So You Want A Show Network?

Tom Hammond, www.itwinkle.org, tominohio@gmail.com

So You Want A Show Network?

Overview

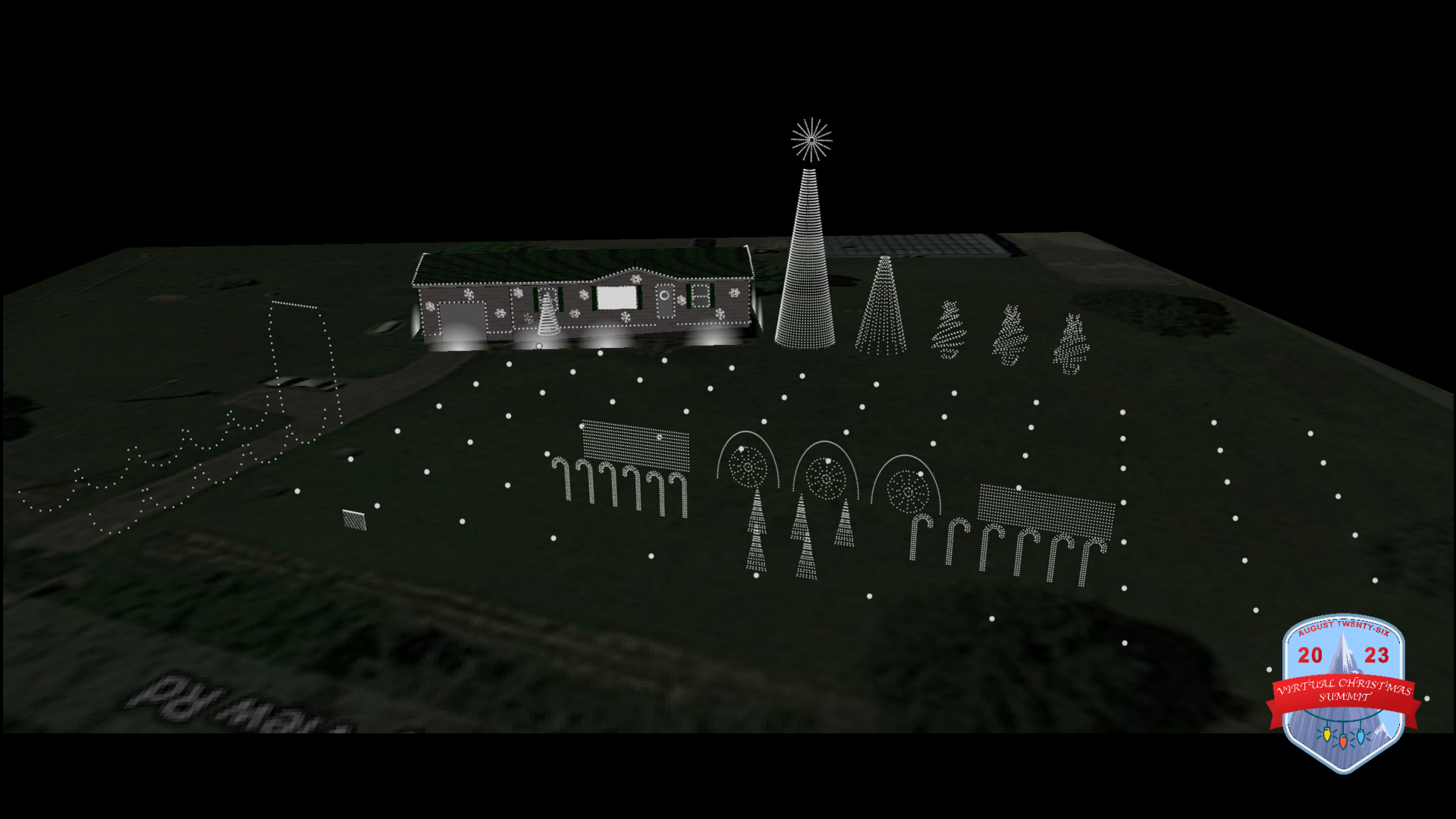
- Why have a show network?
- Bandwidth
- Protocols
- How networking works
- Improve your existing network
- Create a show network
  - Routing vs. proxy vs. VPN

Tom Hammond

Where are you from?

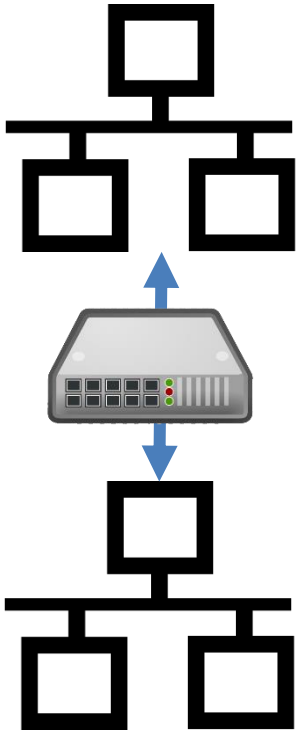
- I.T. tech of 35 years at University of Akron OH
- 11 years of shows
- 63,507 pixels (8,036 network pixels)
- National recognition
- iTwinkle.org to watch & control show

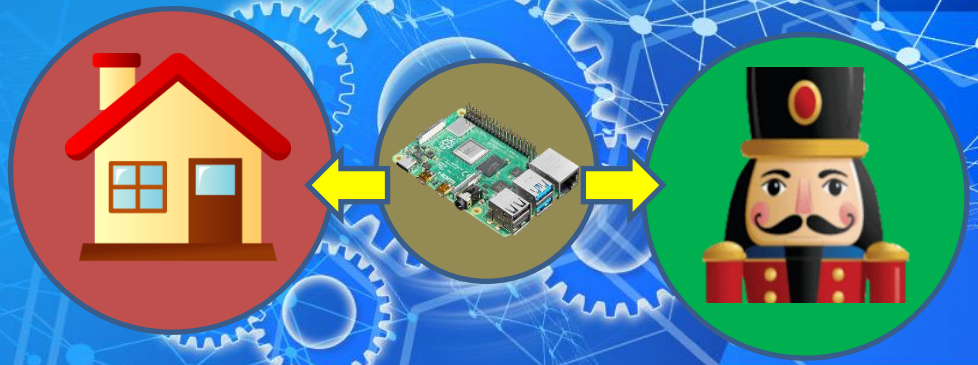
A picture is worth a thousand words


AUGUST TWENTY-SIX
20 23
VIRTUAL CHRISTMAS SUMMIT

What is a Show Network?

