So You Want a Show Network?

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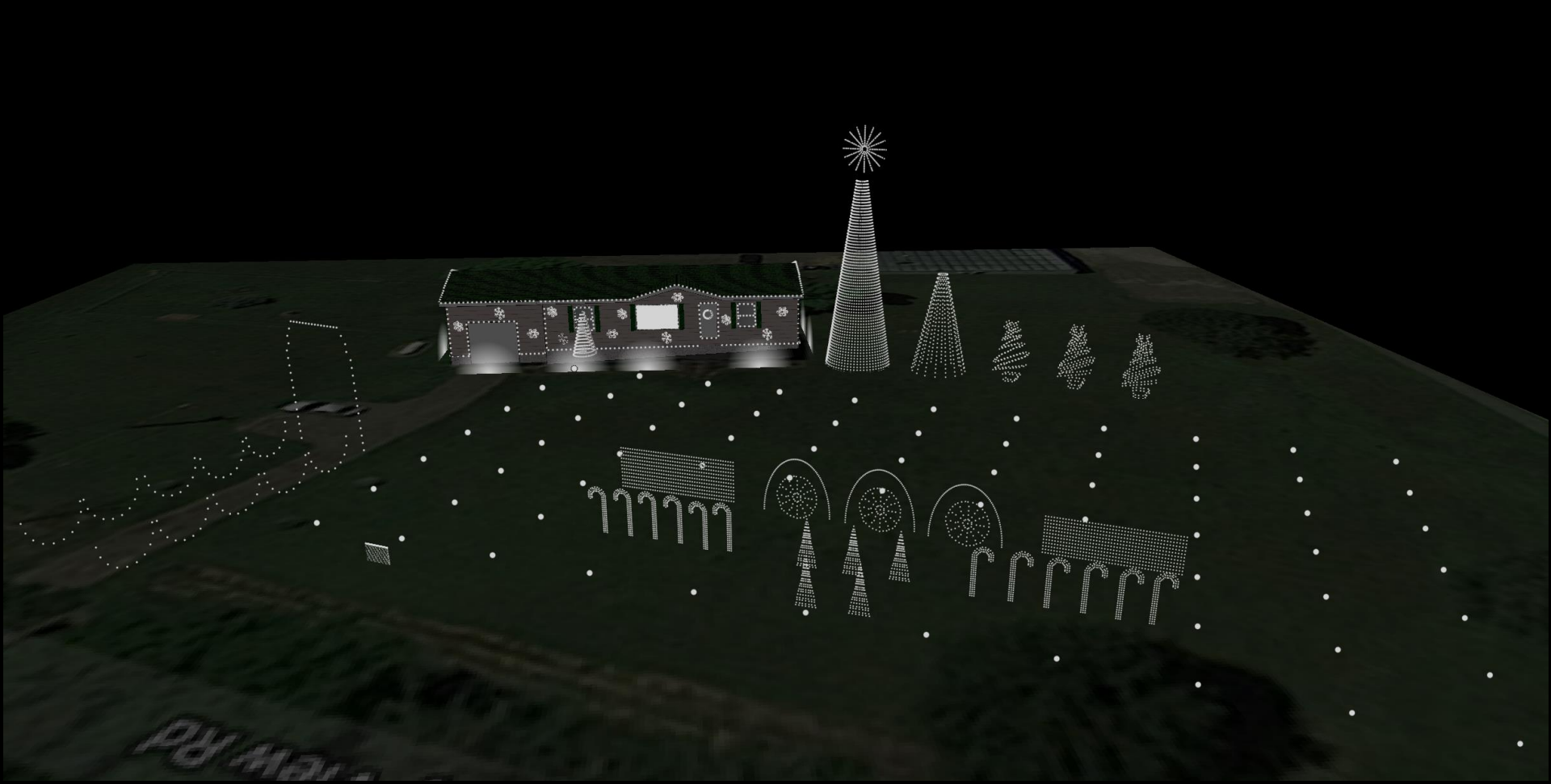
A picture is worth a thousand words

About Me

- I.T. for 35 years at University of Akron OH
- 12 years of shows
- 64,500 pixels (8,000 network pixels)
- National recognition
  - iTwinkle.org to watch & control show

