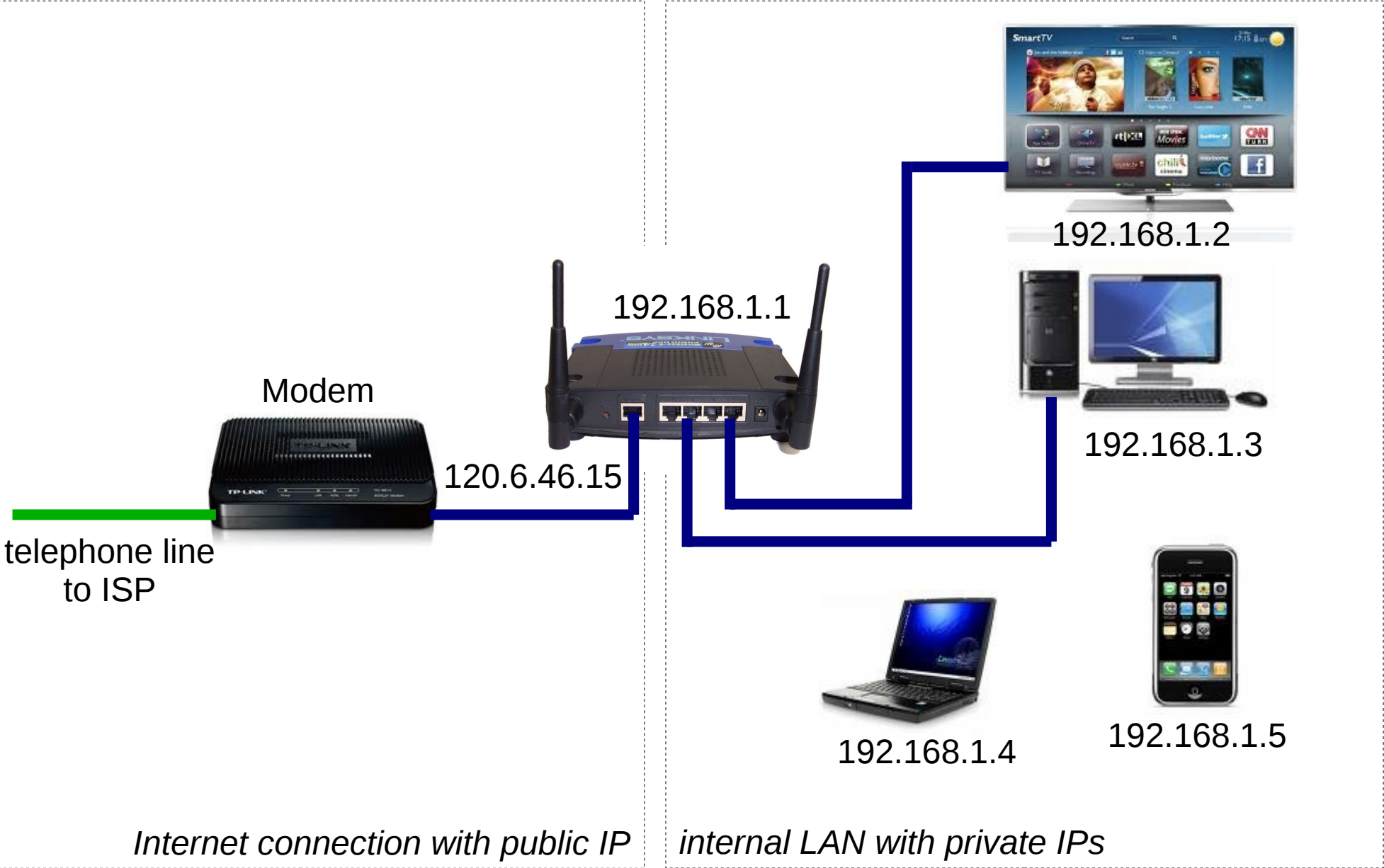