- Separate network wiring for your show, apart from your home network
- Two networks can't see nor interfere with each other, unless a router/proxy/VPN is used to join them

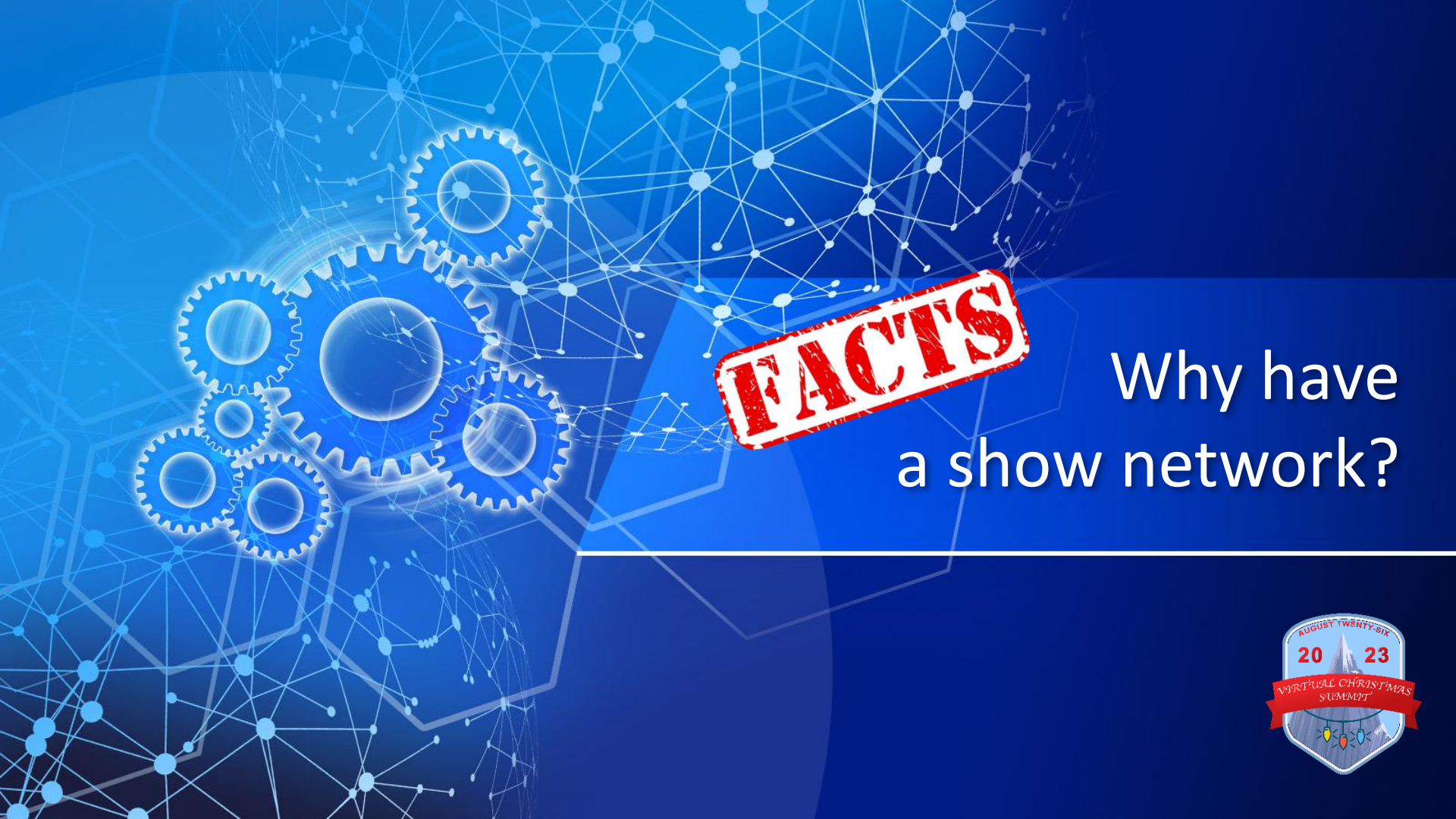




Why have a show network?

Why a Show Network?

- **Bandwidth limitations**
  - Shows consume lots of bandwidth
- **Poor Wi-Fi coverage**
  - Give show network its own SSID
- **Security concerns**
  - Hackers can invade your network



Why have a show network?

Why have a Show Network?

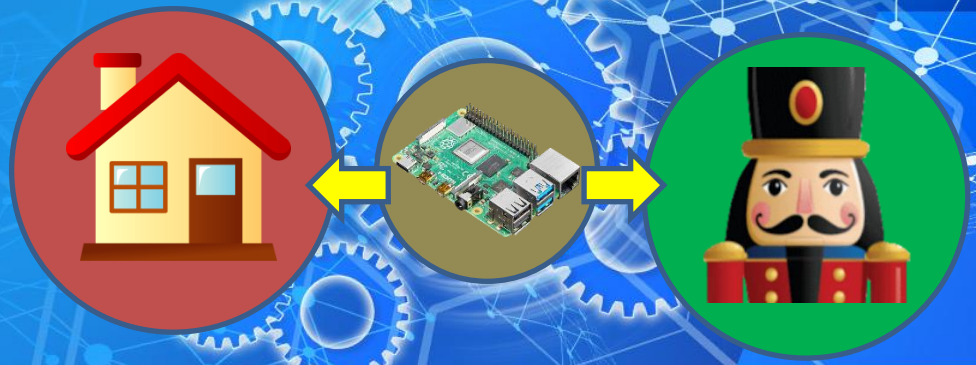
- **Bandwidth limitations**
  - Pixel shows take a small fraction of bandwidth
    (1-2% of 1Gbps Ethernet bandwidth for 10,000 pixels at 20 FPS)
  - Other home uses (movies, video games) are low bandwidth, too
  - Ensure home network uses good gear

Why have a Show Network?

- **Poor Wi-Fi coverage**
  - Separate SSID still uses same spotty Wi-Fi network
  - Pushing pixel data via Wi-Fi can be problematic
    - Instead, use Wi-Fi for multisync packets and routing between networks
  - Use good Wi-Fi gear for home network

Why have a Show Network?

- **Security concerns**
  - Keeping public from your home network is a valid point
  - Separating networks adds unnecessary complexity
  - Instead, improve home network security. It benefits everyone at home, not just your show (firewall, router options).



Good reasons to have a show network

Why have a Show Network?

- **Wired controllers but no Ethernet from house**
  - Use Raspberry Pi as router via Wi-Fi
- **House Wi-Fi spotty or Wi-Fi only controllers**
  - Show network on its own Wi-Fi router
- **Have a ton of pixels**
  - 1Gbps network can drive over 1M pixels at 20fps, 500k pixels at 40fps (using DDP)


1 GBPS
100 MBPS
10 MBPS

Bandwidth

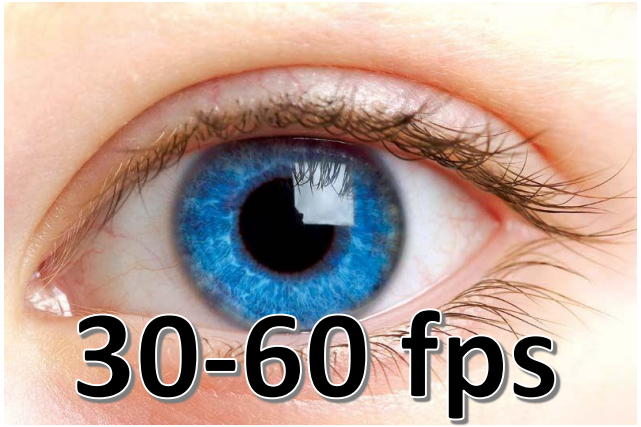

AUGUST TWENTY-SIX
20
23
VIRTUAL CHRISTMAS SUMMIT

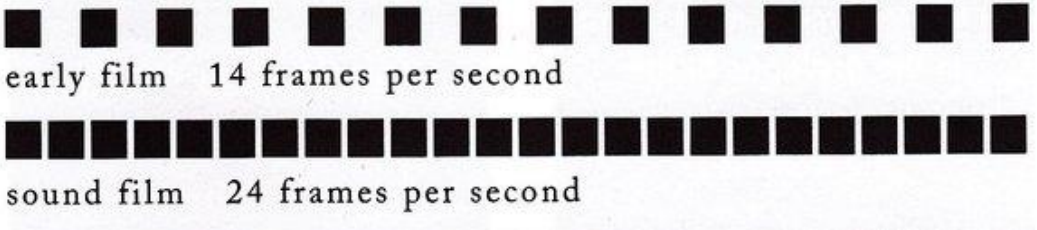
Bandwidth

- FPS differences (frames per second)
- Protocol differences
- Show bandwidth
- Bandwidth comparisons

