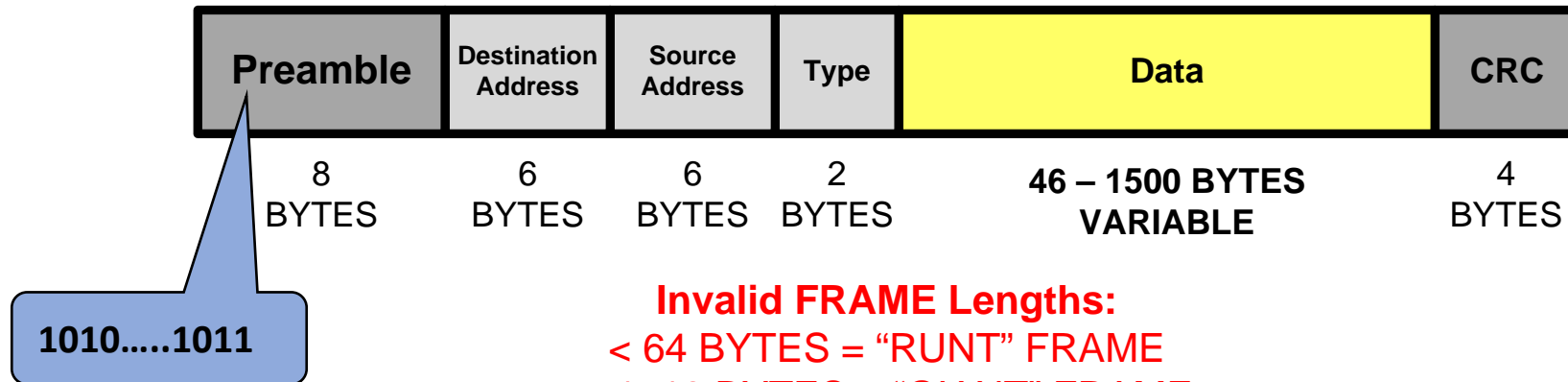
Managed
Ethernet
Switch

- Learn MAC Addresses – Build “Table”
- Filter / Forward Ethernet Frames
- Flood Ethernet Frames
- Provide Loop Avoidance - Redundancy (Avoid loops where redundant links exist)
- Provide Security Features
- Provide Multicast Support

Basic Switch Functions

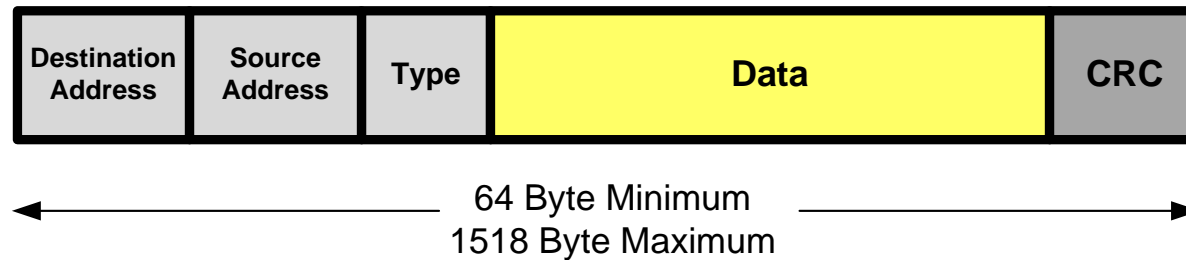


The Ethernet II (DIX) Frame



Invalid FRAME Lengths:
< 64 BYTES = "RUNT" FRAME
> 1518 BYTES = "GIANT" FRAME

Note – Preamble Not Used in Frame Length Calculation



Be Aware That Other Frame Types Exist !

Comment About MAC Address Formats

Always 48 Bits – Expressed as Hexadecimal

REMEMBER – MAC Can Be Represented in Several Formats:

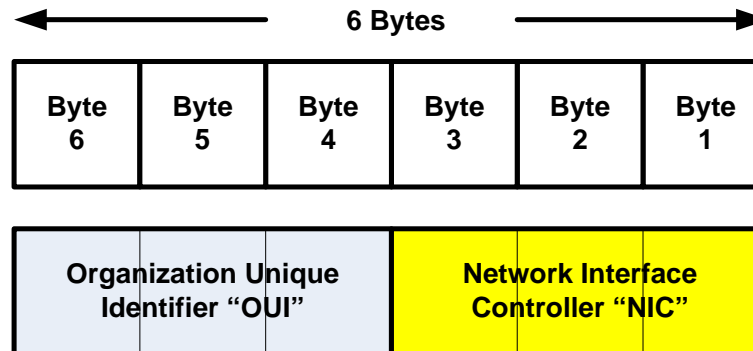
00:A0:C9:14:C8:29

00-A0-C9-14-C8-29

00A0.C914.C829

Broadcast MAC Address:

FF:FF:FF:FF:FF:FF



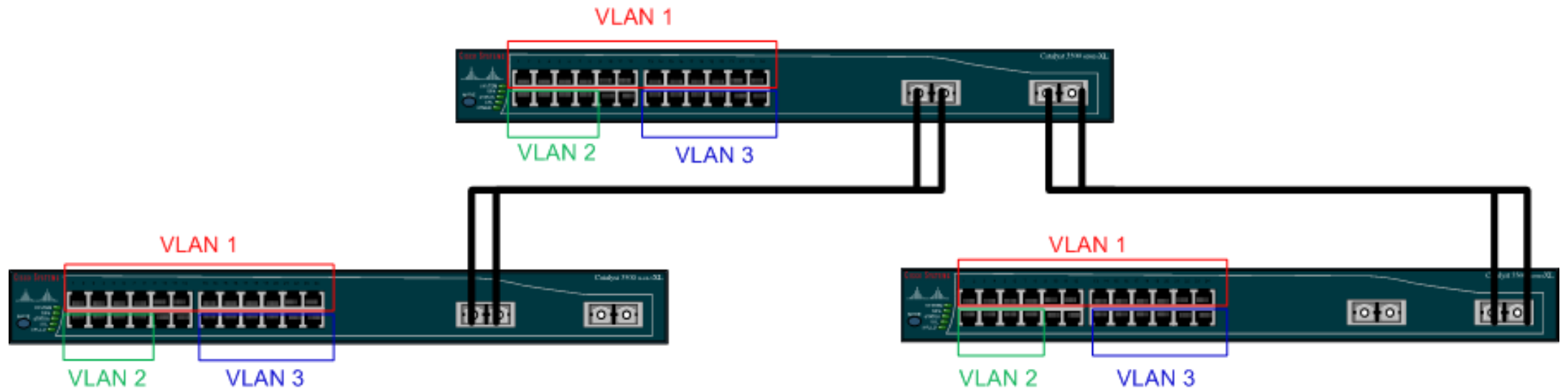
Virtual Local Area Network – VLAN

- Allows Separation or Segmentation of Networks Across a Common Physical Media
 - Creates Subset of Larger Network
 - VLAN Controls Broadcast Domain Reach – Each VLAN is a Broadcast Domain
 - Architecture Flexibility
 - Performance & Security Impact
- Static Port Based VLAN(s)
 - Most Popular
 - Manual Configuration
 - Switch Port Security Features
- Dynamic Port Based
 - MAC-Based VLAN(s)
 - Assignment Based Upon Host MAC Address
 - Protocol-Based VLAN(s)
 - Assignment Based Upon Host Protocol

