

BVCC General Meeting

August 14, 2017

Home Networking: Principles & Hardware
Joel Ewing

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Networks

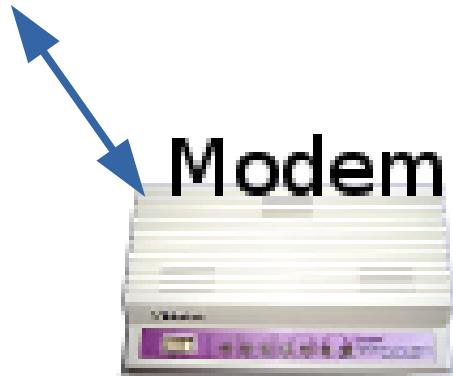
- **Basic terminology: Network, LAN vs WAN, “addresses”, sub nets**
- **Devices supporting local networks: modems, routers, switches**
- **How to Connect devices: Ethernet cable, Wi-Fi**
- **Options for dealing with Wi-Fi coverage issues: WiFi extenders, Powerline Ethernet Adapters, MoCA Adapters, 3-Band WiFi Systems**

Networks

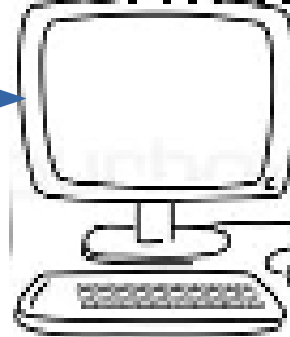
- **Two or more “computer” devices connected together**
- **Devices at a one site – Local Area Network (LAN)**
- **The Internet – Wide Area Network (WAN)**
- **The Internet and all but some very old networks operate using TCP/IP (Transmission Control Protocol / Internet Protocol)**

The Old Days (1990's)

External World



Computer
or Terminal



Home Network 2017

- **Infra Structure:**
 - 1 Cox modem, 1 GB WiFi Router , 1 GB switch
- **2 desktops (wired)**
- **2 laptops (wireless or wired)**
- **2 iPhones**
- **2 iPads**
- **1 Apple Watch**
- **2 Apple TVs**
- **1 Smart TV**
- **2 WiFi printers**
- **1 insteon light/appliance controller**
- **1 Raspberry Pi 2 (experimental)**
- **Assorted older, rarely used devices**
- **WiFi Devices brought by house guests**

Networks

- Each device belonging to a LAN must have a unique IP address, consisting of four integers separated by periods, as in 192.168.0.5 . Specific IP address ranges are reserved for “private” LAN usage.
- A subnet is a range of IP address of devices that can directly communicate with each other. To send data outside the subnet, at least one device on the subnet must also have a 2nd network connection to the “outside” and serve as a “gateway” to the outside world. That role is typically played by a router, which by default assigns itself the first address in the LAN subnet, like 192.168.0.1 and tells all the other subnet devices to use that as a gateway.
- Typical home networks are defined as one subnet with addresses either in 192.168.0.0 - 192.168.0.255 or in 192.168.1.0 - 192.168.1.255 , but there are many other possibilities. Windows File and printer sharing occur within a subnet. If two LAN subnets are connected together, they must have different ranges of addresses.

Networks

- Each device directly connected to the Internet must have one or more unique non-private WAN IP addresses. Ranges of addresses are assigned to countries and to various ISPs within that country, and the ISPs then assign their allocated IP addresses either permanently or temporarily to the device their customers attach to the ISP modem. You communicate to other external sites by using their WAN IP address -- their internal LAN addresses are not directly accessible.
- Numeric IP addresses sometime change, and since most people remember names better, a system of domain names (like “bvcompclub.org”) was established and Domain Name Servers (DNS) provided to look up the corresponding numeric address (like 66.96.149.32) for a domain name. A router also tells other devices on a LAN subnet the numeric IP address to use for DNS queries.

IPv4 vs IPv6

- IPv4 (four-number a.b.c.d addressing) is limited to just under 4.3 billion (256^4) unique address, which will eventually be a problem – the only reason it isn't already a serious problem is because LANs at different sites can re-use the same ranges of private IP addresses.
- New devices have support for both IPv4 and IPv6, which increases the addresses to 8 numbers of 65,536 values, or an astronomical 65536^8 unique addresses. Cox actually assigns my house modem both an IPv4 and and IPv6 address (a very ugly value of 2600:8804:9f00:400:e0f3:d0b:405f:df1b/64) and my hardware and Operating Systems are supposed to support IPv6 as well. I haven't tried accessing any sites using their IPv6 address, but the idea is that when the change becomes necessary, it should be fairly unventful because the support is already in place.