FPS differences

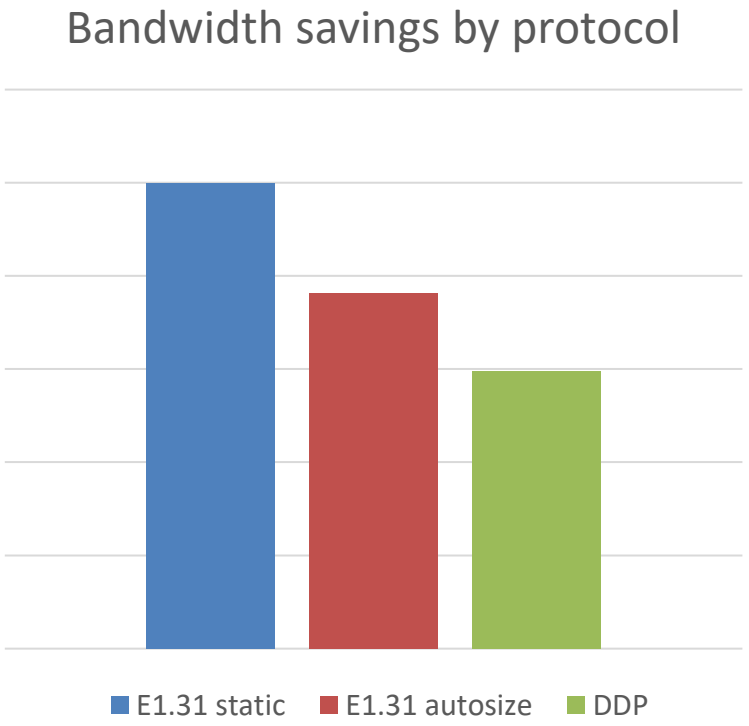
- How often your pixels animate per second
- 20fps is default, 40fps is popular
  - “good” vs. “silky smooth”
- Double the FSEQ size and network bandwidth





Protocol differences

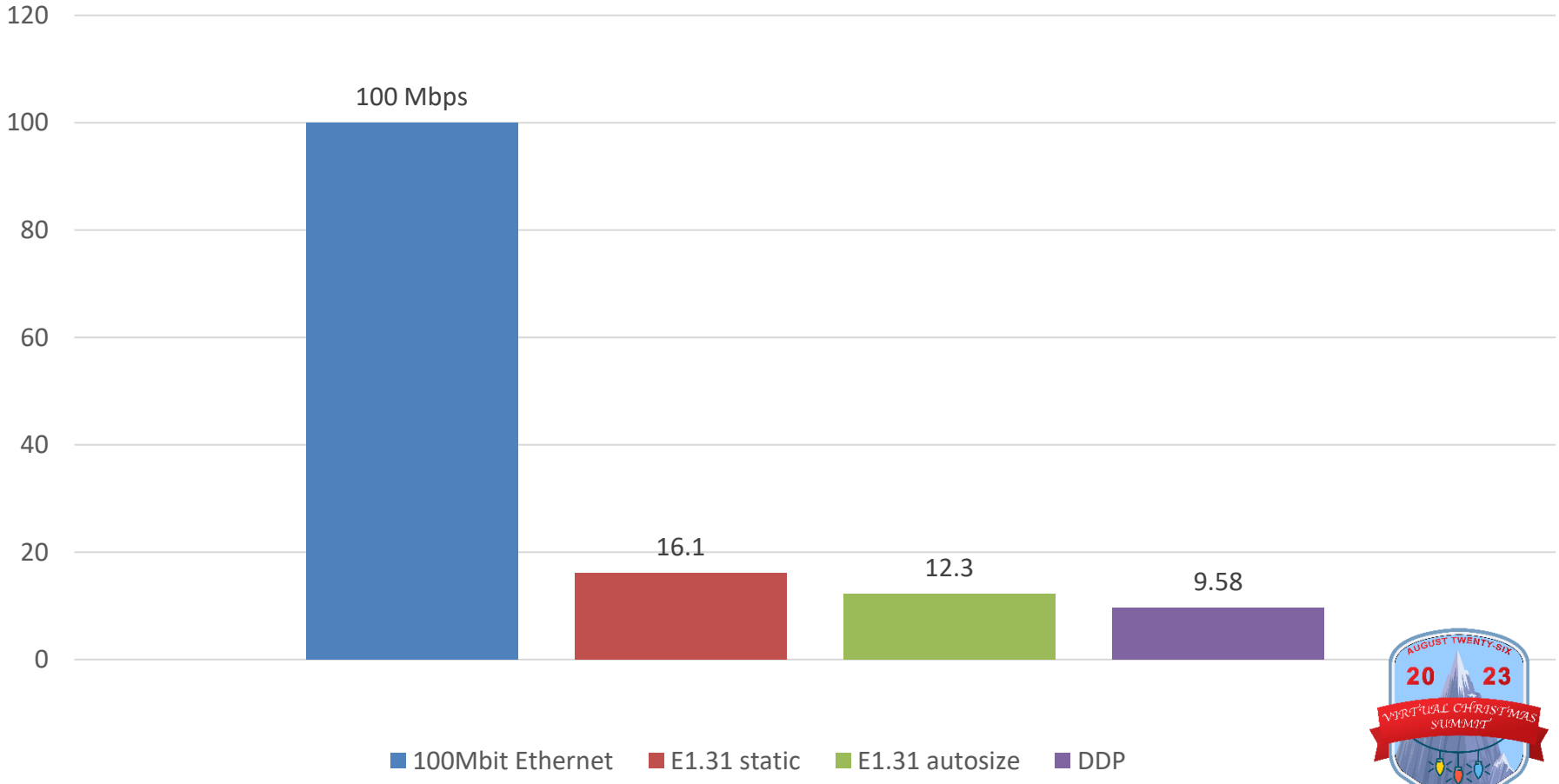
- DDP (Distributed Display Protocol)
  - Up to 40.5% more efficient than E1.31
- E1.31 (Streaming ACN)
  - Auto (universe) Size is about 23.6% more efficient than static size