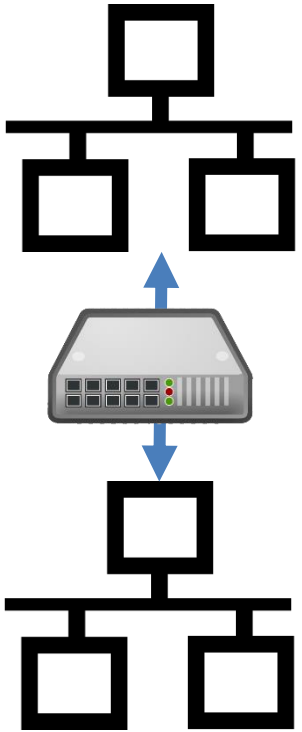


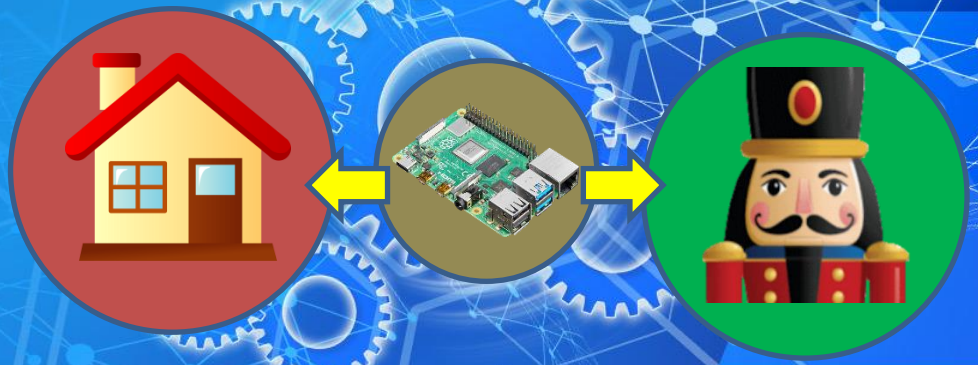
Introduction

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

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

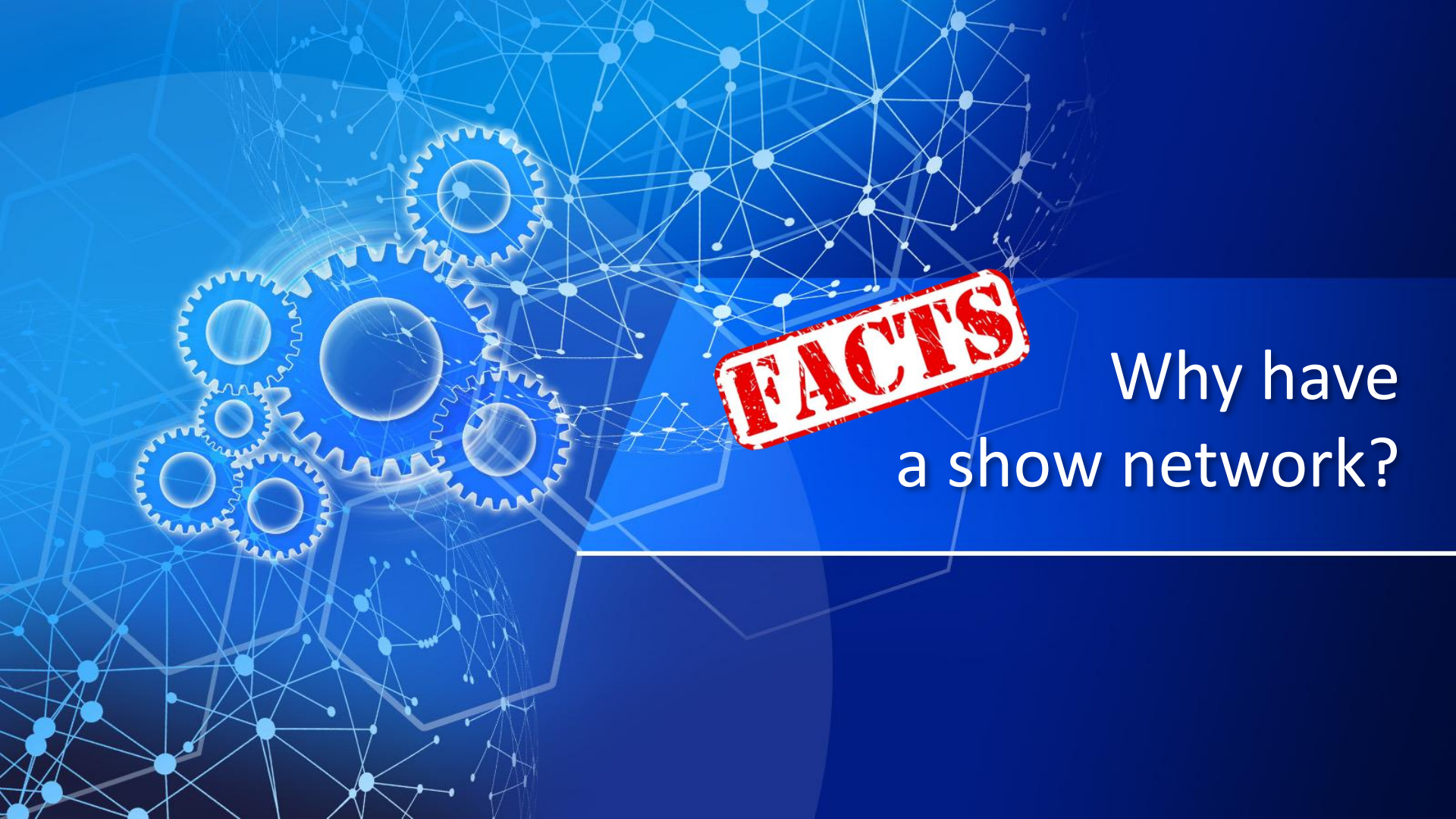




Why have a show network?

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?

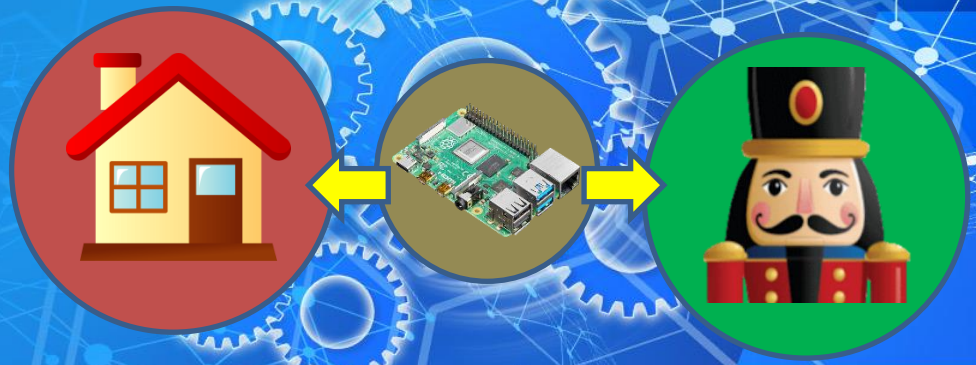
- **Bandwidth limitations**
  - Pixel shows take a fraction of bandwidth
    (1-2% of 1Gbps Ethernet for 10,000 pixels)
  - Other home uses (movies, video games) are low bandwidth, too
  - Ensure home network uses good gear

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 (setup a strong firewall)



Valid reasons to have a show network

Why have a Show Network?

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

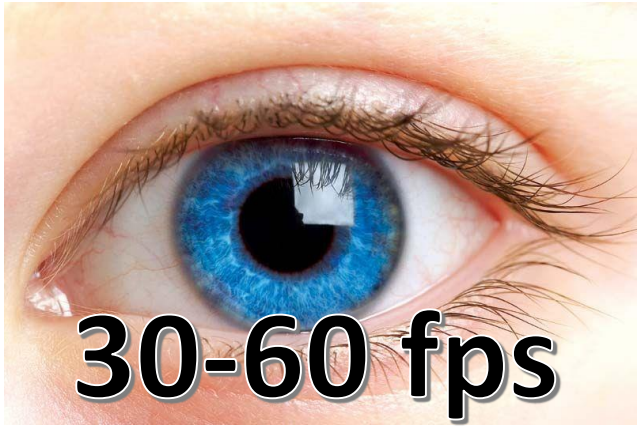
Bandwidth

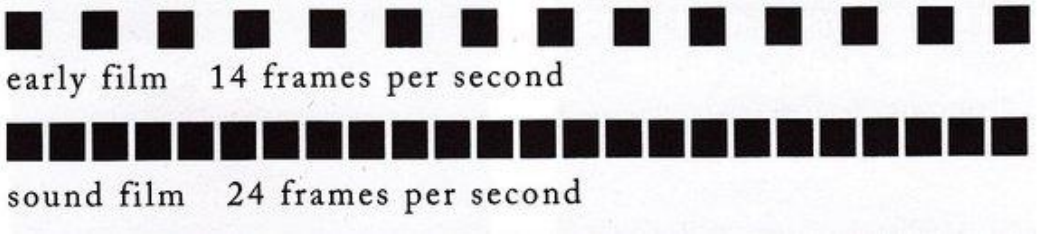
Bandwidth

- FPS differences
- Protocol differences
- Show bandwidth
- Bandwidth comparisons