Hardware

- **Modem**
- **[WiFi] Router (may be combined with modem)**
- **Ethernet switch**
- **Ethernet hub (avoid)**
- **WiFi Range Extender**
- **Powerline Ethernet Adapter**
- **MoCA Adapters**
- **Three-band WiFi Systems**

Modem

- **Name comes from radio technology: MODulator-DEModulator**
- **Converts analog signal (modulated RF) from Internet Service Provider to standard computer digital interface (Ethernet).**
- **Provides identification and diagnostic info to ISP; Provides WAN IP address and DNS IP addresses to device attached to Ethernet port (could be a computer, but in most cases should be a router)**
- **Typically rented from ISP. If purchased elsewhere, must be compatible with ISP specifications.**

Router

- **Connected via Ethernet cable to modem, or in some cases combined in one box with modem.**
- **A “firewall” – isolates LAN devices from Internet WAN but allows controlled access to Internet**
- **Assigns unique LAN IP addresses to local devices and passes DNS information to the LAN.**
- **Usually provides WiFi connectivity for LAN**
- **Provides multiple ethernet ports for LAN devices, routes data among WiFi and wired LAN devices and serves as gateway for devices on the LAN to exchange data with a device at some other Internet address.**
- **Wired connections support multiple concurrent transmissions within the LAN – WiFi only allows one transmission per “channel” at a time**
- **Typically configured/queried via web server interface, typical LAN address of 192.168.0.1**

Router

- **If router doesn't allow Internet to "see" a device on the LAN or internal LAN IP addresses, how is a computer on the LAN able to access the Internet?**
 - **With a few exceptions connections (called a "socket") between a LAN computer and an Internet site are always initiated by the LAN computer. Each socket also specifies a logical port number for both the source and destination. Some destination port numbers are reserved for specific services (e.g., http = 80, https = 443)**
 - **The router knows the address is not to another LAN computer but to the Internet so it initiates a connection between itself and the remote Internet site, relays data from the LAN computer to the remote site, and relays data coming back from the remote site on that socket back to the same LAN computer. From the remote computer's perspective, it is talking to the router, which has an external WAN address accessible from the Internet. This process involves what is called NAT (Network Address Translation).**