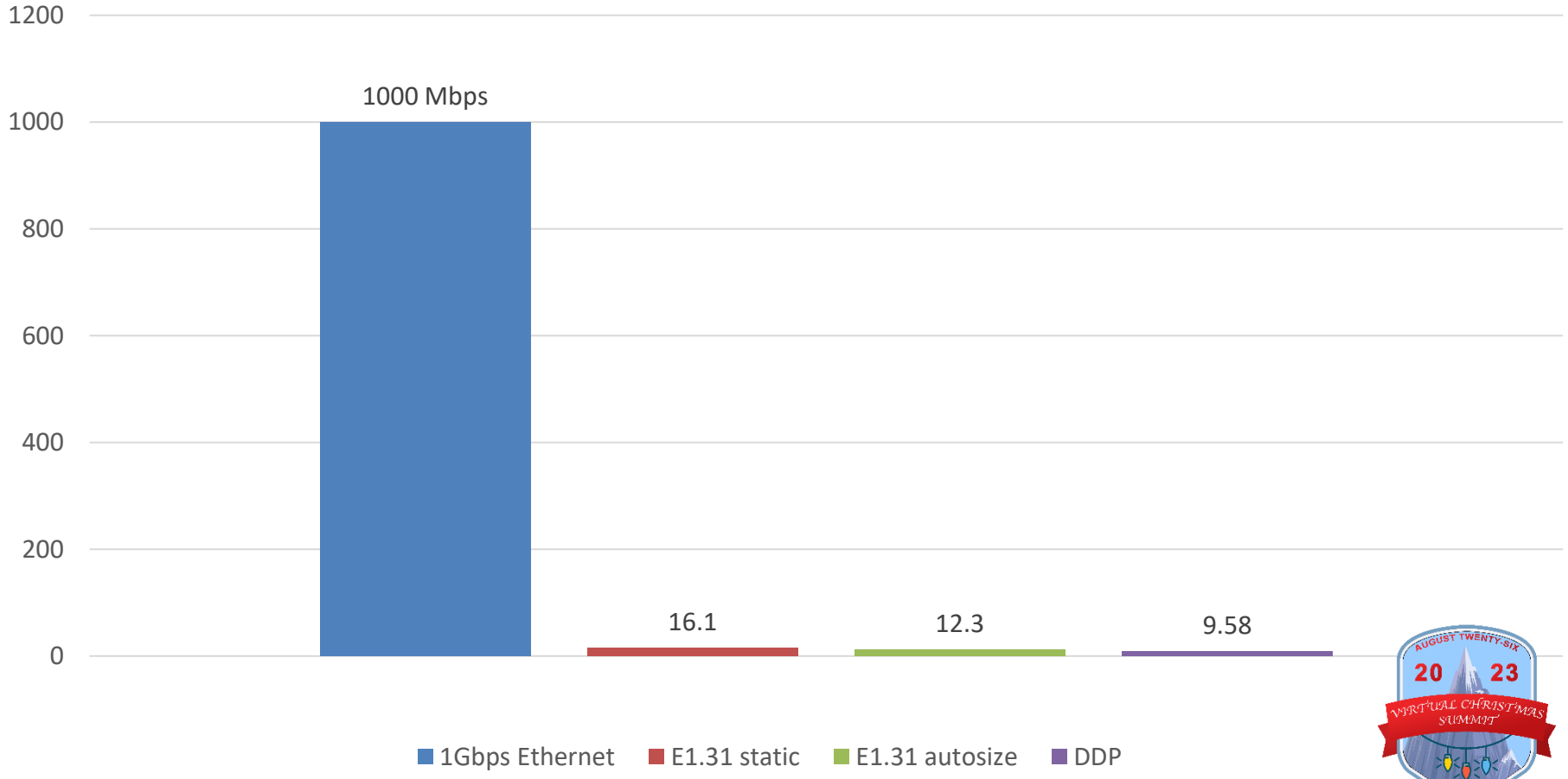
Show bandwidth

- Shows do not consume much bandwidth
  - 10,000 pixel show (20 fps) can consume:
    - 16.1Mbps with E.131 static
    - 12.3Mbps with E.131 auto size
    - 9.58Mbps with DDP
  - On a 100Mbps wired network, this is only 9.58-16.1% of network bandwidth (1-2% of gigabit network)

Bandwidth consumption for 10,000 pixels (20 FPS) on a 100Mbps network



Bandwidth consumption for 10,000 pixels (20 FPS) on a 1Gbps network



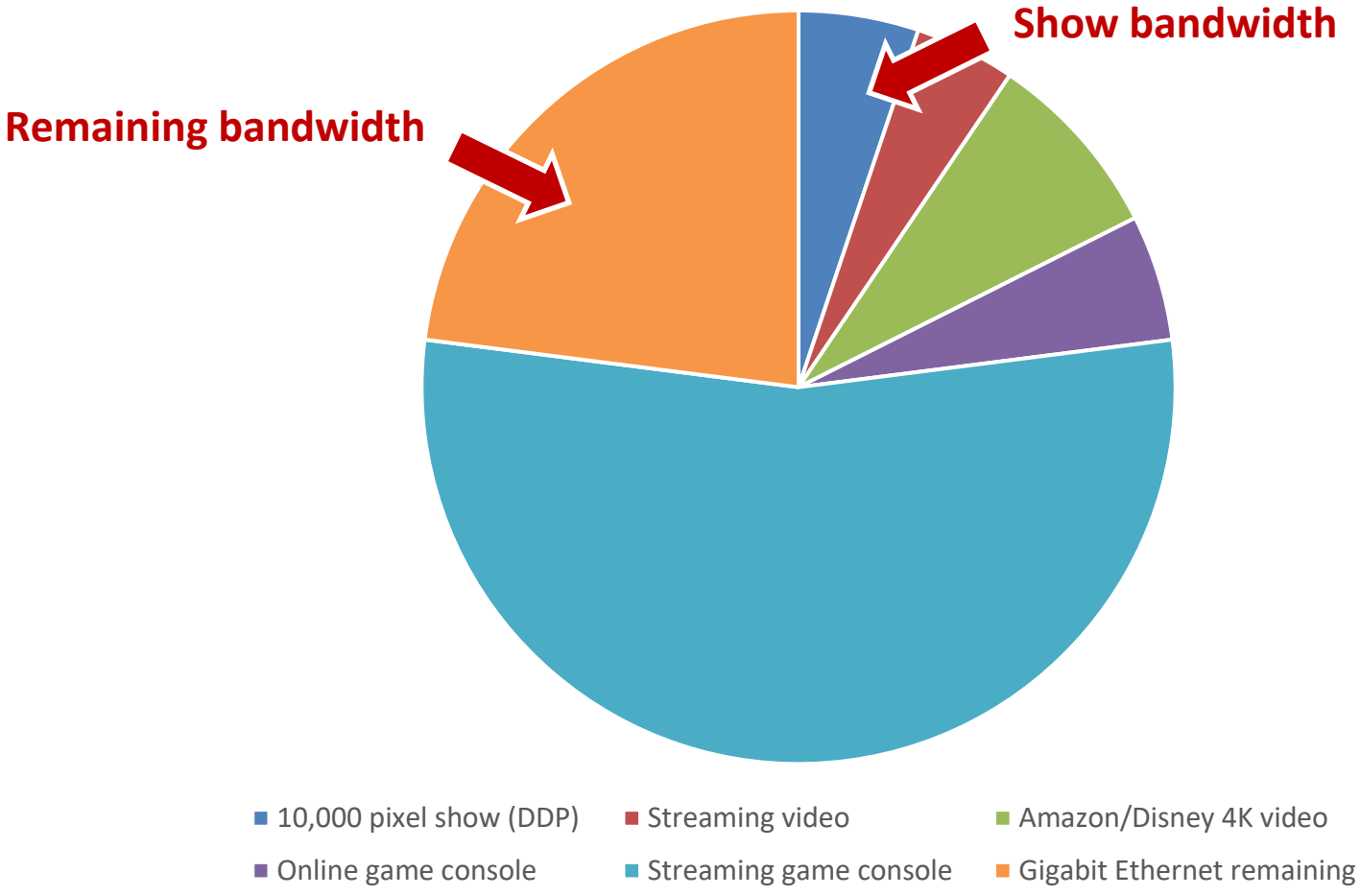
Bandwidth comparisons

- Gigabit switch: 1,000Mbps
- Wi-Fi 5 router 6,900Mbps*
- Wi-Fi 6 router 9,600Mbps*