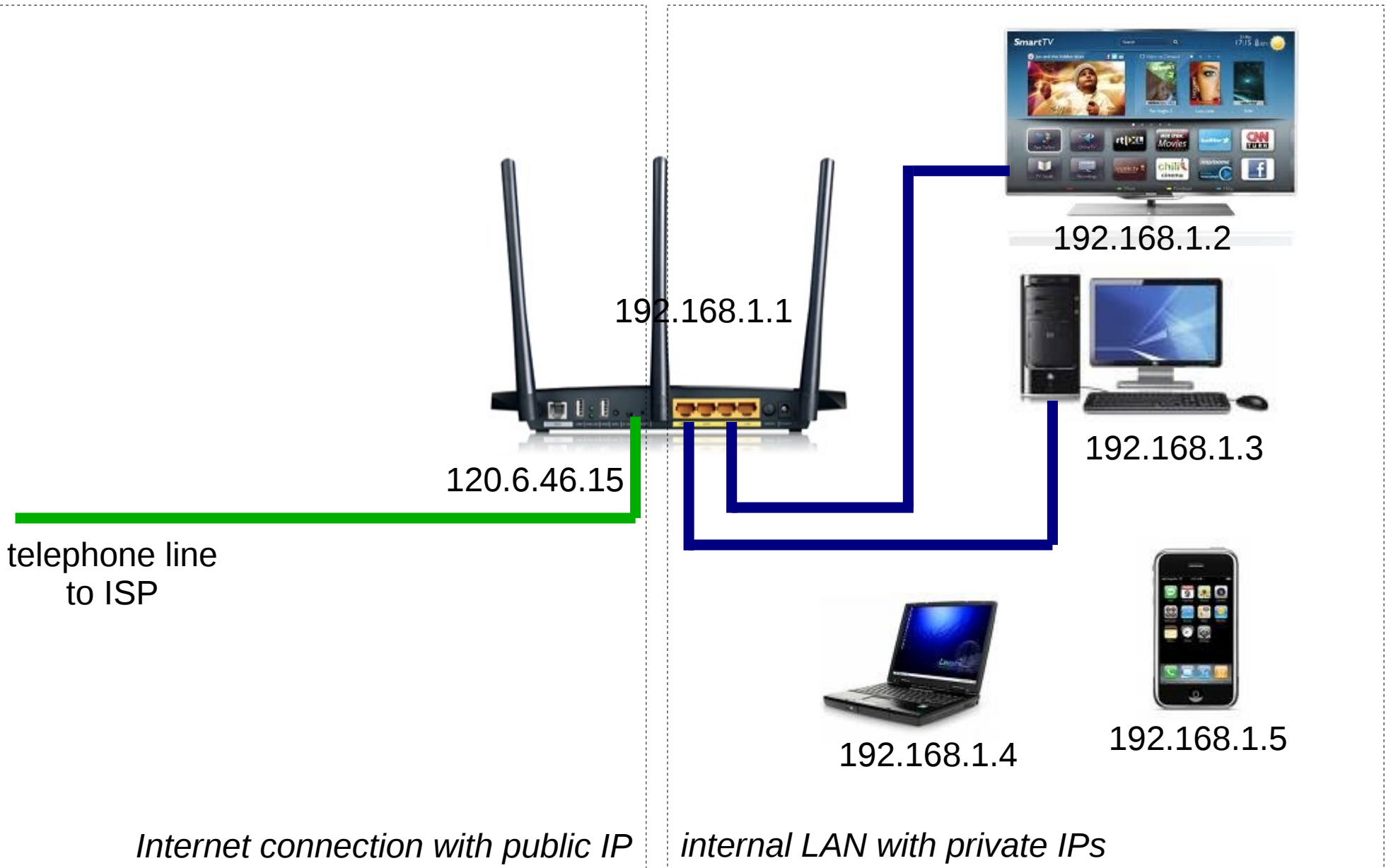