FPS differences

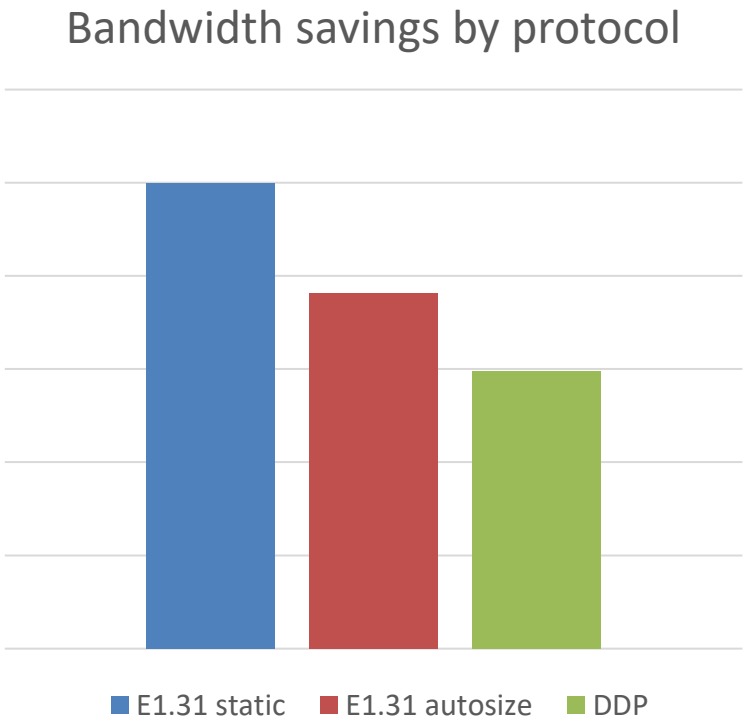
- How fast your pixels update per second.
- 20fps is default, 40fps is popular
  - “good” vs. “silky smooth”
- Double the FSEQ size and network bandwidth
- Slower rendering