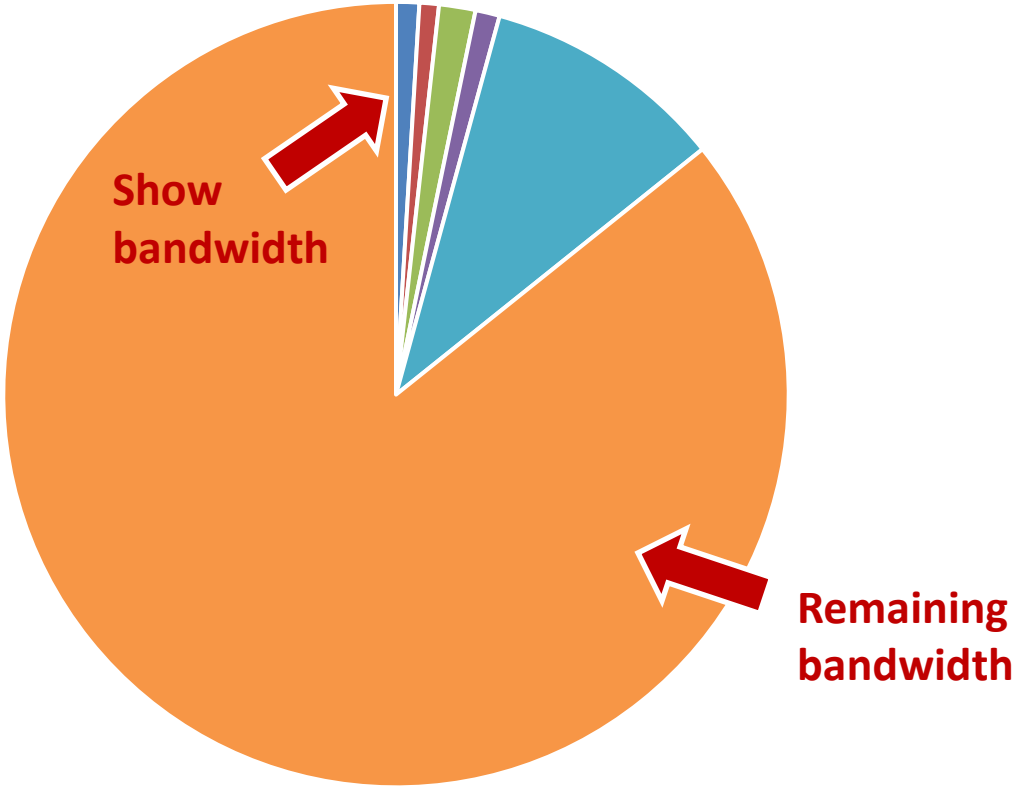
- 10,000 pixel show (DDP): 9.58Mbps
- Streaming video: 8Mbps
- Amazon/Disney 4K video: 15Mbps
- Online disc game console: 3-10Mbps
- Streaming game console: 100Mbps (up to)

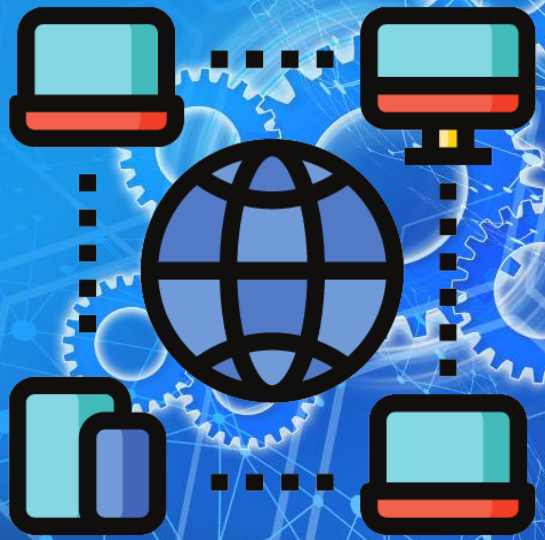
* Speed and consistency affected by environment, people's phones & portable devices, RF interference

Bandwidth consumption for 10,000 pixels on a 100Mbps network



Bandwidth consumption for 10,000 pixels on a 1Gbps network

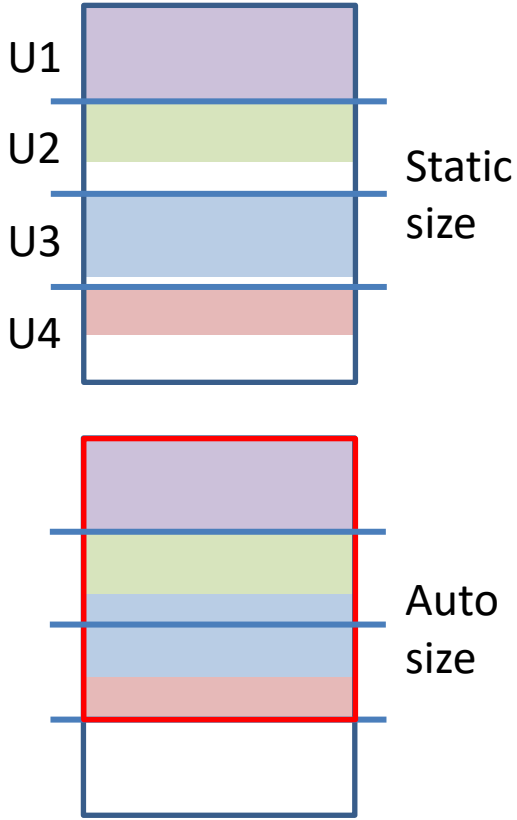




Protocols
E1.31 vs DDP

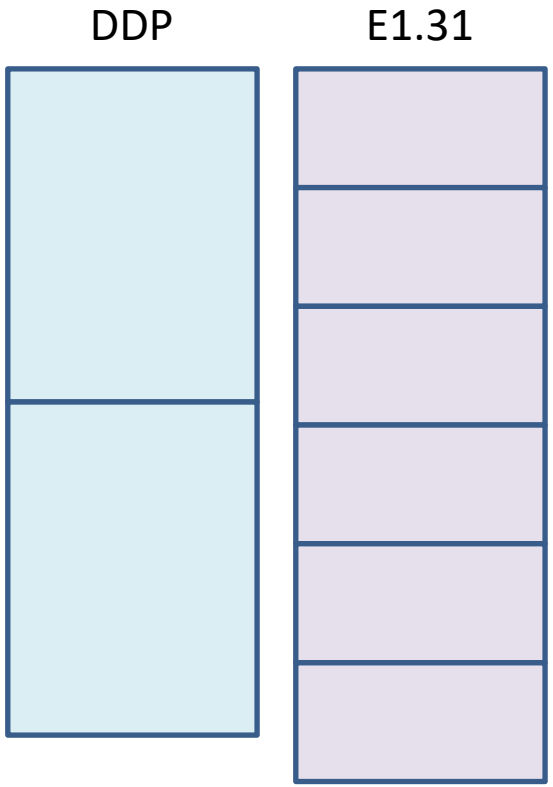
E1.31 vs DDP

- E1.31
  - Pixel data (channels) divided into universes
  - Each universe holds 512 channels
  - Packet size limited to 512 bytes
    - 100 universes = 100 packets
  - Auto Size vs. Static universes