Router

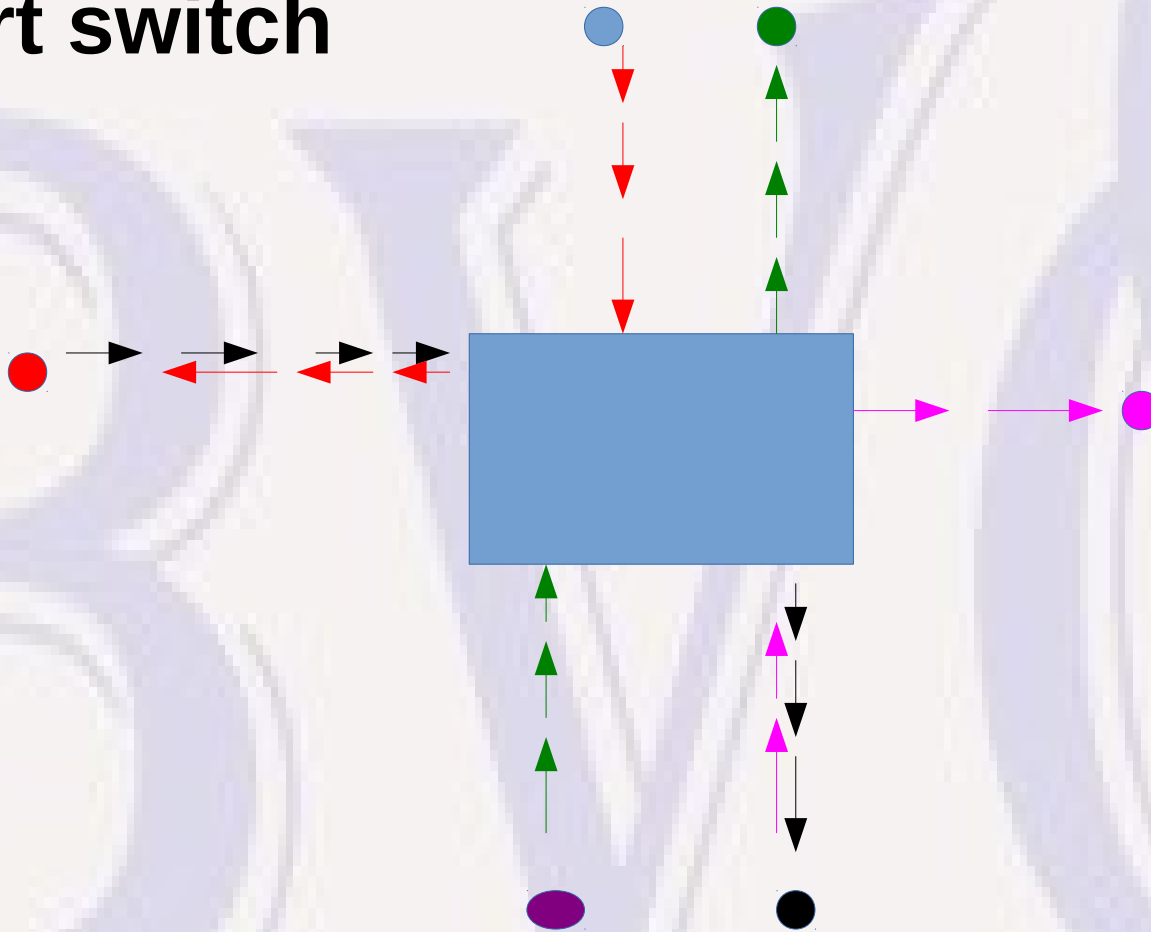
- In some special cases, a particular type of out-bound socket request is always associated with a following in-bound socket request from the remote site. Routers are smart enough to know this and will associate the in-coming connection request to the router to the appropriate LAN device.
- If a particular service function on a LAN device needs to be accessible to in-bound connection requests from the Internet, the router can be configured to forward a request for a particular port to some specific LAN device.

Ethernet Switch

- **Switches are used when multiple devices need a wired Ethernet connection and only one Ethernet connection is available**
- **Recognizes the address(es) of devices associated with each port and when receiving a data packet, will send it out on a path that will reach the intended destination.**
- **Some varieties not configurable. Requires one of its ports to have a path back to a router in order for connected devices to get a device addresses allocated or have access to DNS support.**