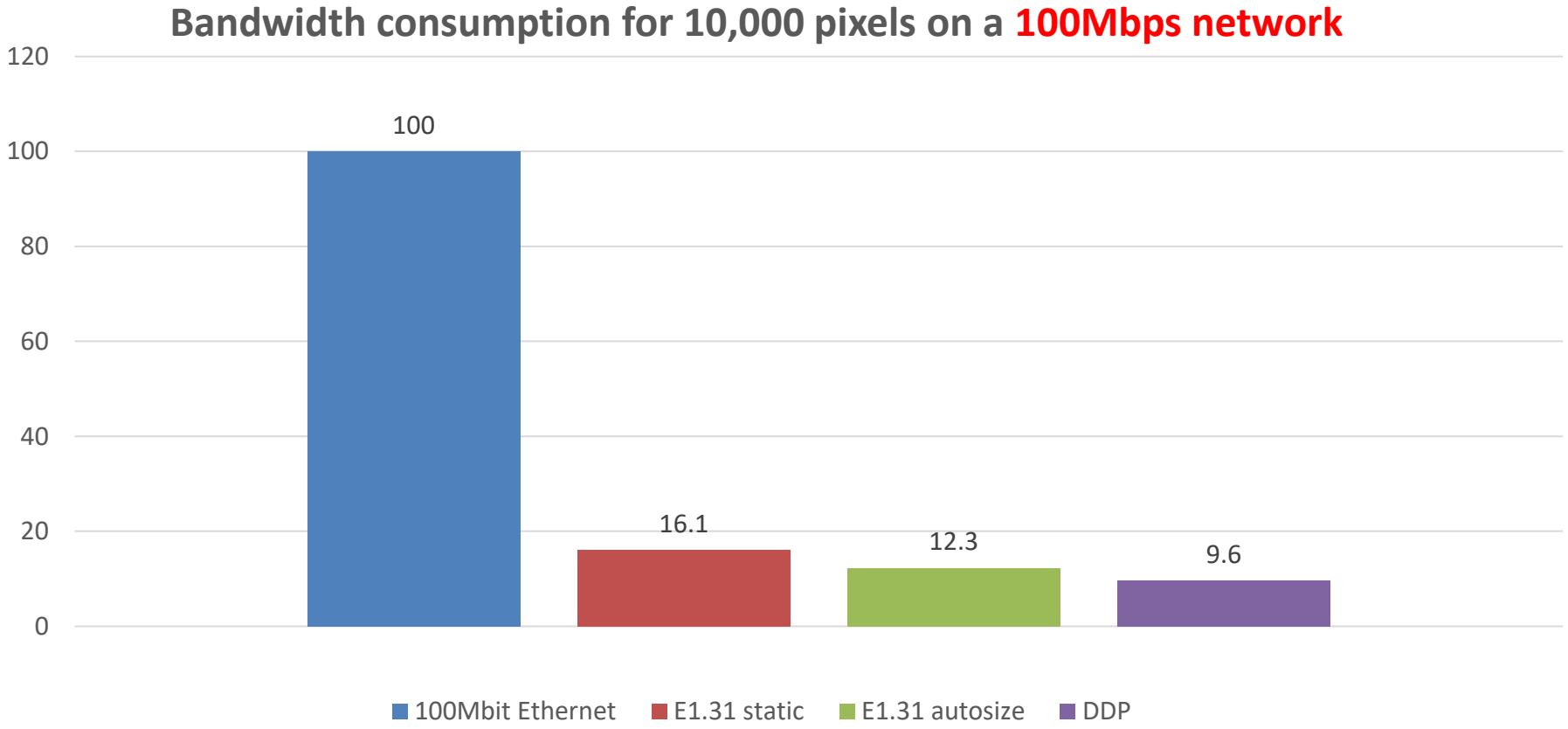


Protocol differences

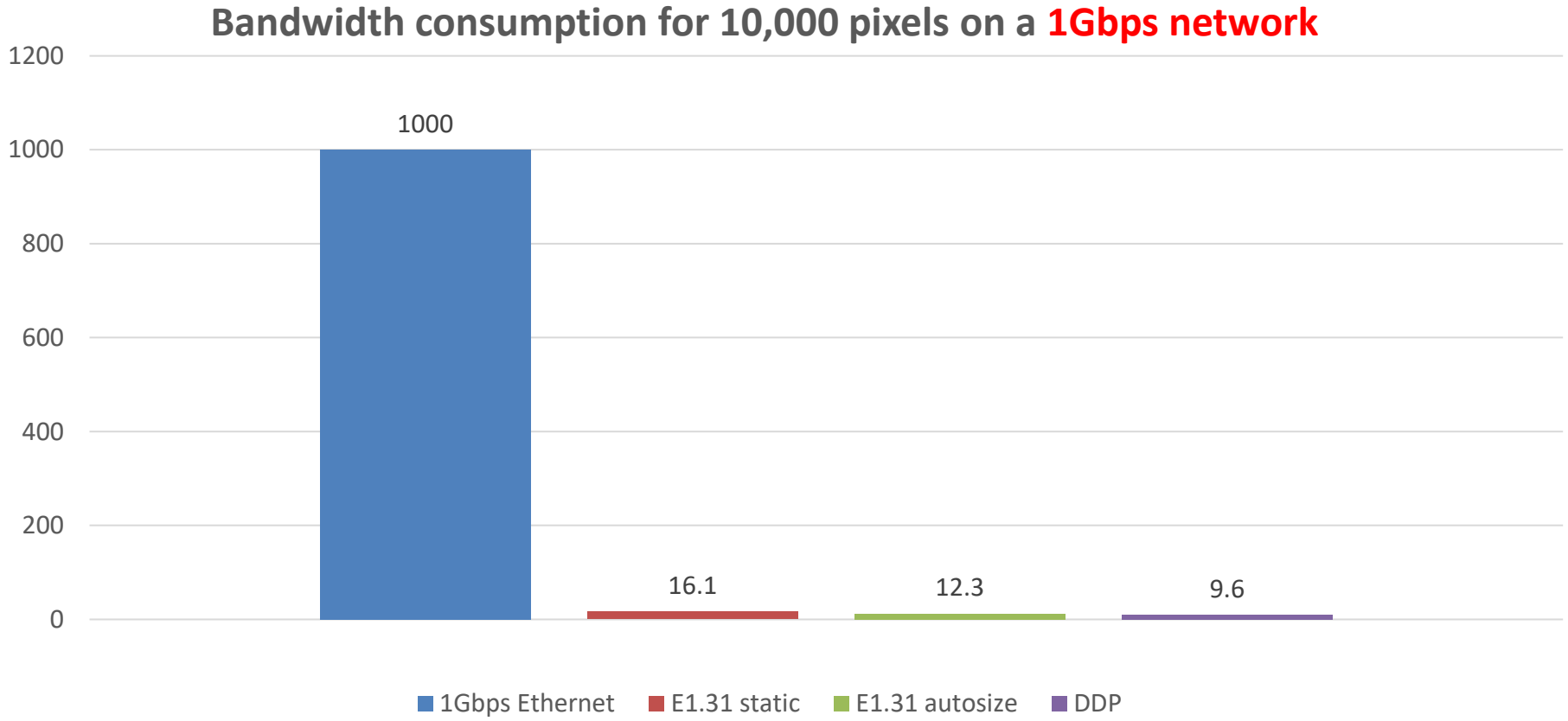
- DDP
  - Up to 40.5% more efficient than E1.31
- E1.31
  - Auto (universe) Size is about 23.6% more efficient than static size