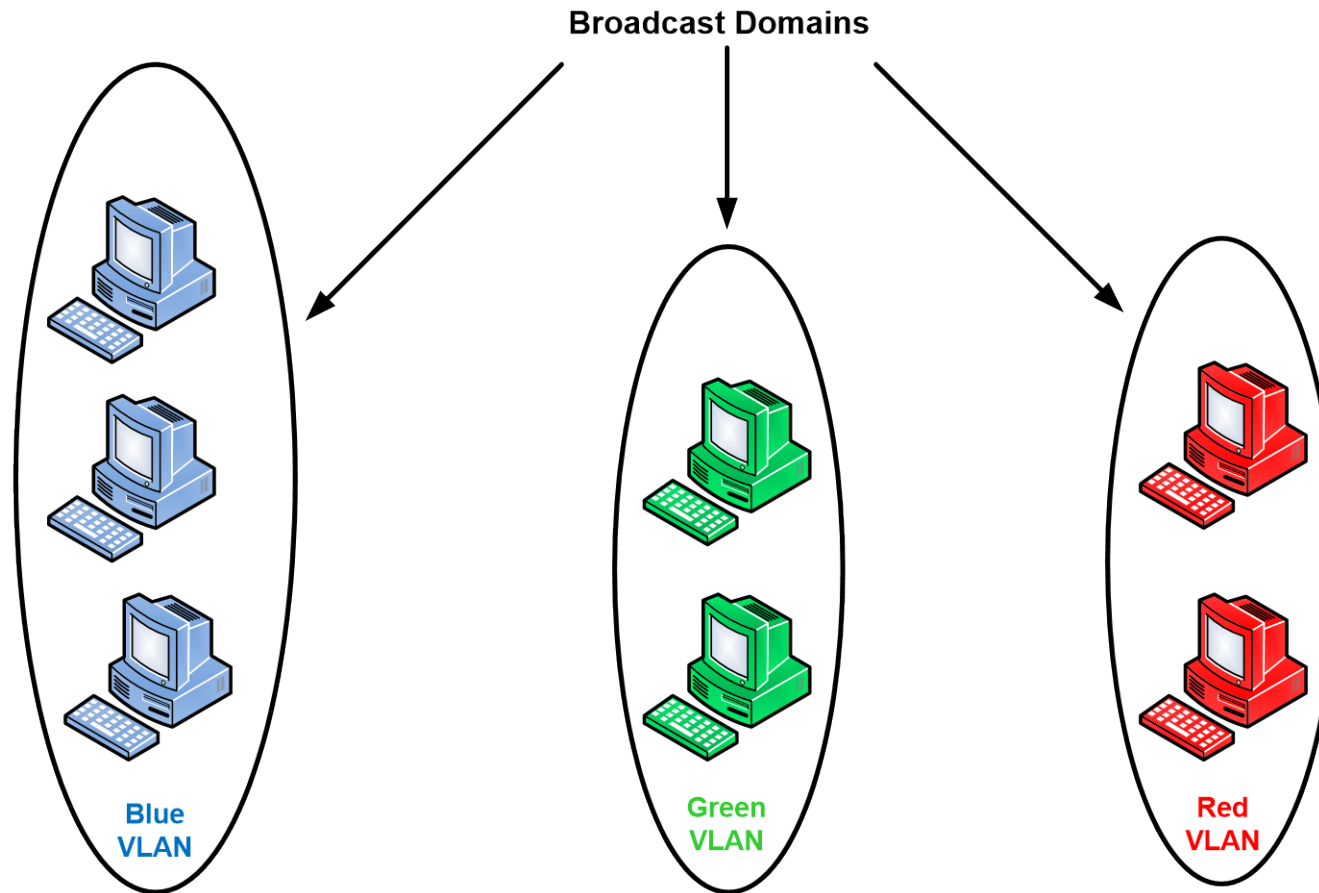


***What Happens in the VLAN,
Stays in the VLAN***

VLAN Implementation Example



Broadcast Domains



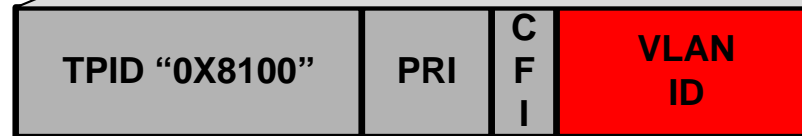
No Connectivity Exists Between Broadcast Domain, Networks, or Subnets!