E1.31 vs DDP

- DDP
  - Absolute channel addressing (no need for universes)
  - Packets are larger (smaller headers, more room for data)
  - Packet size up to 1,440 bytes
  - 23.4% bandwidth savings



E1.31 vs DDP

E1.31	DDP
• Channels divided into universes	• No need to divide channels
• 512-byte packets (many packets)	• Up to 1,440-byte packets (fewer packets)
• 72% efficiency	• 94.9% efficiency

Improving your home network

Improving Your Home Network

- **1Gbps Ethernet switch (devices, too)**
- **DDP protocol on FPP and controllers**
  - If you must use E1.31, enable Universe Auto Size
- **Wi-Fi 5 or 6 router with MIMO**
  - Understand networking before getting into enterprise mesh gear (Unify)
- **Lower FPS from 40 to 20**

RPi 3: 100Mbps
Falcon V3: 100Mbps

How data communication works

OSI Model

- Open Systems Interconnection Model
- Finalized in 1980
- Seven layers

OSI Model

- **OSI Layers**

7. Application	xLights, web browser
6. Presentation	Data format & encoding
5. Session	Communication channels
4. Transport	TCP controller UI (stateful), UDP xLights data (stateless)
3. Network	Data packets, routing packets (router)
2. Data Link	Network protocols, MAC address (switch)
1. Physical	Ethernet cable & card, Wi-Fi radio

MAC & TCP/IP addresses

- MAC: Media Access Control

  00-1B-63-84-45-E6

- Transmission Control protocol / Internet Protocol

  192.168.1.2

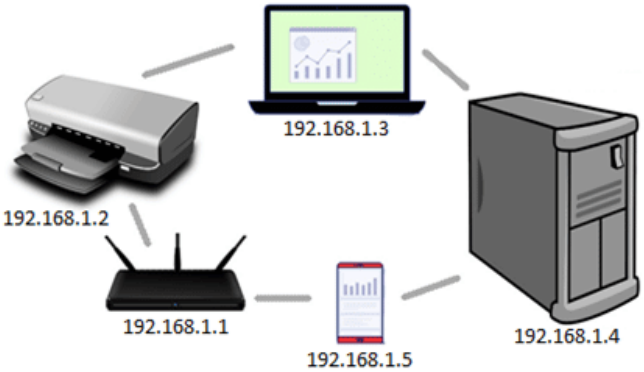
MAC & TCP/IP addresses

- **MAC address**
  - Layer 2 of OSI model
  - Physical addressing
  - Stamped in each hardware device
  - Unique for every device on network
    - Computer, FPP, controller
    - Phone, Smart TV, Wi-Fi printer

MAC & TCP/IP addresses

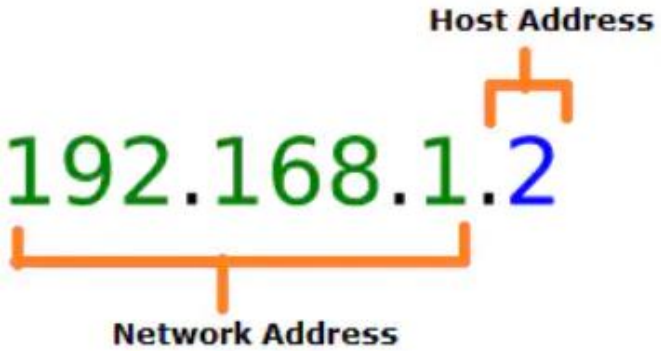
- **TCP/IP address**
  - Layer 4 of OSI model (transport)
  - **TCP** = packet delivery
  - **IP** = Logical addressing
    - Unique number for every device using your network (X.X.X.X)
  - It's how devices "find" each other
    - Computer, FPP, controller
    - Phones Smart TV, Wi-Fi printer

192.168.1.2



Subnets

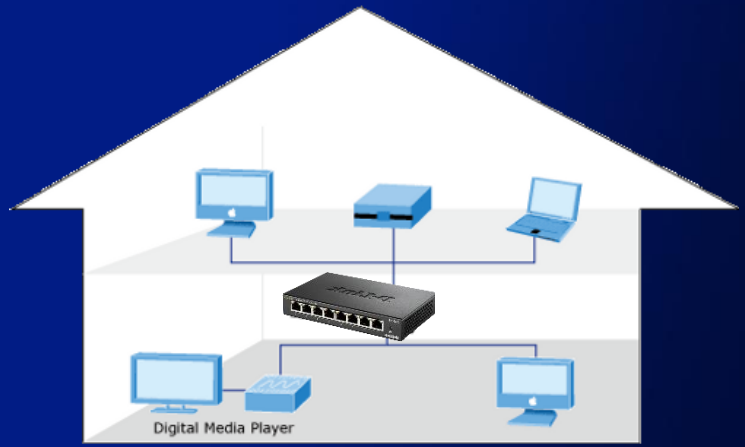
- Each network in your home is called a “subnet”
  - Network address:
    - First 3 numbers of IP address
    - (x . x . x . x)
  - Host address:
    - Last number unique for every device on your network (x . x . x . x)



Switches and Hubs

Switches

- Connects devices in a network to each other, enabling them to talk by exchanging data packets

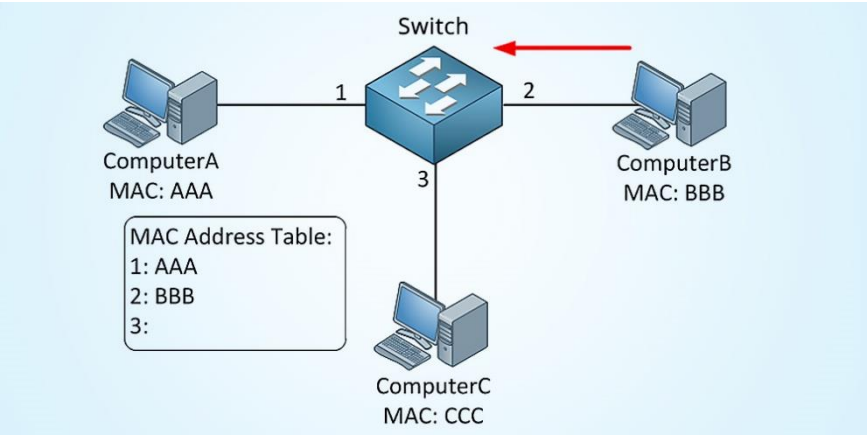


AUGUST TWENTY-SIX
20 23
VIRTUAL CHRISTMAS SUMMIT

Switches

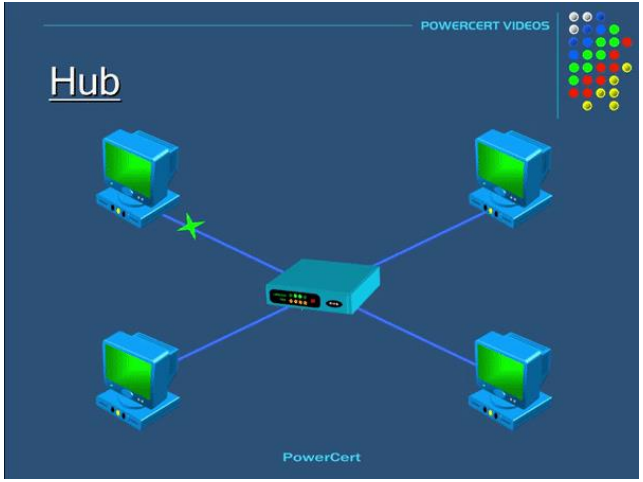
1. Learns all devices' MAC addresses
2. Initially floods data to all ports & devices
3. Responding devices' MAC address saved to "ARP table"
4. Later on, data sent only to correct device