Switch

6-port switch

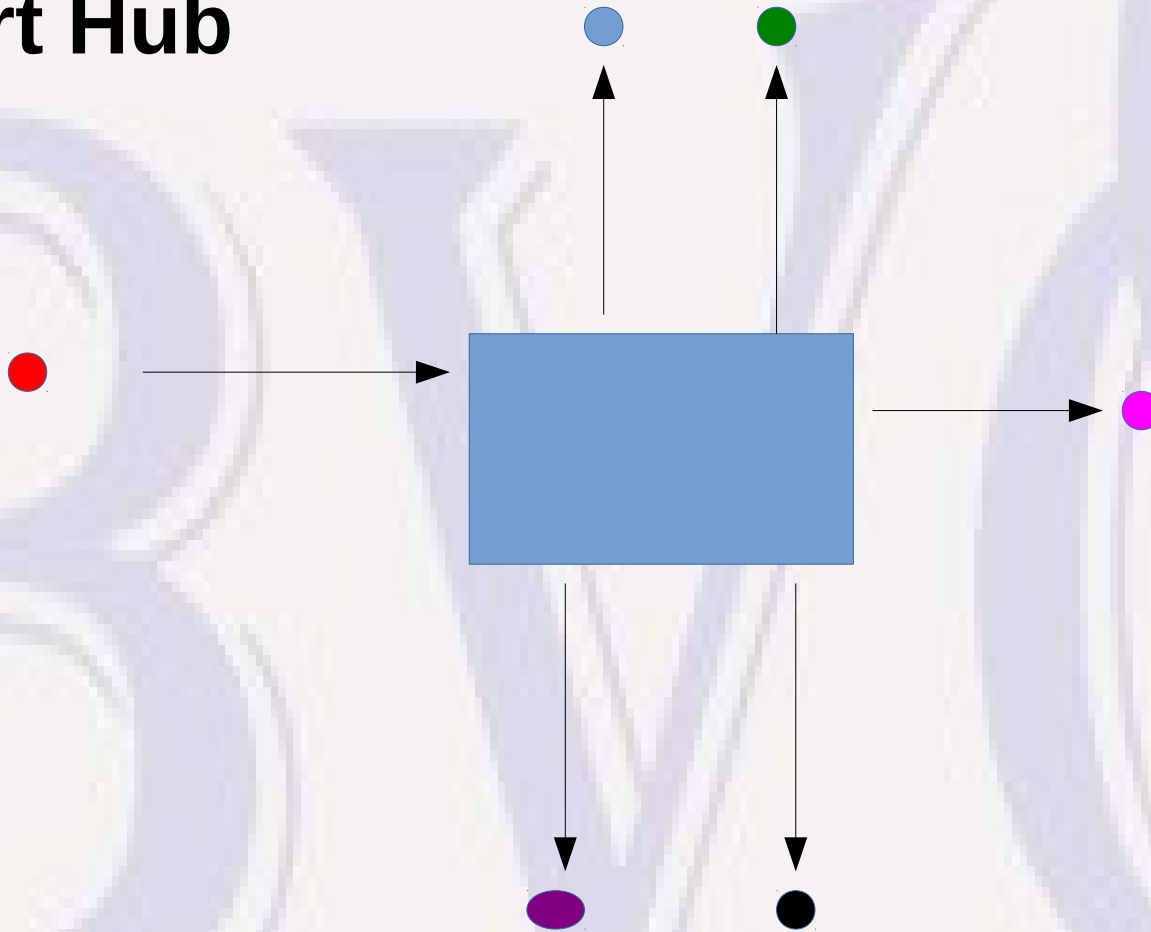


Ethernet Hubs

- **Simpler/cheaper than a switch – became available for home use when switches were much more expensive**
- **Provides connectivity function like a switch but much lower throughput: half-duplex. Only one device on hub can transmit at a time and its data is mirrored to all other devices (and ignored by a device unless addressed to it). Performance constrained by slowest connected device.**
- **Wiser to spend slightly more and get a switch**

Ethernet Hub

6-port Hub



Connecting Devices to LAN

- **Choice is either wired Ethernet cable (10/100/1000 Mbps) or WiFi wireless network**
- **Ethernet cable – much more reliable and potentially higher throughput, but may be difficult to retrofit in homes that lack network wiring. Recommended where possible, esp. for devices already located in same room as a wired Ethernet interface.**
- **WiFi convenient, as eliminates the need for wiring. Some devices (smart phones, pads, tablets) lack support for wired Ethernet. Depending on home environment, may be difficult to get good WiFi coverage everywhere.**

Ethernet Cabling

CAT-6 Cable

RJ-45 Connector



Ethernet Cabling

- **For “professional” looking permanent home installation, can add CAT6 cable and RJ-45 jack to existing home telephone or coax outlets, or install a new outlet box.**
- **Some homes built in recent decades without network wiring have actually used CAT5 or CAT6 wiring for phone outlets using only two of four twisted pairs. It may be possible to add RJ-45 connectors and use the other two pairs to create a 100 Mbps wired Ethernet connection between two phone outlet boxes without running any new cable.**

“Virtual” Ethernet Cables

- **WiFi Extenders** that communicate with base router via WiFi typically have an ethernet port that can be used for a remote wired Ethernet connection
- **Power-Line Ethernet Adapters** supposedly allow you to plug two adapters into a power outlet and use the power wires to logically simulate an Ethernet cable between the adapters. (I've only had marginal success with these, but YMMV)
- **MoCA Adapters** – uses a home TV Cable Coax distribution system to piggy-back Ethernet over the home coax. Sounds very promising. Not compatible with satellite TV. Cox uses this technique in their advertised “Panoramic” WiFi systems.