Adding the 802.1Q VLAN Tag

ETHERNET FRAME

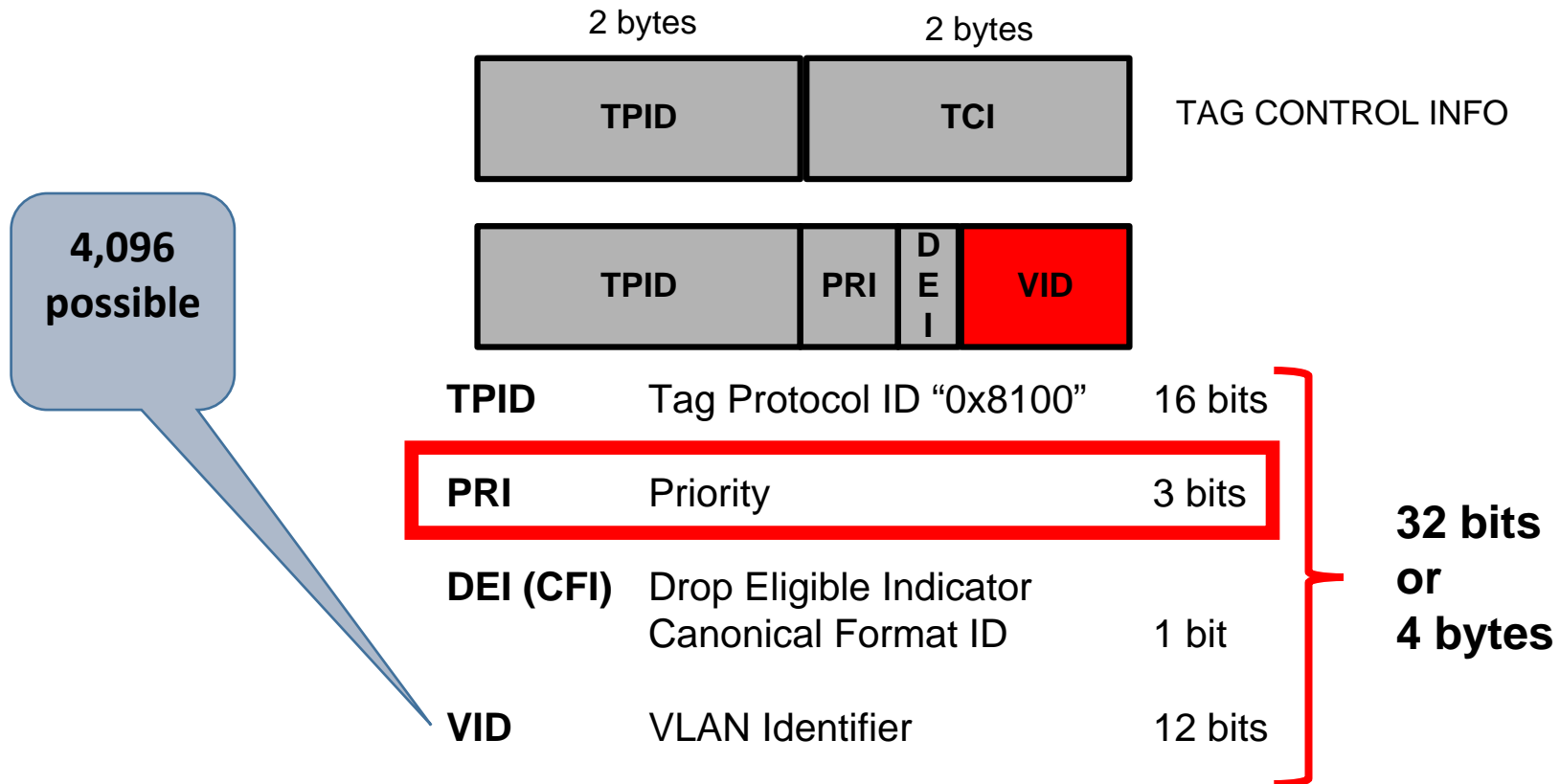


802.1Q ETHERNET FRAME



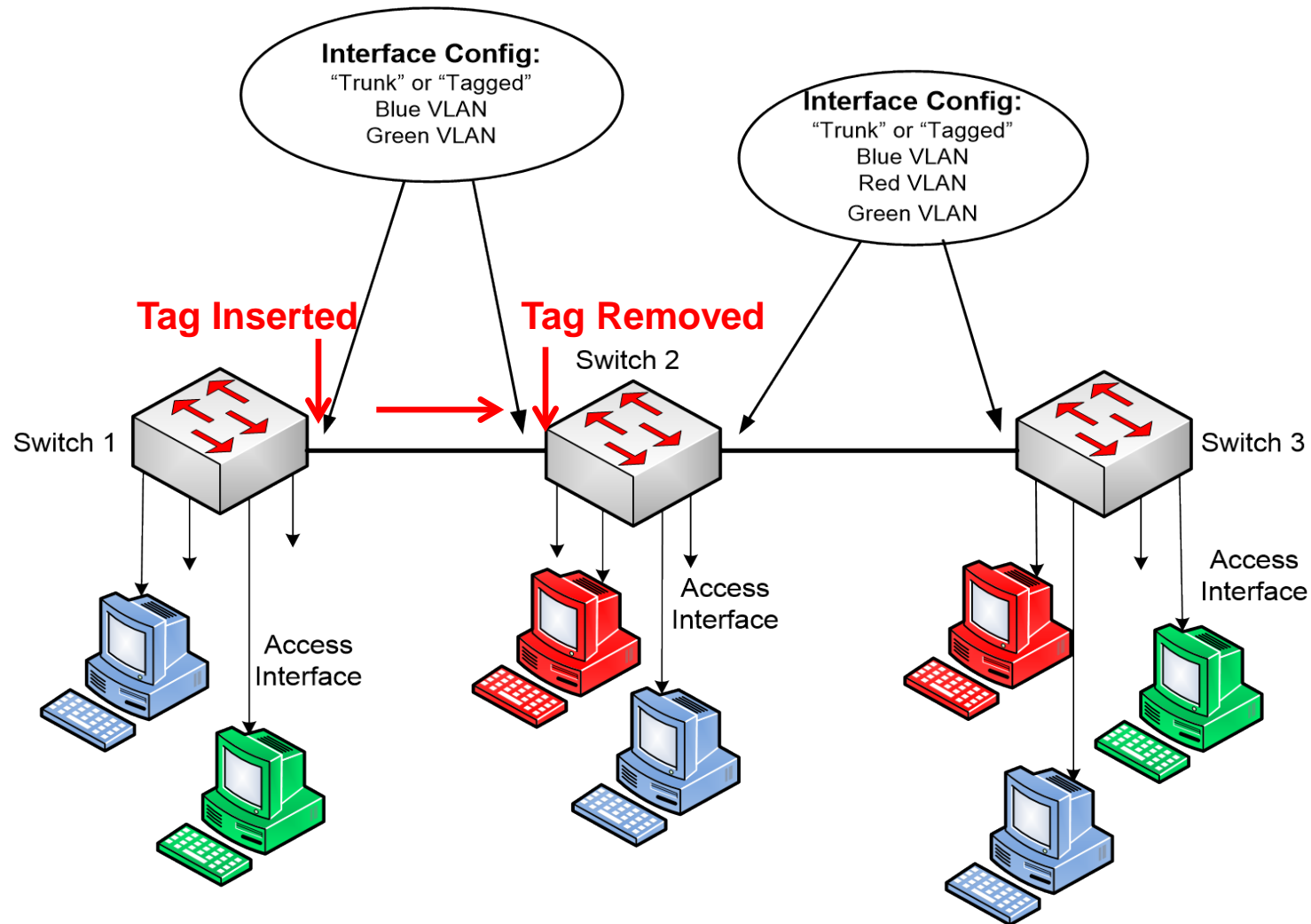
802.1Q TAG

The 802.1Q Tag in Detail



Be Aware – Proprietary VLAN Tags Exist (ie Cisco “VTP & ISL”)
Double & Triple Tagging Can Occur

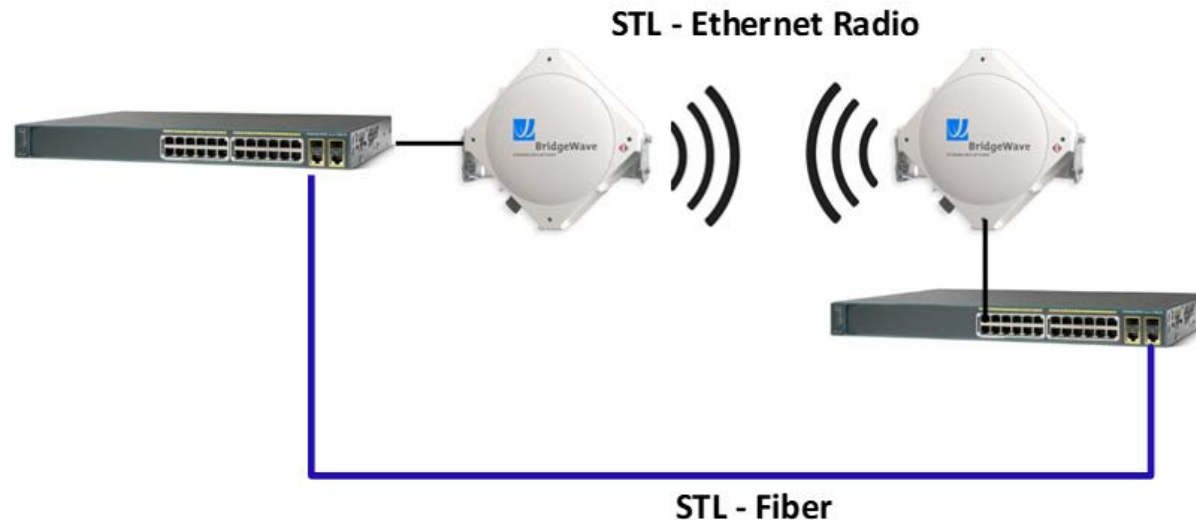
Switch Interface Configuration



Tag added to frame at Egress trunk interface / Tag stripped at Ingress trunk interface