Bandwidth differences



Bandwidth differences



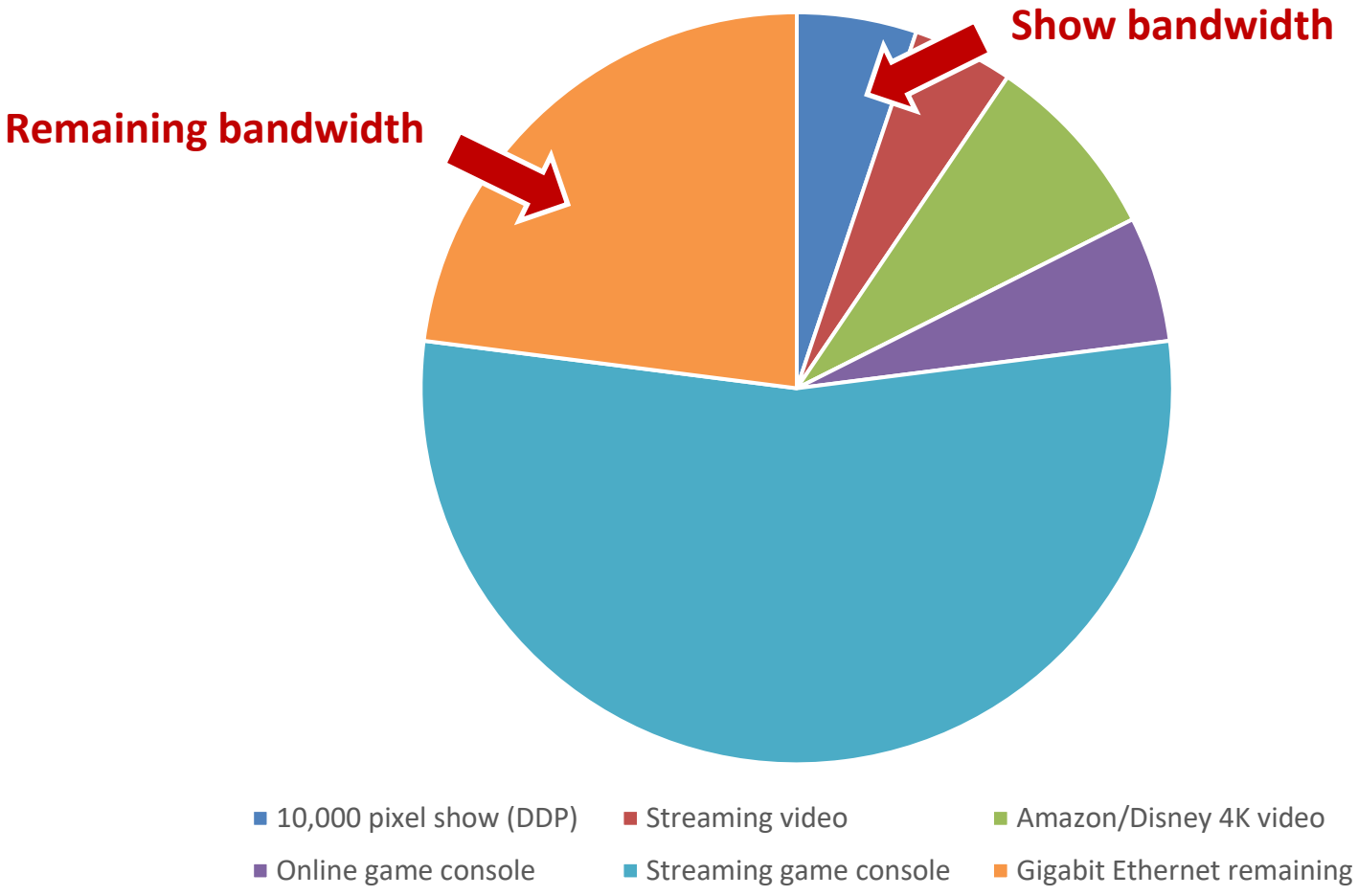
Bandwidth comparisons

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

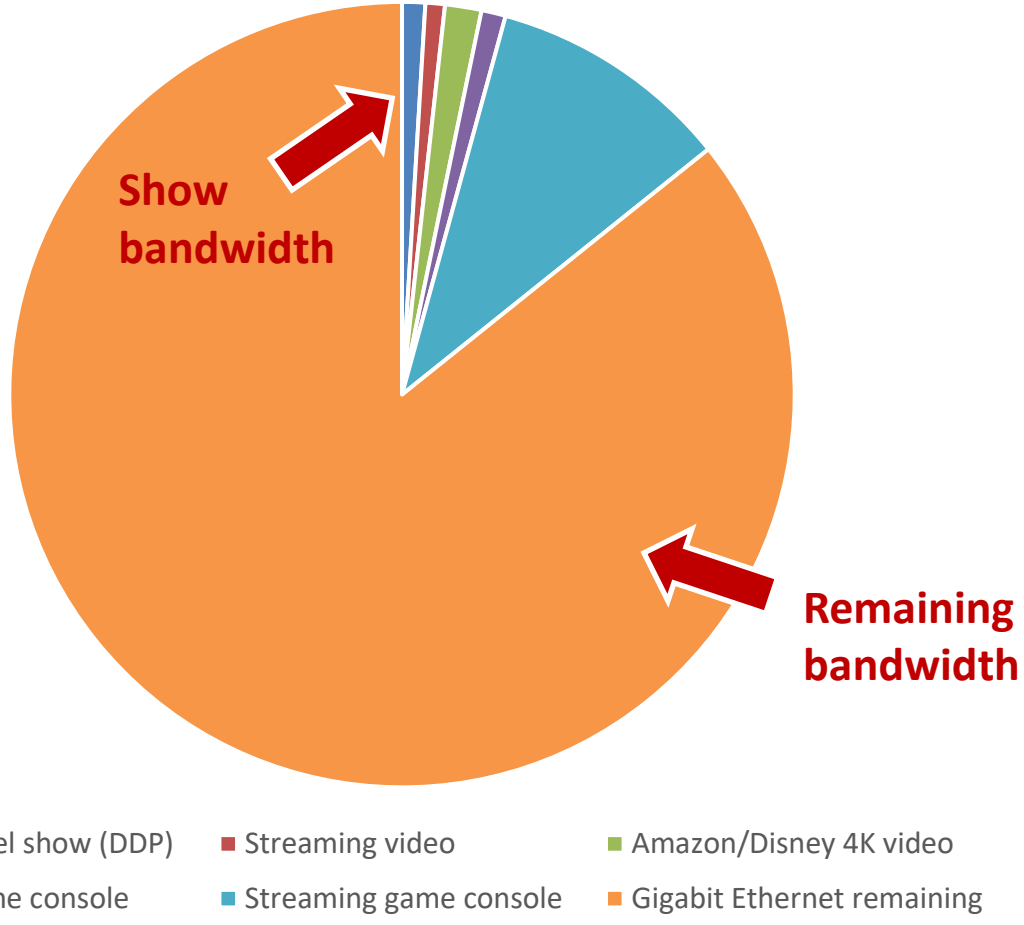
- 10,000 pixel show (DDP): 9.6Mbps
- Streaming video: 8Mbps
- Amazon/Disney 4K video: 15Mbps
- Online disc game console: 3-10Mbps
- Streaming game console: 100Mbps (up to)

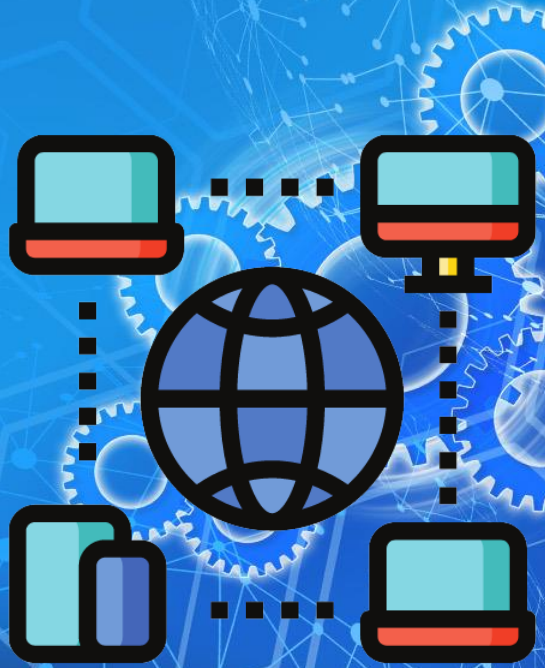
* Speed and consistency affected by environment, people's phones & portable devices, RF interference