WiFi

- **Most routers now have WiFi support**
 - **Protocol Progression: 802.11 a/b/h/n/ac**
 - **newer routers support two freq bands, chooses “channel(s)” within each band to minimize interference from other WiFi access points**
 - **Only a single device can be transmitting data in a WiFi channel at one time – high data rate demand from too many devices using the same channel at the same time may degrade performance.**

WiFi Coverage

- **Best if WiFi access point is centrally located in house and mid-way vertically in room.**
- **Signal is attenuated by passing through walls and other obstructions.**
 - **Brick & stone worse than wood, metal worst**
 - **More attenuation the thicker the wall**
 - **A thin wall at an acute angle looks thick**
 - **Signal may be marginal in some rooms**



Extending WiFi Coverage

- **Need to get another WiFi access point in or closer to areas with marginal reception**
 - **WiFi Range Extender**
 - **Powerline Ethernet Adapter**
 - **Multimedia over Coax Alliance (MoCA) Adapters**
- **Additional WiFi access points could also potentially be used to increase WiFi bandwidth in areas with multiple devices with high data rates.**

WiFi Range Extender

- **Extender like Netgear EX2700 (\$30) – place between router and problem area. Must be able to communicate with both the router and with the problem area via WiFi. Easy to configure (with WPS). Cons: potentially uses up half your WiFi bandwidth relaying signals to/from your base router.**
- **Better solution, if you have wired Ethernet available closer to the problem area: find a WiFi Access Point that can be connected to the router via Ethernet cable rather than by WiFi (similar to Ubiquiti UniFi AP-AC-PRO). An extra WiFi router can in many cases be configured and connected to work like a wired-Ethernet WiFi range extender, but router User Manuals are unlikely to convey how to do this.**

Netgear EX2700 WiF Extender



Powerline Ethernet Adapters

- **Two or more powerline ethernet adapters may be plugged into power outlets to create a virtual Ethernet Hub, where an Ethernet port is at each of the adapters. If one of the ports can be connected to your router, then all adapter Ethernet ports are on the LAN.**
 - **Cons: may not work, depending on electrical interference in your environment (barely worked at my house, 1.5 Mbps vs 100 Mbps claimed);**
 - **Pros: if does work, power goes everywhere in house**
- **May be able to get a combined adapter/WiFi, otherwise could connect adapter port to Ethernet port on a WiFi extender.**

TPLink PA4010 Power Line Adapter



MoCA Adapters

- **Ethernet over Coax adapters, \$152 for two Actiontec MoCA v2.0 adapters, speeds up to 1 Gbps. Can coexist on home coax distribution system with Cox cable signals – not compatible with satellite TV**
- **More expensive so haven't yet tried out, but this looks like the best way to extend a quality LAN connection to otherwise unreachable points where there are coax outlets. Avoids issues of interference encountered with powerline adapters: coax is shielded and nature of cable TV signals is known and predictable.**
- **If intent is WiFi extension, need to connect adapter to an Ethernet WiFi extender device. May eventually be a combination MoCA/WiFi adapter on the market, but model selection of MoCA adapters still somewhat limited. Good news is prices are dropping.**

Actiontec MoCA Adapters



Cox Panoramic WiFi

- **Uses MoCA to add remote WiFi access points in WiFi “dead” zones.**
 - **Pros: The approach is sound. Not totally clear from the hype, but they may have integrated the modem and WiFi router with MoCA interface into a single device, and the remote devices may also have MoCA and WiFi integrated into a single device. Also convenient, Cox does setup.**
 - **Cons: the new modem/router is not the fastest currently available, rents for more per month than standard modem/router, there is a monthly rental charge for each remote MoCA/WiFi device, and at this point the devices are “rent only”. Also, if the new router doesn’t support some feature you really need, there aren’t any simple alternatives to purchase.**