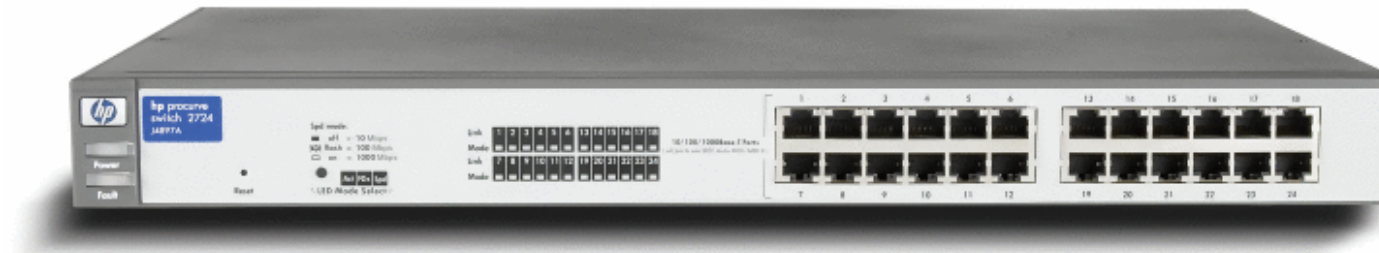
Frame or Forwarding Loops – Spanning Tree Protocol “STP”

- Ethernet Design Requires Only 1 Path Between Hosts
- Multi-Switch Links Create Frame or Forwarding Loops
- When Forwarding Loop Occurs:
 - Frames Circulate Around Loop Endless
 - Increase Link Traffic – Overload Occurs
 - Creates “Broadcast Storm” - Brings “Network to It’s Knees”
 - Increase Switch MAC Table Size – Overwrite Occurs – “Switch Crash”
- IEEE 802.1d Bridging Standards Incorporate Spanning Tree Protocol (STP) to Prevent

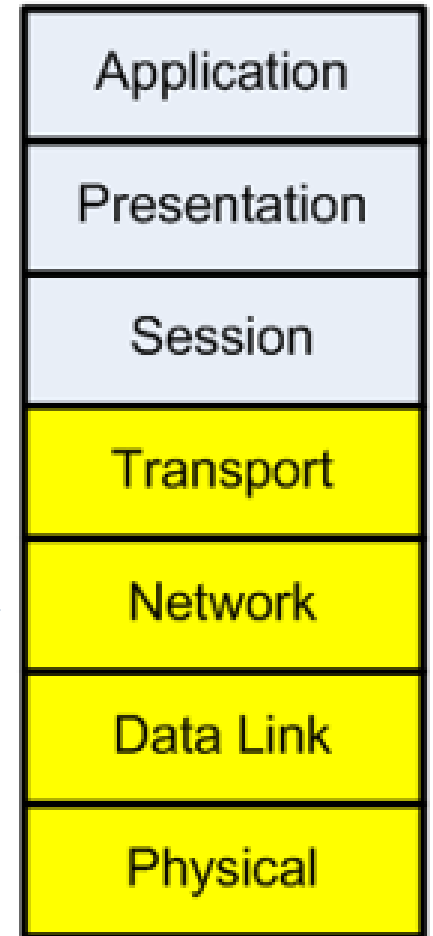
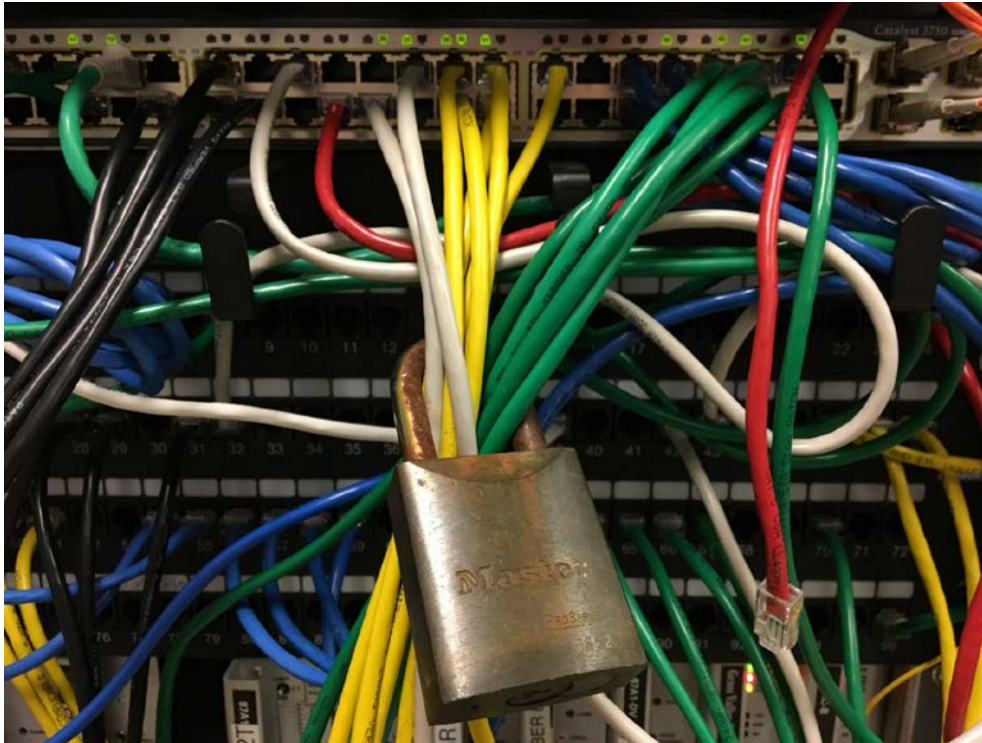


Multicast Support

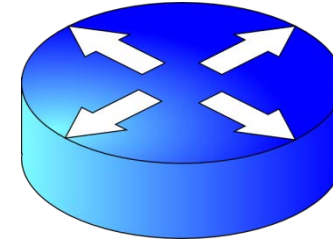
- Multicast Bridges IEEE and IETF Standards
- Multicast May Be Seen as “Broadcast” Traffic to the Ethernet Switch:
 - IE FWD to ALL Switch Ports
- Multicast Enabled Ethernet Switch
 - Layer 2 Implementation of Layer 3 IGMP
 - IGMP “Snooping” Utilized
 - Listens to IGMP Frames – Prunes Ports Unless Multicast “Listener” Host (IGMP Client) is Present



The Network Layer & Above



The Router



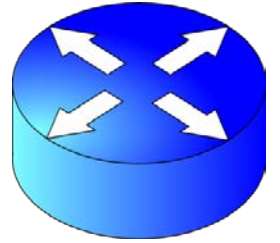
- Router Functions:

- Learn Available Networks
- Maintain Accurate Routing Information Based (RIB) or “Routing Table”
- Translate Layer 2 Headers (where different network types)
- Prevent Loops (where redundant paths)
- Determine “Best” Packet Forwarding Path (destination network)