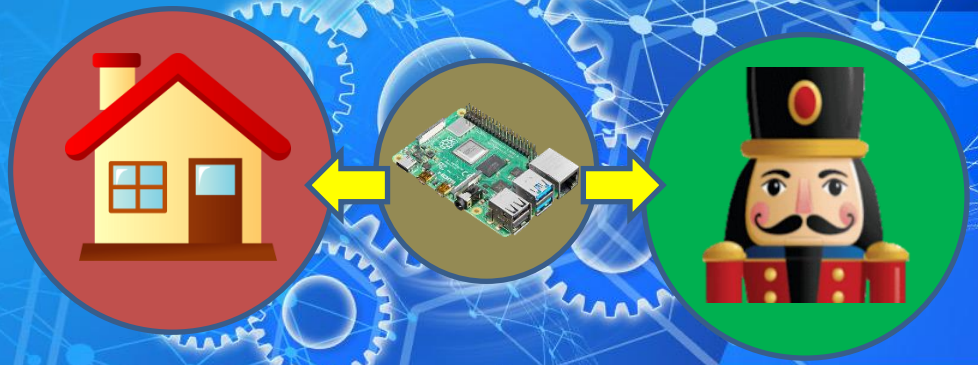
- "Learn, flood, forward"



Hubs

- Hubs do not “learn”
  - Show data is sent to all ports & devices always
  - Waste of bandwidth
  - If it’s really old, toss it
  - If it’s 100Mb, toss it





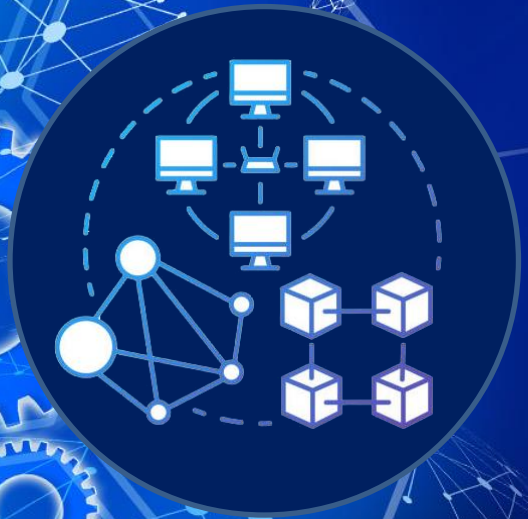
How to setup a show network

Connecting networks

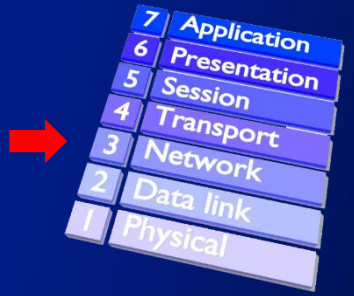
- **Goal**
  - Create a connection between home and show networks so that data passes to/from them
- **Methods**
  - Routing, Proxy, VLAN

What is Routing?

- Selects a path for data within a network or between multiple networks



- Layer 3 of OSI Model (network)



What is a Proxy?

- Software application intercepts data from home network, then sends it to the show network
- Destination thinks data originated from proxy, not from home network
- Level 7 of the OSI model (application)

Routing vs. Proxy Pros & Cons

Routing

No xLights configuration

Two-way: show devices can access Internet for date/time

Cons:

A bit harder to setup (modify computer OS)

Proxy

No need to modify computer OS

Cons:

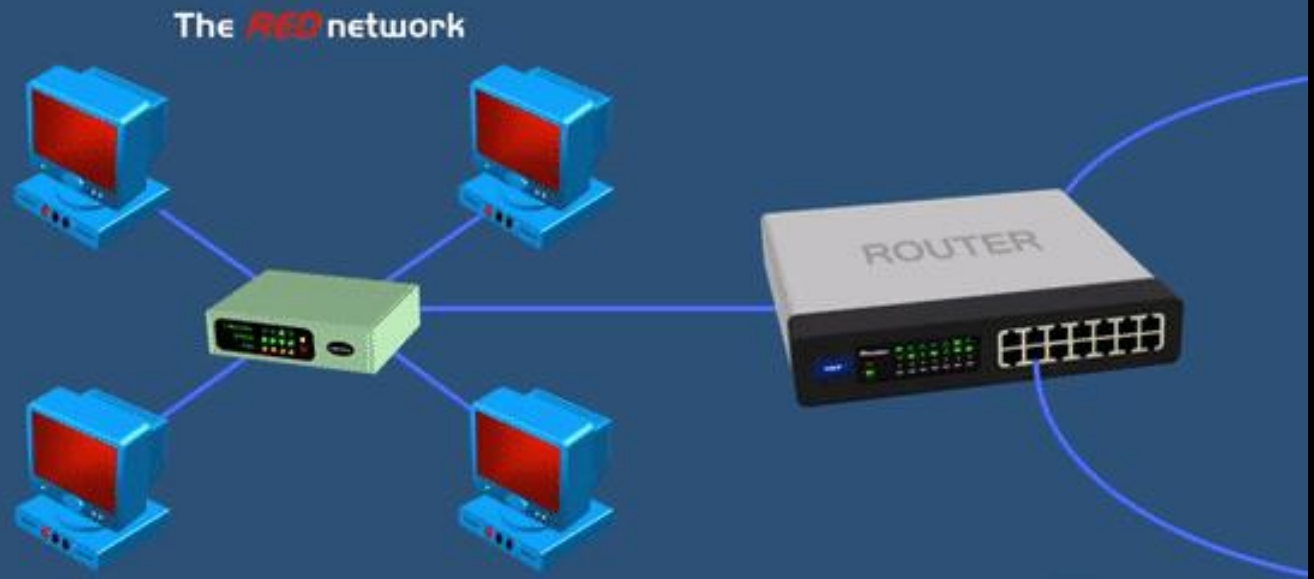
xLights, FPP, and every show network device must be configured