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



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

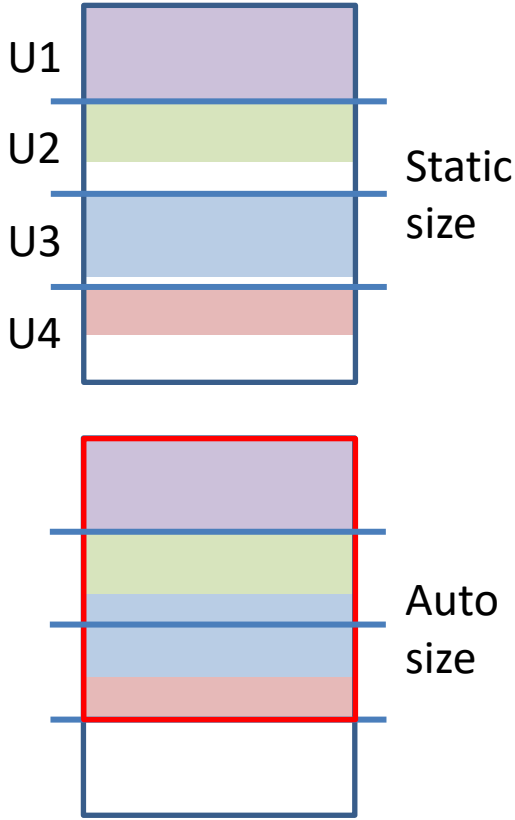




Protocols
E1.31 vs DDP

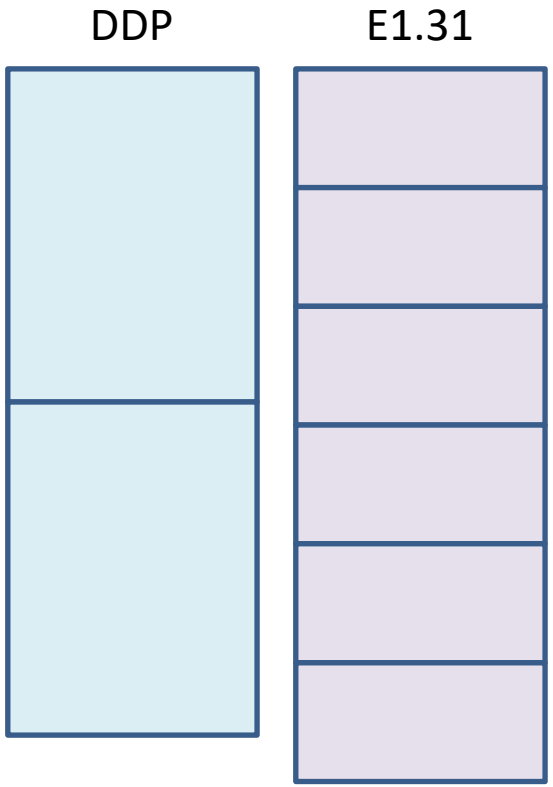
E1.31 vs DDP

- E1.31 (Streaming ACN)
  - 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 (Datagram Delivery Protocol)
  - Absolute channel addressing (no need for universes)
  - Packets have 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 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, mesh**
  - Understand networking before getting into enterprise gear (Unify/Ubiquity)
- **Lower FPS from 40 to 20**

RPi 3: 100Mbps
Rpi 4/5: 1,000Gbps
Falcon V3/4: 100Mbps

How data communication works

OSI Model

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

OSI Model

- **OSI Layers**

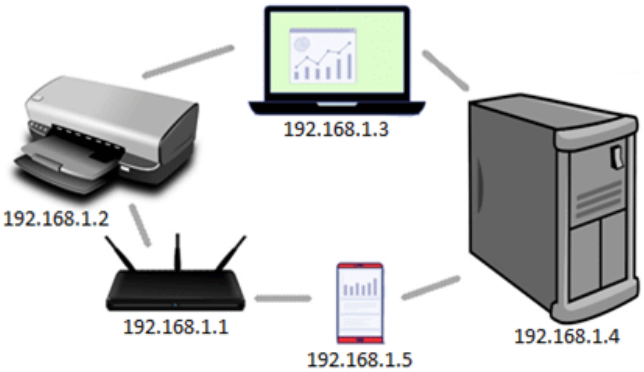
1.	**Physical**	Ethernet cable & card, Wi-Fi radio
2.	**Data Link**	Network protocols, MAC address (switch)
3.	**Network**	Data packets, routing packets (router)
4.	**Transport**	TCP controller UI (stateful), UDP xLights data (stateless)
5.	**Session**	Communication channels
6.	**Presentation**	Data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

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

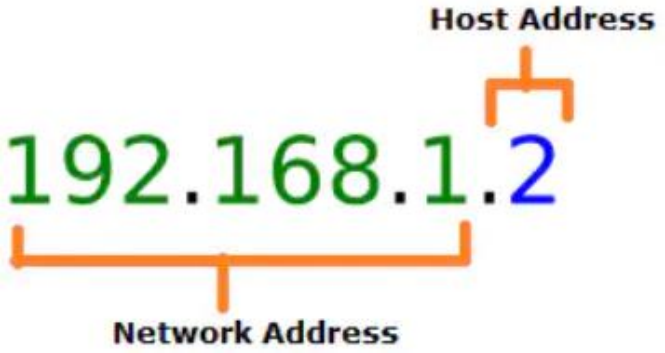
MAC & TCP/IP addresses

- **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



TCP/IP subnets

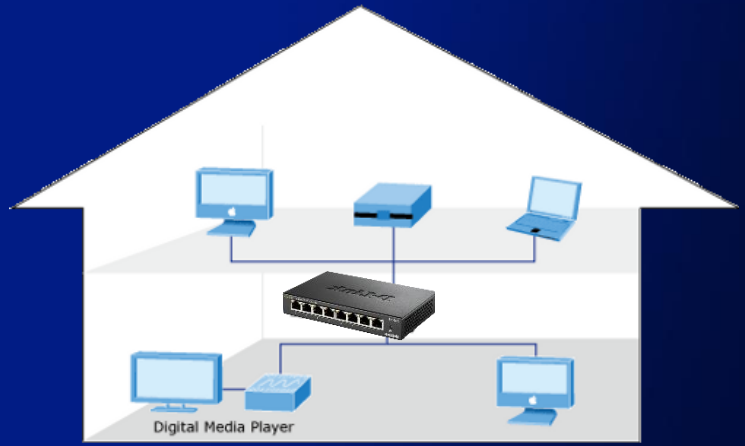
- Each network in your home is a “subnet”
  - Network address:
    - First 3 numbers of IP address
    - (x . x . x . x)
  - Host address:
    - Last number, unique for every device on your network (x . x . x . x)



Switches and Hubs

Switches

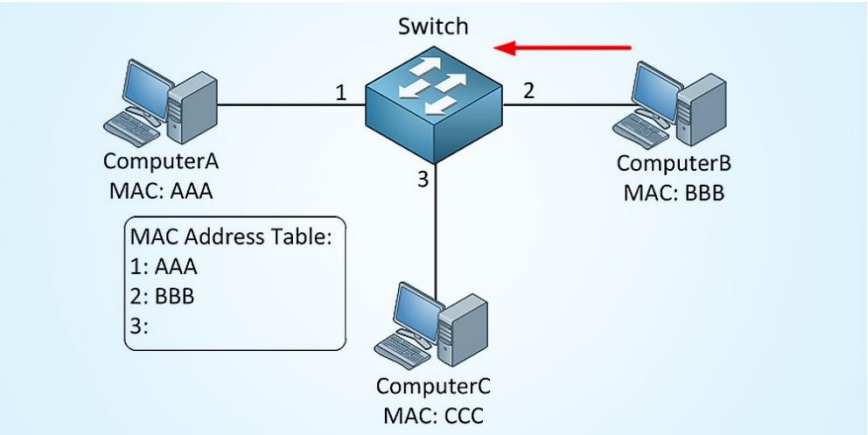
- Physically connects devices in a network to each other, enabling them to exchange data packets