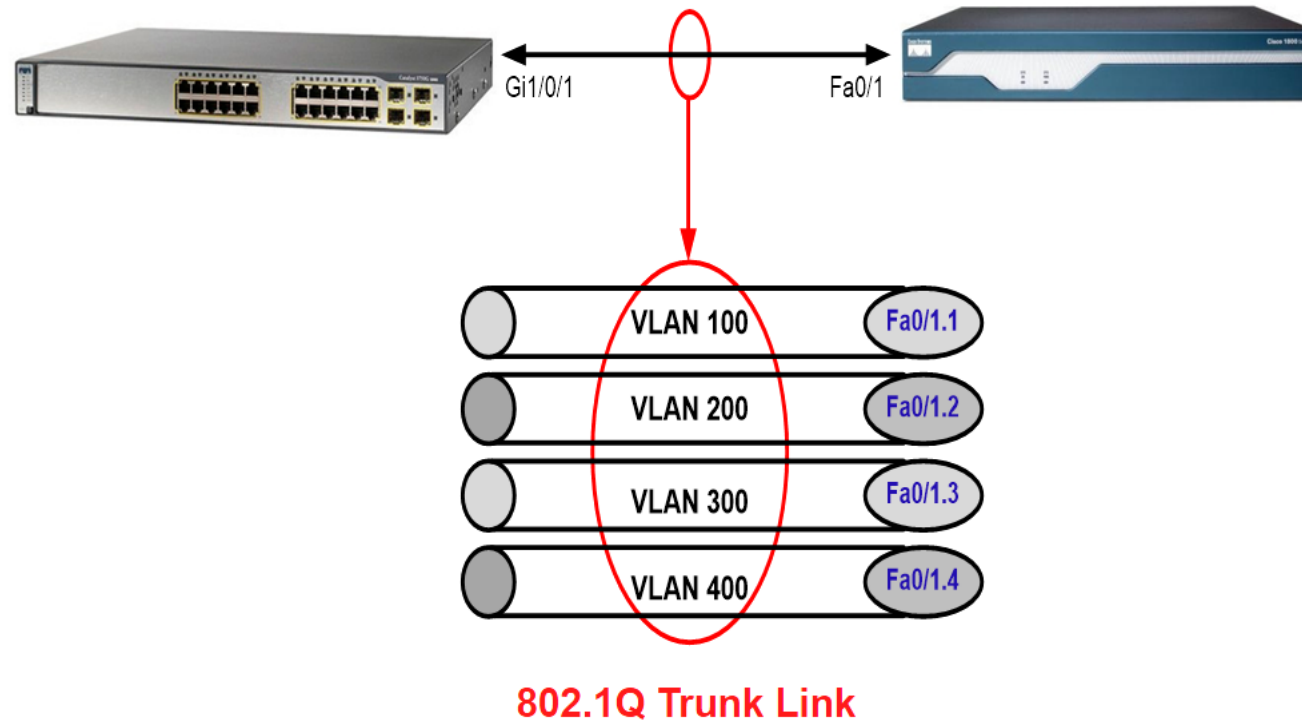
- Destination-Based Routing:

- Packet Header Decoded – Get Destination Address
- Destination Address Lookup in Routing Table (RIB)
- Determine Egress Interface to Forward Packet To
- Re-Encapsulates Layer 2 Header Information

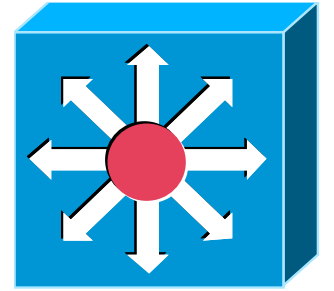
“Router-on-A-Stick”



- Common terminology to describe a Switch & Router connected via a “Trunk” (tagged) link



“Layer 3” Ethernet Switch



- “Marketing Terminology” Applied to a One Box Solution:
 - Layer 2 Switching
 - Layer 3 Routing
- **Layer 3 Switch** Performs Both!
- Multilayer Switch Port Types:
 - Conventional Switch Layer 2 Port
 - Layer-3 Port Routed Port



ATSC 3 - Secured Transmission System

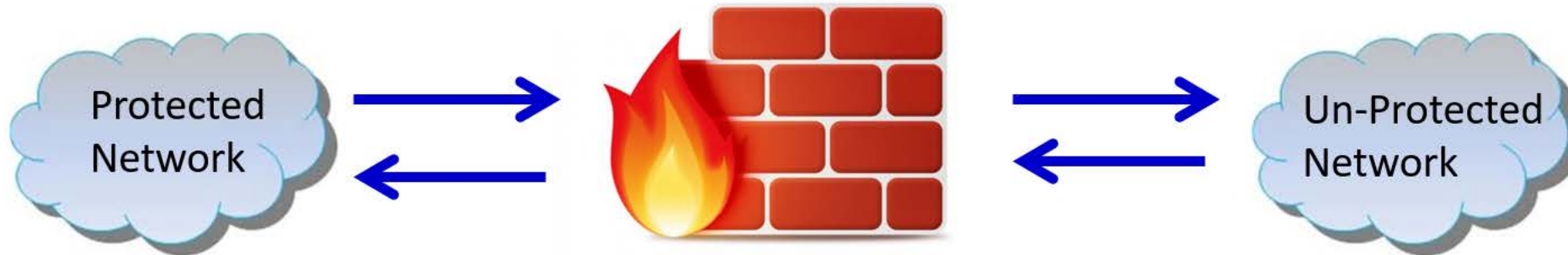
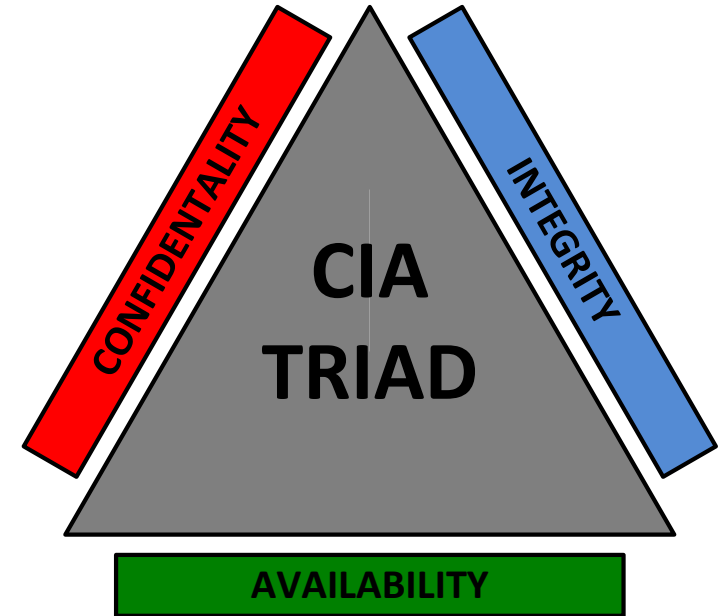
- ATSC 3.0 Inherent Mitigations - [ATSC A/360:2018](#)
 - TLS
 - Transport Layer Security v1.2 / 1.3
 - IETF RFC 8446
 - DNSSEC
 - Domain Name Service Security Extensions
 - IETF RFC 6840
 - Cryptographically Signing
 - IETF RFC 5751
 - DRM Encryption



**ATSC Standard:
ATSC 3.0 Security and Service Protection**

Network Security Techniques

- Physical Security
- Switch Port Security
- Packet Filtering (permit / deny):
 - Access Control List - Stateless Packet Filtering
 - Firewall - Stateful Packet Filtering
- Encryption



Filtering Parameters:
IP Source Address
IP Destination Address
Protocol
Connection Status
Source Port Number
Destination Port Number