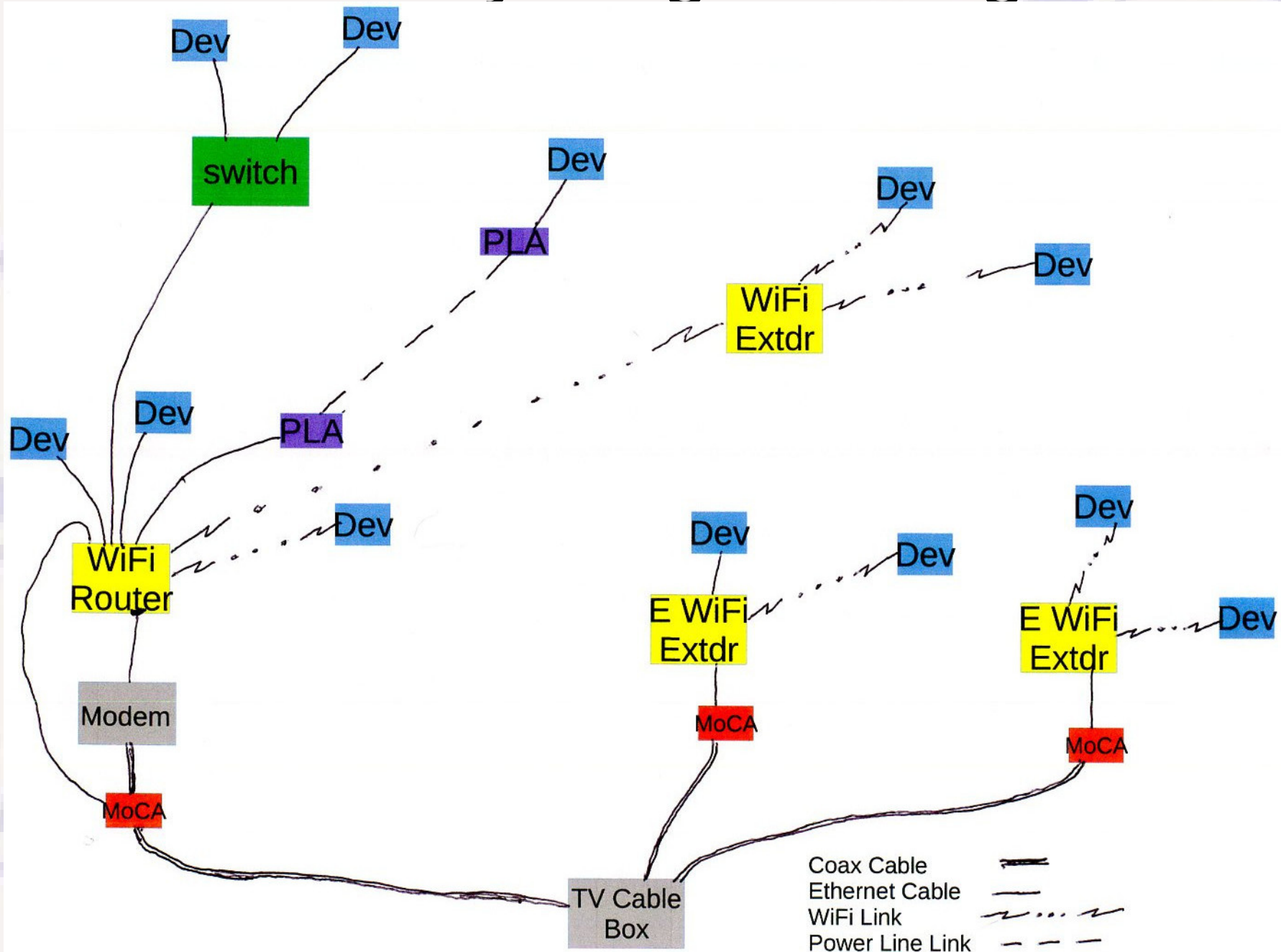
Three Band WiFi Systems

- **Last time at Best Buy, these were the new boy on the block. Not cheap, \$300 - \$500**
- **The differences are**
 - **Includes several remote WiFi access points which may be positioned to improve coverage and increase bandwidth.**
 - **Remote WiFi access points and base stations and 3 RF bands are integrated together in some way that is claimed to allow transparent selection and assignment of access points and bands to devices to maximize how many devices can communicate efficiently at the same time in the same room.**
 - **WiFi bands used to communicate to base WiFi router are chosen to minimize interference with user-device communication**