Switches

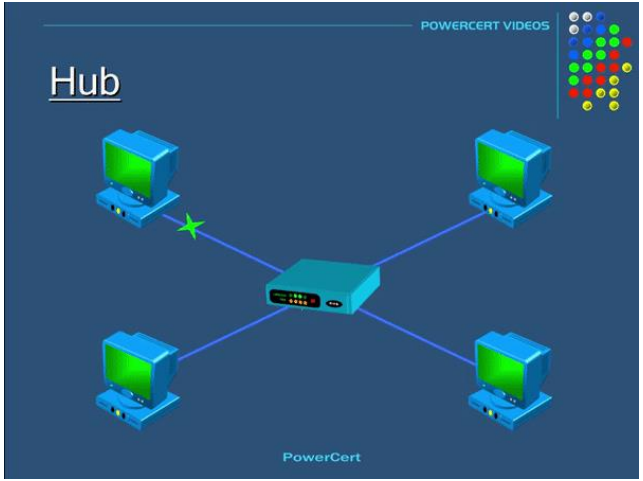
1. Learns all devices' MAC addresses
2. Initially floods data to all ports & devices
3. Responding devices' MAC addresses saved to ARP table
4. Later on, data sent only to correct device

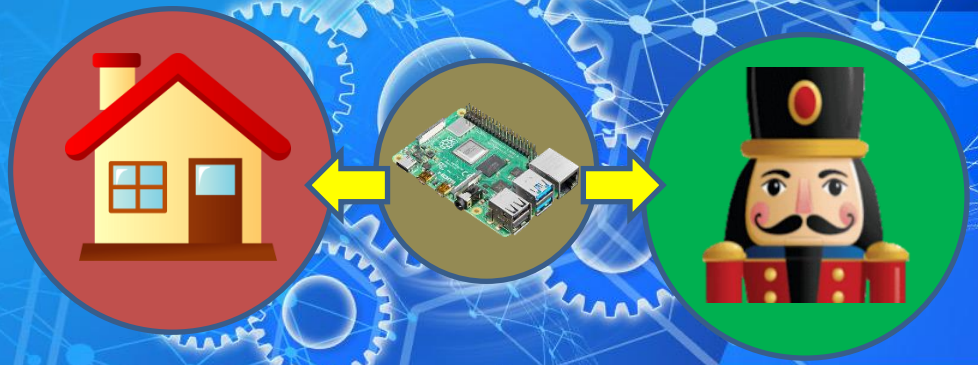
- "Learn, flood, forward"



Hubs

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





How to setup a show network

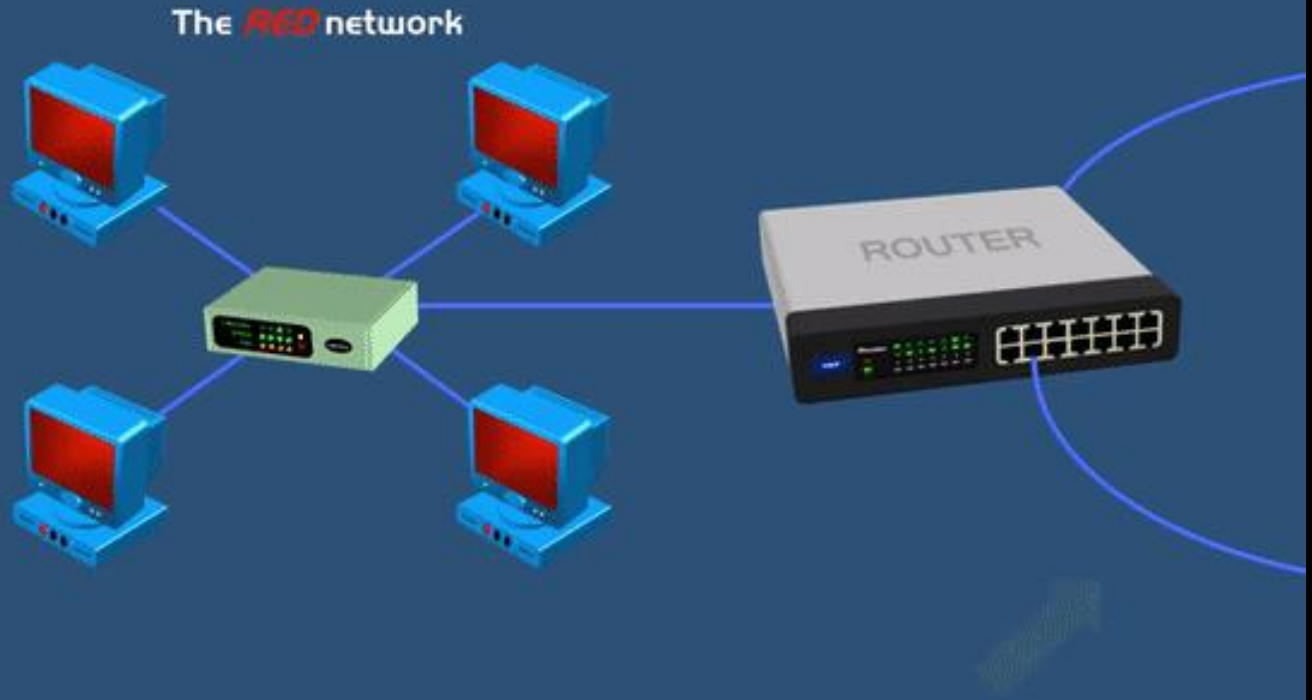
Connecting networks

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

What is Routing?