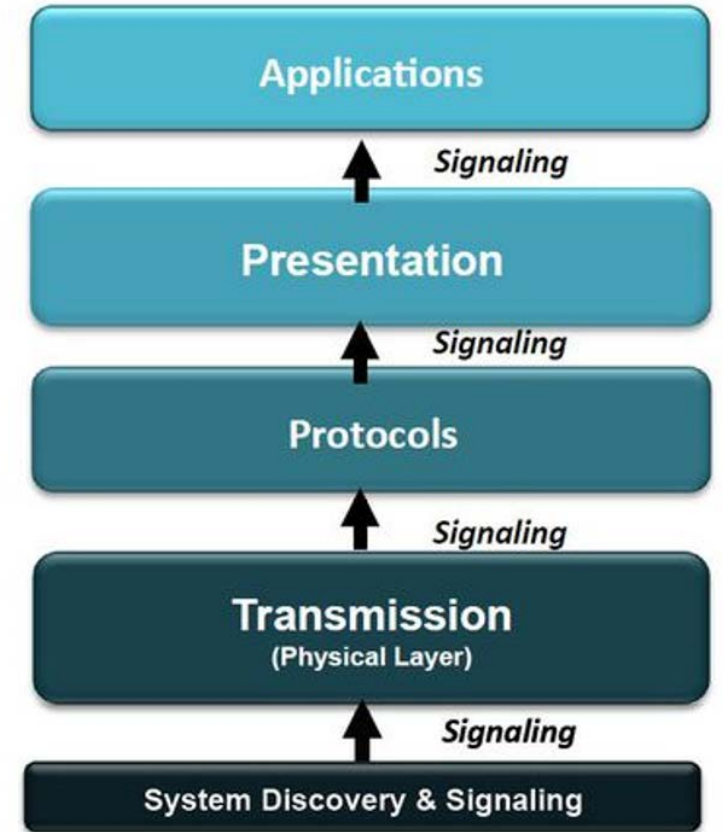
“IPsec”

Internet Protocol Security

- **IPsec** – End-to-End Scheme to Encrypt Communications
- Layer 3 Implementation
- Modes:
 - Tunnel Implementation (VPN Packet Encapsulation)
 - Transport (Host-to-Host Payload) Implementation



Closing Thoughts!



My Closing Thoughts



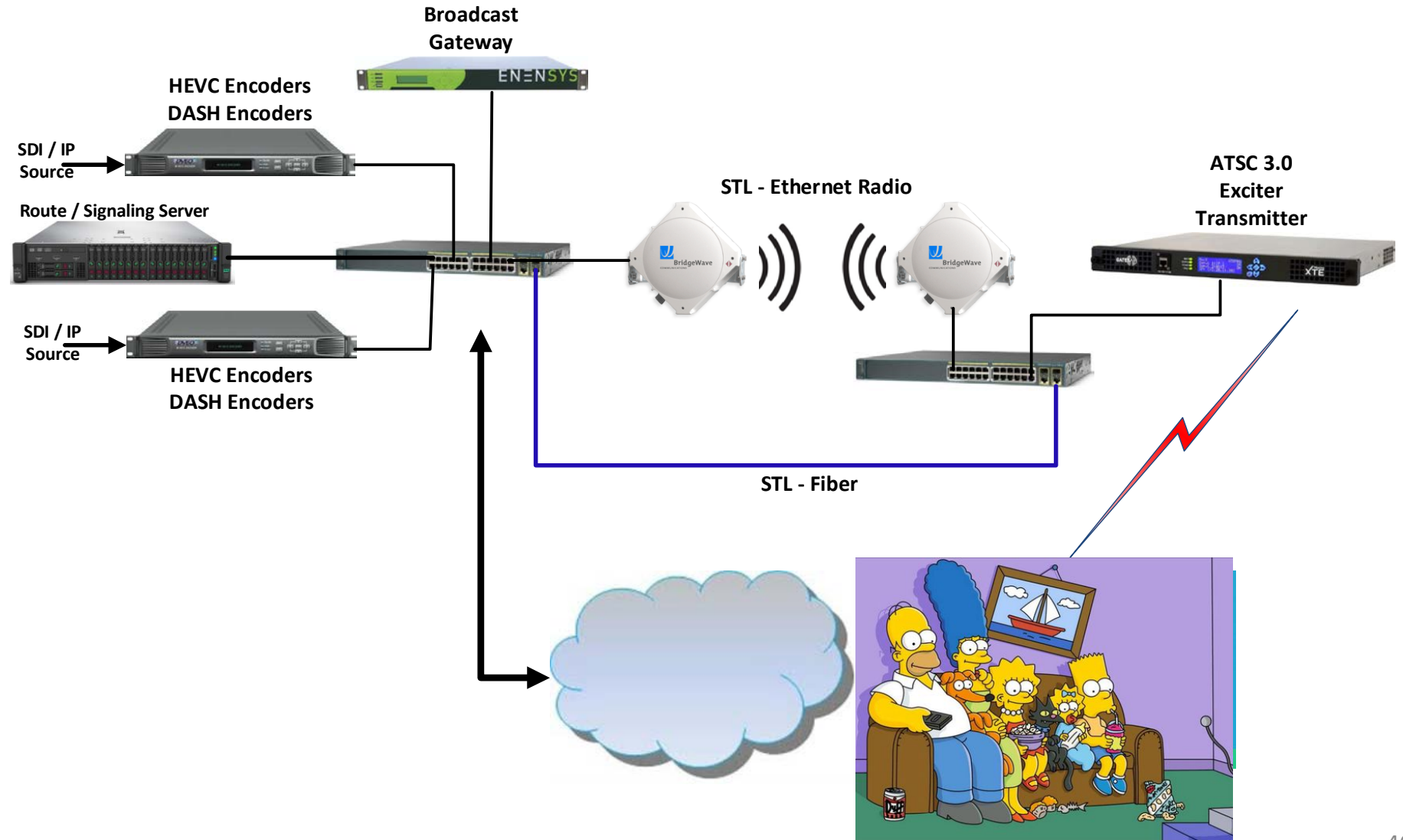
- Use of the Internet Protocol “IP” Brings Unique Features to ATSC 3 & Key to Terrestrial & Broadband Integration
 - Flexible & Scalable Transmission System
 - Enhanced Emergency Alerting
 - Enables Terrestrial / Broadband Integration
 - Provides Interactive Application Support
- Networking Knowledge is Essential for the Broadcast Engineer
 - ATSC 3 is Realtime Media Content – QoS Matters
- Follow the OSI Model Data-Flow Layers in Implementation – Focus Upon:
 - Physical Layer – Know Ethernet In-Depth
 - Understand Ethernet Switching – VLAN Implementation
 - Know the Internet Protocol including QoS & Multicasting