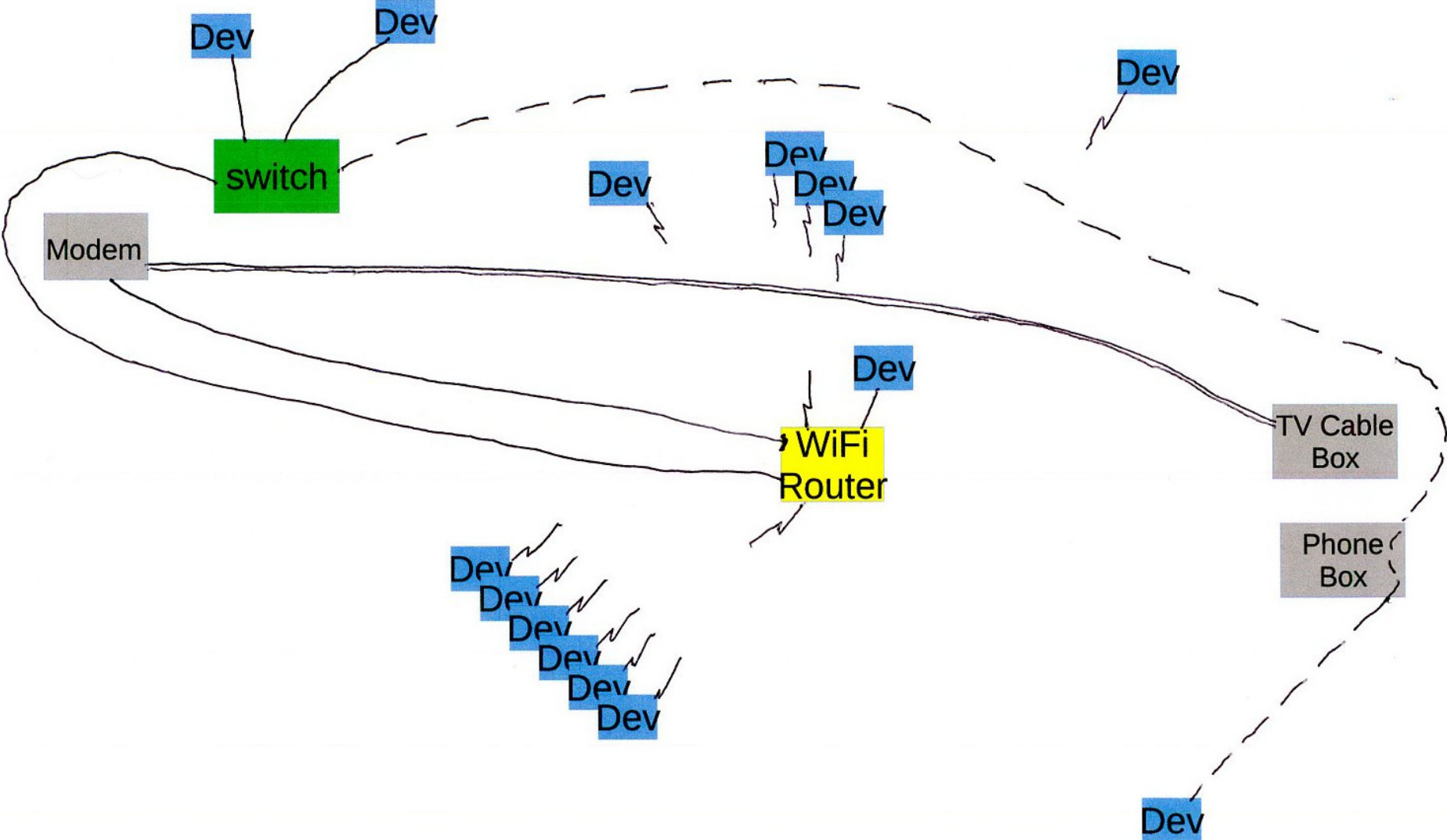
Three-Band WiFi Systems




- **If house has some serious obstructions to WiFi signals, there could still be some WiFi coverage issues.**
- **Sizable investment makes experimentation unattractive, but prices may fall.**
- **WiFi bandwidth is not currently an issue at my house. If I were re-building my home network from scratch, I would still take an incremental approach and buy a WiFi router, and perhaps at least one MoCA v2 adapter pair and use that to drive a separate Ethernet/WiFi Extender in the deadest WiFi region of the house.**

How Everything Fits Together



My Network



Coax Cable 
Ethernet Cable 
WiFi Link 
1/2 phone CAT5 