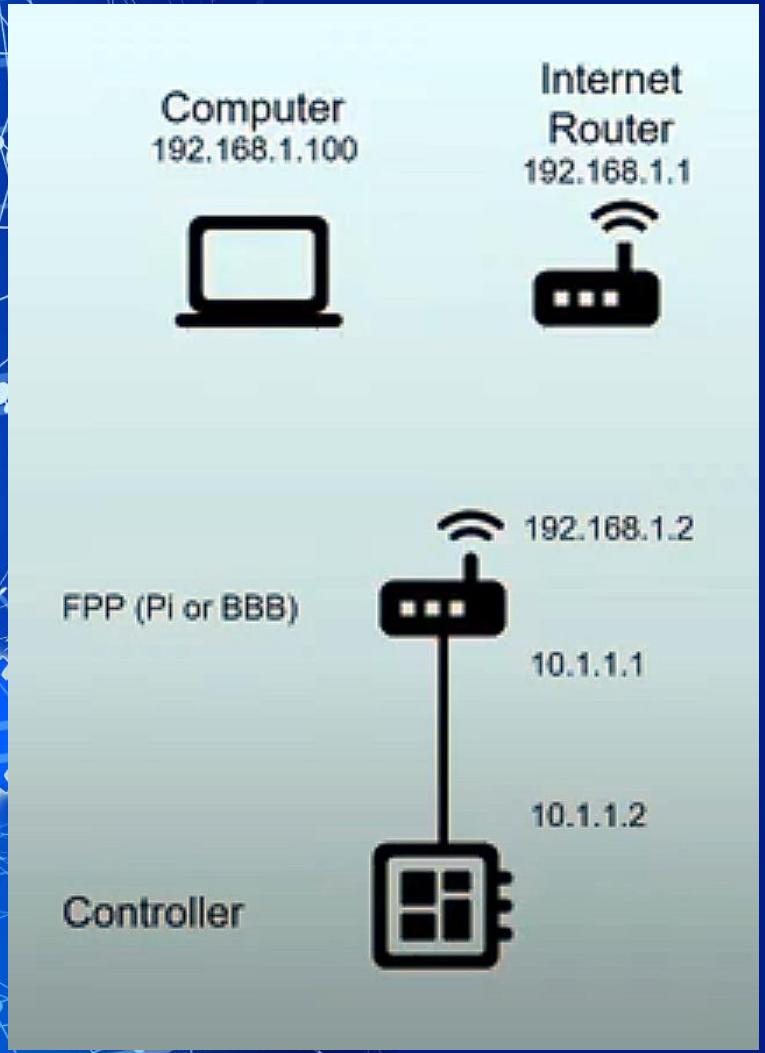
- Networking device that forwards data packets between networks
- Selects a path for data within a network or between multiple networks
- Layer 3 of OSI Model (router)

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), "foot in each door"
  - Enables two-way communication between networks

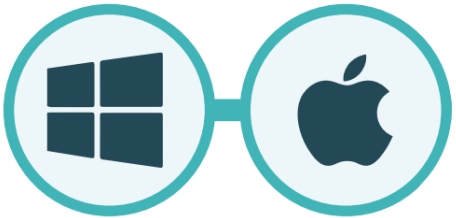


Use your RPi as a router to your show network

- Wi-Fi on RPi and home router connects two networks

Routing

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



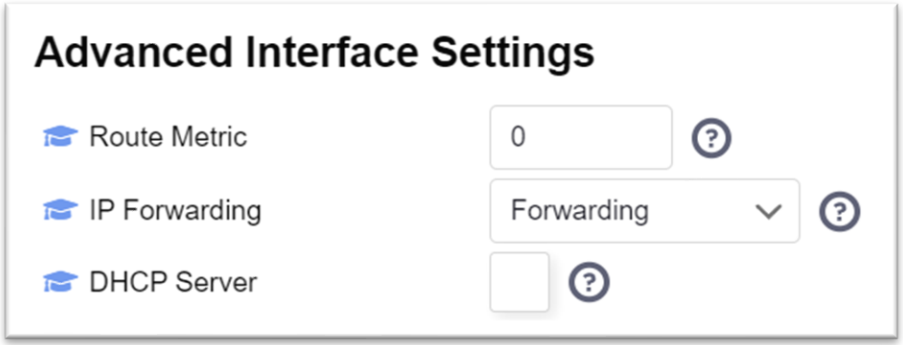
Routing

- **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

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



Routing

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

What is Proxy?

- Operates on a higher level in the OSI Model (7. Application) than routing
- Can be more secure as data flow is one-way and packets encrypted
- Not really necessary for xLights (routing is better)

What is Proxy?

- RPi intercepts data from home network, sends it to show network
- Destination thinks data originated from proxy (RPi)
- Show network devices cannot communicate back to home network (cannot retrieve date & time)

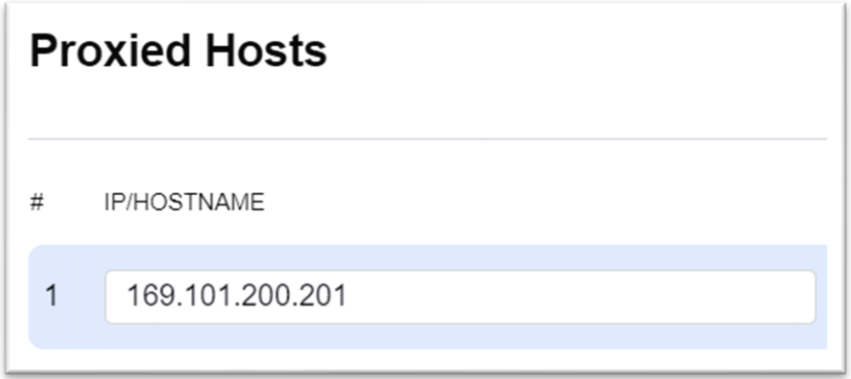
Proxy

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

FPP Proxy IP/Hostname	169.101.200.200
Force Local IP	
Start Universe	1

Proxy

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



Routing vs. Proxy Pros & Cons

Routing

Pros:

No xLights configuration

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

Cons:

A bit harder to setup (modify computer OS, unless you have a “static route” router)

Proxy

Pros:

No need to modify computer OS

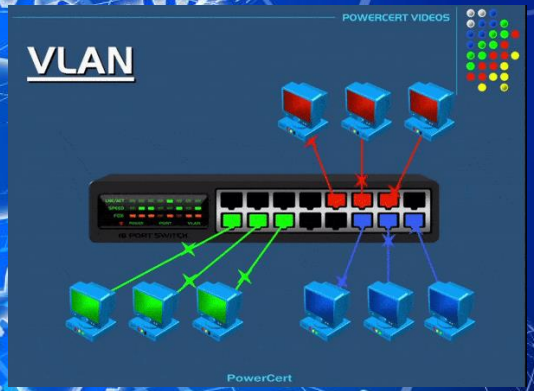
Cons:

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

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

VPN (Virtual Private Network)

- Segments a network 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 & VPN

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 & Thank You!

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