My Closing Thoughts

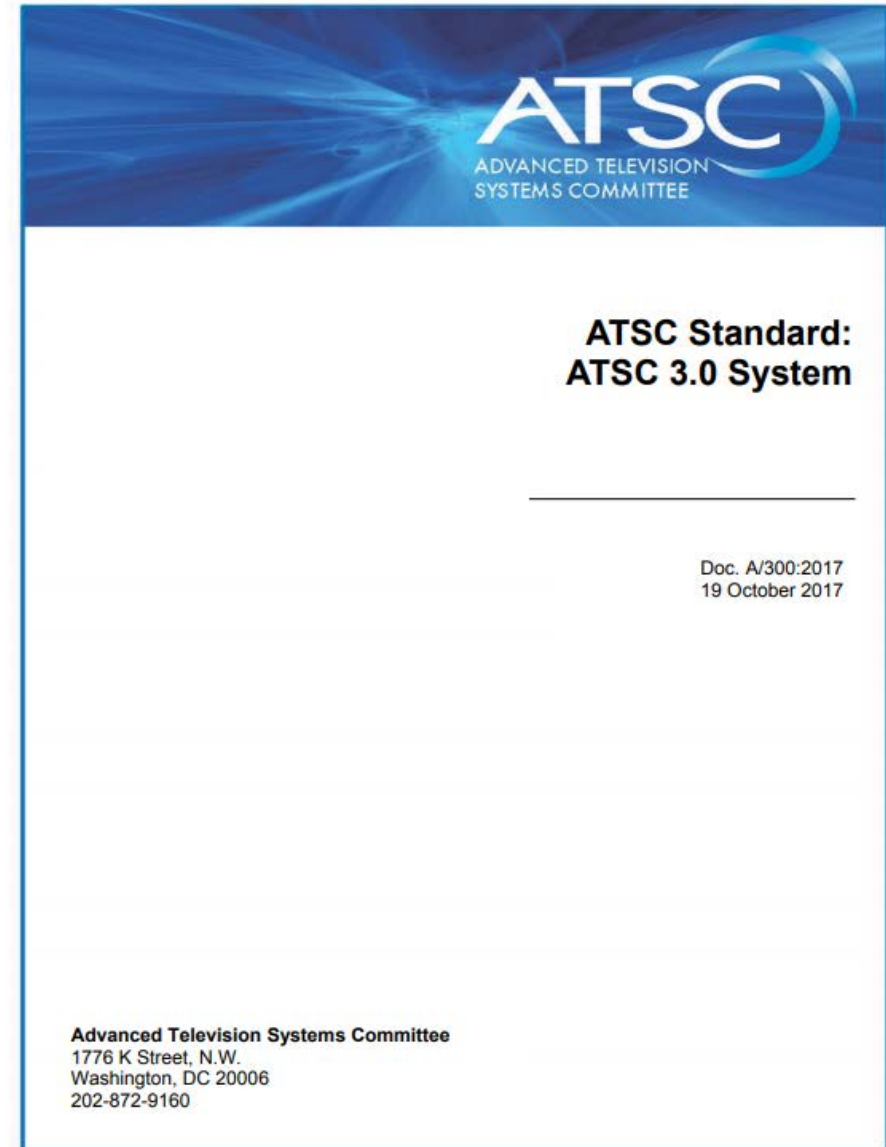


- Utilize Managed Ethernet Switches
- Implement a VLAN Segmented Network Design
 - One Host per Collision Domain
 - Minimize Broadcast Domains
 - Improve Performance / Enhance Security
- Utilize IEEE 802.1Q Tagging or “dot 1Q” to Create VLAN(s)
- Spanning Tree Protocol (STP) Required When Redundant Links Exist
- Implement Security Upfront – Not an Afterthought - IP is Not Secure – It Must Be Secured!
- Use Packet Filtering / Firewall(s) to Limit **Ingress & Egress**
- Use VPN Anytime the Public Internet is Utilized

A Possible Future View



References:



<https://www.atsc.org/standards/atsc-3-0-standards/>

Learning More About ATSC 3

SBE ATSC 3.0 Networking Series

[ATSC 3.0 Networking: Module 1 Introduction to ATSC 3.0 Station Architecture, Networking Standards and the Physical Layer](#)

Wayne Pecena, CPBE, 8-VSB, AMD, DRB, CBNE presents this multi-part webinar series that will provide a foundation in networking technology utilized in an ATSC 3.0 infrastructure. ATSC 3.0 promises to revolutionize the television broadcast industry with integration of traditional over-the-air (OTA) signals and broadband delivered IP content. A key attribute of the ATSC 3.0 standard is the use of the Internet Protocol (IP) as the transport platform. The use of IP as a core transport platform creates the need for the broadcast engineer to have a high competency in networking technology to successfully design, build, and support the ATSC 3.0 infrastructure.

[ATSC 3.0 Networking: Module 2: Ethernet Switching](#)

Wayne Pecena, CPBE, 8-VSB, AMD, DRB, CBNE presents Module 2 of this multi-part webinar series that will provide a foundation in networking technology utilized in an ATSC 3.0 infrastructure. In Module 2, ethernet switching will be discussed in depth to include network architecture design for performance and security use of vlans to provide network traffic isolation. ATSC 3.0 promises to revolutionize the television broadcast industry with integration of traditional over-the-air (OTA) signals and broadband delivered IP content.

[ATSC 3.0 Networking: Module 3: IP Routing](#)

Module 3 completes the ATSC 3.0 Networking Series presented by Wayne Pecena, CPBE, 8-VSB, AMD, DRB, CBNE. In this final Module, IP Routing, secure remote access and security best practices to insure reliable system operation and ongoing support capability will be discussed. ATSC 3.0 promises to revolutionize the television broadcast industry with integration of traditional over-the-air (OTA) signals and broadband delivered IP content.



Learning More About ATSC 3

SBE ATSC 3.0 Series

[ATSC 3.0 Webinar: Module 1 - Introduction to ATSC 3.0](#)

Length 1 hour, 10 minutes

This webinar provides an overview of the ATSC 3.0 system capabilities including physical layer, signaling, audio, video, captions, interactivity, and advanced emergency messaging. You will receive an introduction to the suite of Standards and Recommended Practices documents and an overview of the SBE ATSC 3.0 Specialist Certification.

[ATSC 3.0, Module 2: Overview of the Physical Layer](#)

Length 1 hour, 4 minutes

This presentation covers the scope of the physical standards, the architecture of physical layer, its functional descriptions and the mandatory modes of operation, followed by a few optional technologies and a summary.

[ATSC 3.0, Module 3: Implementation of the Transport and Physical Layers](#)

Length 2 hour, 26 minutes

This presentation examines notional organization of equipment in the system and the protocols that connect the various system elements. It also will look at the wider system context in which the Transport and Physical Layer components are installed and by which they are controlled. Equipment to be covered in detail are Broadcast Gateways and Exciters and the Studio-to-Transmitter Links that interconnect them. Protocols to be covered include the Data Source Transport Protocol (DSTP), the ATSC 3.0 Link Layer Transport Protocol (LLTP), the Studio-to-Transmitter Link Transport Protocol (STLTP), Error Correction Coding, Security elements, and several other aspects of the systems that deliver ATSC 3.0 data to transmitters and control their emissions. Also covered will be implementation of Single-Frequency Networks (SFNs), Channel Bonding, and other models of operation of the ATSC 3.0 Physical Layer..

[ATSC 3.0, Module 4: MPEG Media Transport Standard and its Use in ATSC 3.0](#)

Dr. Youngkwon Lim, Principal Engineer, Samsung Research America and Dr. Kyungmo Park from SK Telecom are presenters. After successful development and deployment of media delivery standards such as MPEG-2 Transport Streams and ISO Base Media File Format, MPEG has developed new standards for IP-based services, namely MPEG Media Transport (MMT) and Dynamic Adaptive Streaming over HTTP (DASH). Developed for industry, MMT has enjoyed the benefits of MPEG-2 TS while considering migration to IP-based delivery. Japanese Super Hi-Vision was the first broadcasting service to adopt MMT. ATSC 3.0 then also adopted it. In this webinar, the important features of MMT utilizing benefits of IP while preserving useful features of MPEG-2 TS and how they have been harmonized with ATSC 3.0 standards will be presented.