One-way: show devices (other than master FPP) cannot see Internet for date/time

Router

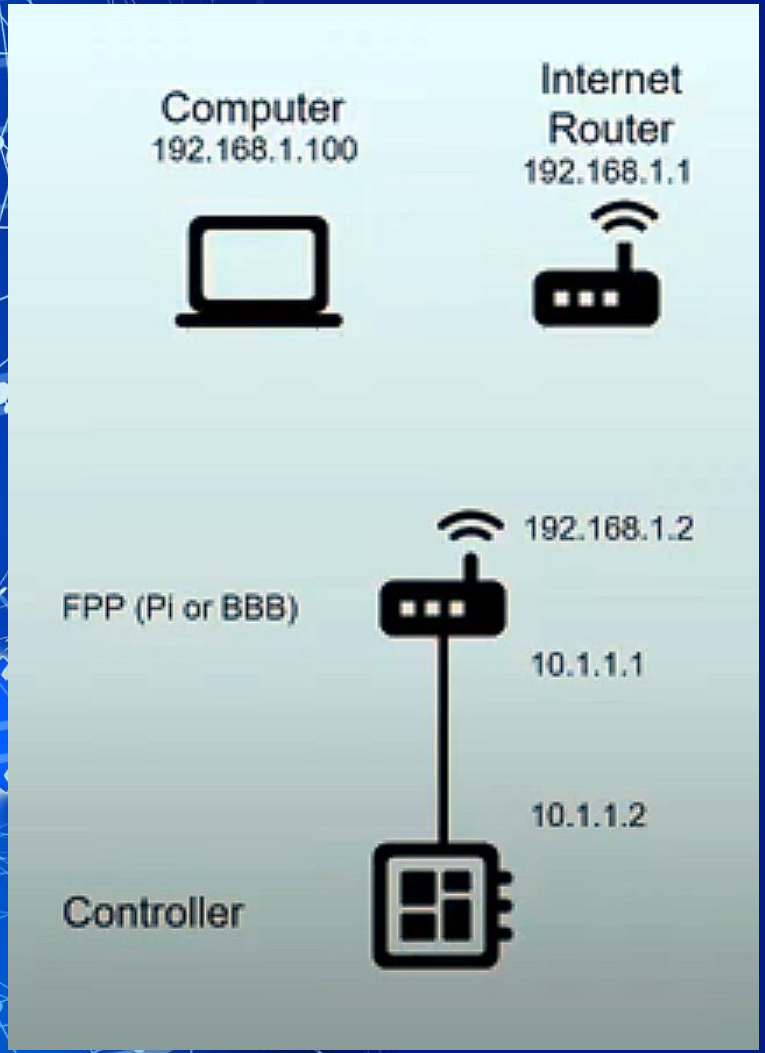
- Networking device that forwards data packets between computer networks.

Router



Routers

- **Router allows data to cross networks**
  - Based on destination's **IP address** (not MAC)
  - Routers have two IP addresses (one for each network it exchanges data between)
  - Enables two-way communication between networks

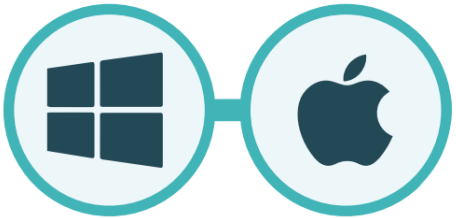


Use your RPi as a router to your show network

- Wi-Fi between home router and RPi connects both networks

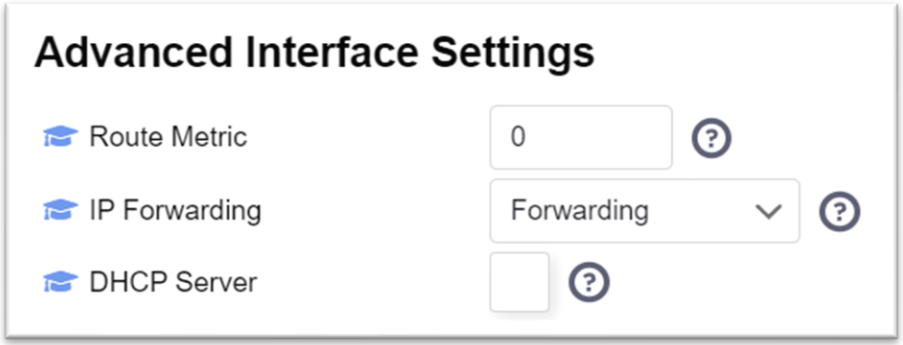
Routing

- **How to setup routing**
  - Enable routing on your RPi or BBB
    - Wi-Fi on RPi joins home and show networks
  - Define “static” route in home computer’s OS
    - OR, get a router that supports “static routes” (no need to modify computer)



Routing

- **In FPP…**
  - Status/Control > Network > Advanced Interface Settings
  - Select “IP Forwarding > Forwarding”
    - Allows home network devices to see show network devices (FPP acts as a router)
    - Enables two-way communication between networks



Routing

- **For Windows…**
  - route ADD (show network subnet x.x.x.0) MASK 255.255.255.0 (RPi IP address on home network) –p
  - Change is remembered at reboot
- **For Mac…**
  - sudo route -n add -net (show network subnet x.x.x.0/24) (RPi IP address on home network)
  - Change is forgotten at reboot

Routing

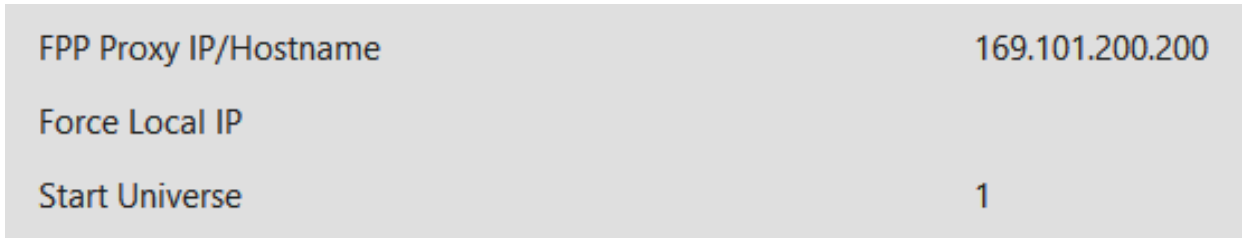
- **Don’t like tweaking your computer?**
  - **Get a better router**
    - Router needs to “define a static route”
      - High-end (enterprise) routers support this
      - Your basic router probably can’t
      - Upgrade existing router firmware with DD-WRT

Proxy

- Application (on the RPi) intercepts data from home network, then sends it to show network
- Show network devices cannot communicate back to home network

Proxy

- **How to setup a proxy**
  - xLights:
    - Set each controller's "FPP Proxy IP/Hostname" to FPP master's IP address on home network
    - Controller IP addresses become the FPP's IP address

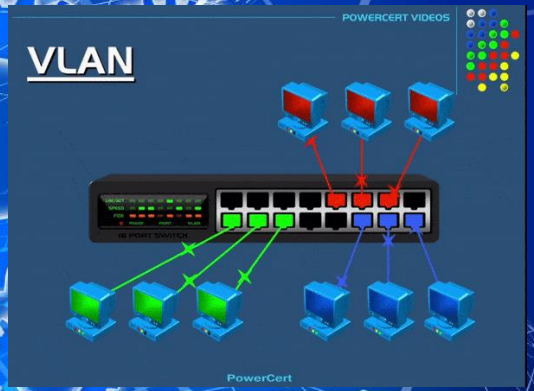


Proxy

- **Master FPP**
  - Status/Control > Proxy Settings
  - Enter controllers' IP addresses
  - FPP forward pixel data to controllers' IP addresses on show network (acts like a repeater)

VPN (Virtual Private Network)

- Segments networks within a switch
- Requires enterprise-level switch
- Overcomplicates things
- Best when home devices and show devices are physically connected to same switch
- Not recommended for show networks



Takeaways

- Shows consume minimal bandwidth (use DDP)
- Don’t overcomplicate things
- Better to improve security (firewall) and performance of existing network
- Replace 100Mbps switches/hubs w/1Gpbs)
- Use Wi-Fi on RPi to join networks
- Routing is better overall than proxy

For More Information…

- Watch this networking video from Virtual Christmas Summit 2021
  - youtu.be/kj2FLPgBAAw
- Watch this video on E1.31 controller networking
  - youtu.be/g0fOZs6UgXw

Questions?

So You Want A Show Network?

Thanks for your participation!

Tom Hammond, tominohio@gmail.com