[ATSC 3.0, Module 5: ATSC 3.0 ROUTE Protocol](#)

Dr. Charles Lo, Principal Engineer at Qualcomm's Standards and Industry Fora Organization presents. This webinar provides an overview of ROUTE, or "Real-Time Object Delivery Over Unidirectional Transport." One of the two application-layer transport protocols specified in ATSC 3.0 standards for the delivery of media services and other data over IP-based broadcast system, ROUTE is specified in the ATSC A/331 standard, and has broad utility in supporting the delivery of real-time (RT) streaming services (e.g., linear TV) and non-real-time (NRT) content (e.g., file-based services) for end-user consumption, as well as signaling, application-related documents, DRM metadata and other types of data for use by receiving devices and application software. Besides reviewing the content delivery aspects of the ROUTE protocol, this presentation also describes the service signal mechanisms defined for ATSC 3.0 that enable the discovery and acquisition of services and contents carried by ROUTE.

[ATSC 3.0: Module 6: Advanced Emergency Information System](#)

The ATSC 3.0 Advanced Emergency Information system enables broadcasters to deliver timely, in-depth emergency-related information to their viewers, which can strengthen the connection between the audience and the station and provide critical information in times of need. The system includes methods for waking up devices in stand-by mode, message targeting, rich media delivery and more. In this webinar attendees will learn about the elements of the ATSC 3.0 standards that enable advanced emergency messaging, along with methods and examples for implementing the system features.

ATSC 3.0 Tutorial Videos from SBE@PBS TechCon 2019

Please note numerically the videos are out of sequence as content was combined appropriately to produce fewer videos. Thus, the complete series includes Parts 1, 2, 4, 6, 7 and 8 and all are now available.

Part 1: The Physical Layer

The fundamentals of transmission change dramatically compared to 8-VSB. Originally, this alone was the motivation for replacing ATSC 1.0. It is the Physical Layer (PHY) that enables single-frequency networks and mobile reception. Beyond OFDM, a bootstrap signal and Physical Layer Pipes (PLPs) empower NextGen over-the-air (OTA) TV to reach receiving devices in an extremely broad set of circumstances and for a multiple of uses.

Members \$59, MemberPlus Members FREE and Non Members \$89. [Register Here.](#)

Part 2: Broadcast Regulations

NextGen regulatory and contractual deployment requirements include simulcasting carriage mandates, program hosting agreement issues for 1.0 and 3.0 stations, government applications and notifications. Meeting these obligations and preserving station cashflow require broadcast engineers to know how far ATSC 1.0 content compression can be pushed and at what cost. Partnering through channel sharing is a big part of broadcasters' deployment plans. Broadcast engineers must provide the technical specifications competently in these legal arrangements.

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Part 4: NextGen/ATSC 3.0 Transmitter Conversion

Converting transmitters and STLs to ATSC 3.0 service and performing the proof-of-performance and acceptance testing are covered by the engineers that build the transmitters.

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Part 6: NextGen Broadcast/ATSC 3.x Scheduler

The Gateway, System Scheduler and Manager is the central piece of a NextGen broadcast transmission system that aggregates all the IP content and assigns it to the proper Physical Layer pipes (PLPs), adding low-level signaling, control, announcement and configuration information that becomes the studio transmitter link (STL) stream that in turn feeds the modulator/exciter of the over-the-air (OTA) transmitter.

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Part 7: Monitoring and Display

An ATSC 3.0 station's first piece of NextGen test equipment might be a dongle with an array of analytical and decoding/player/display software. The first home gateways with limited capability and storage are in the prototype stage. All the aspects of monitoring and display are covered in this section.

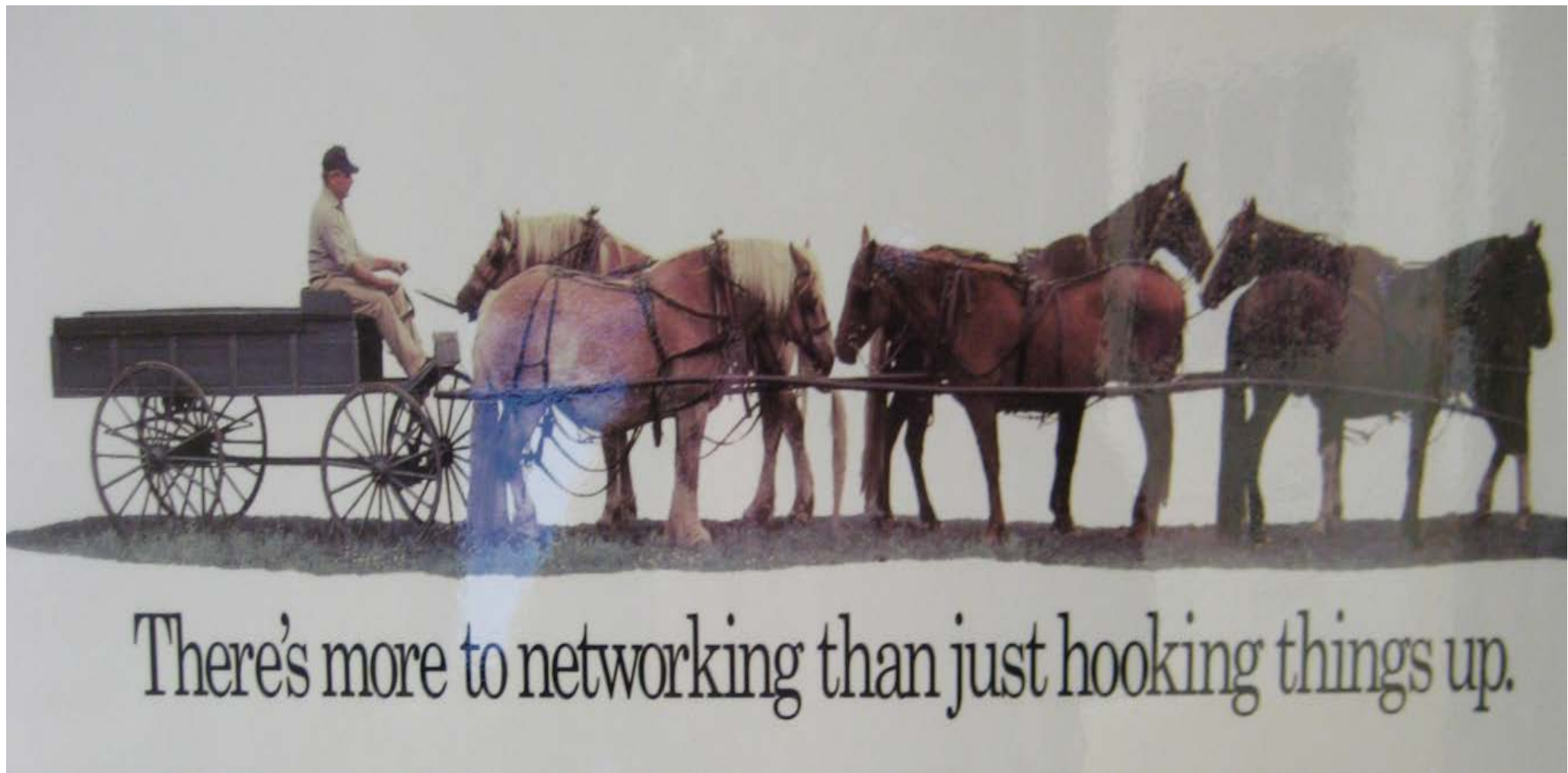
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Part 8: The NextGen Broadcast Station

Stations will first focus on transmitting current content via ATSC 3.0, but the service provides new sales opportunities as well. Operationally, an additional transmission system will be monitored in master control, digital and linear workflows meld, and informing becomes important for processing, validating, curating, and archiving information then distributing it on platforms that now include AEI receiver apps.

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