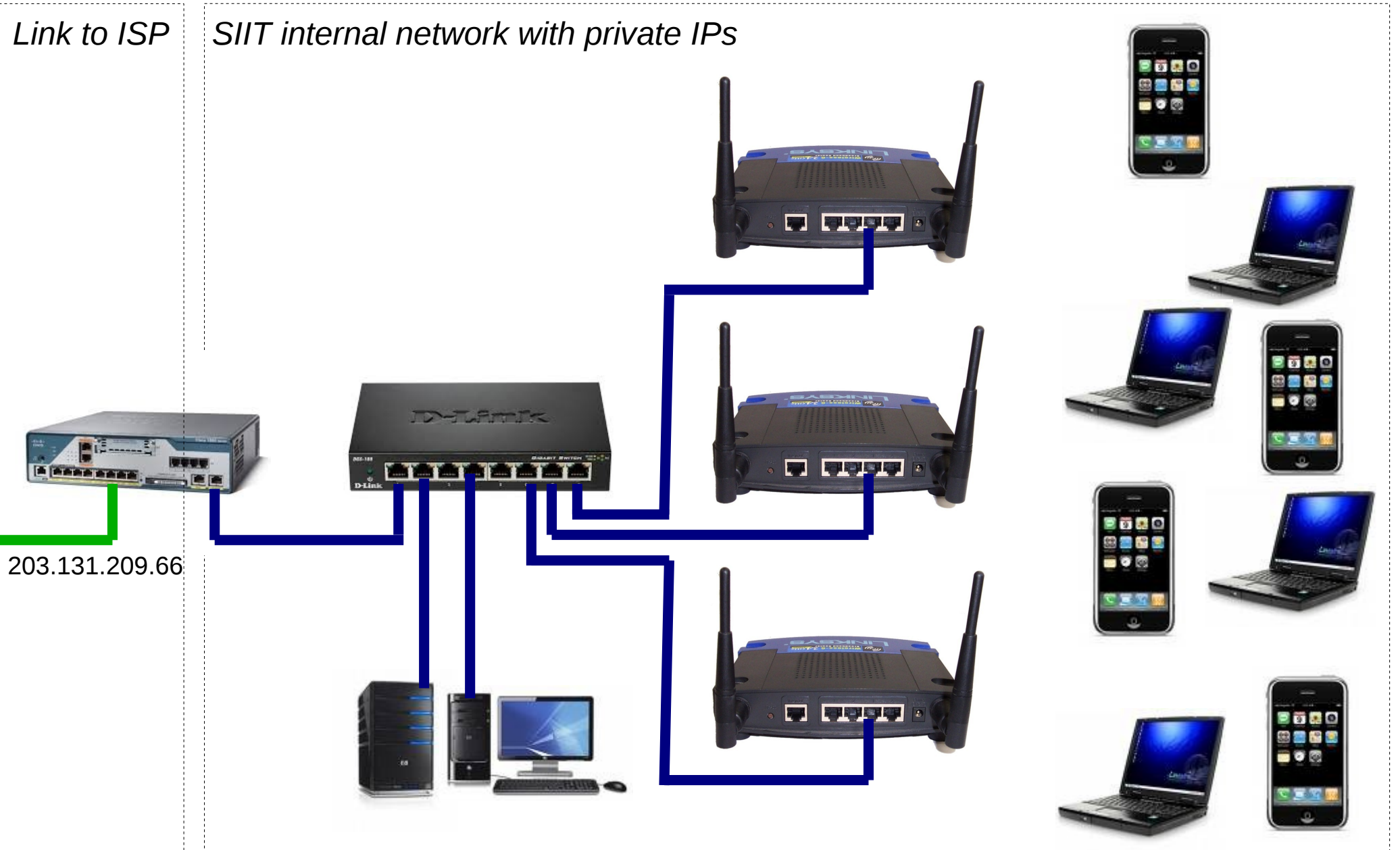
# Wireless Router at Home

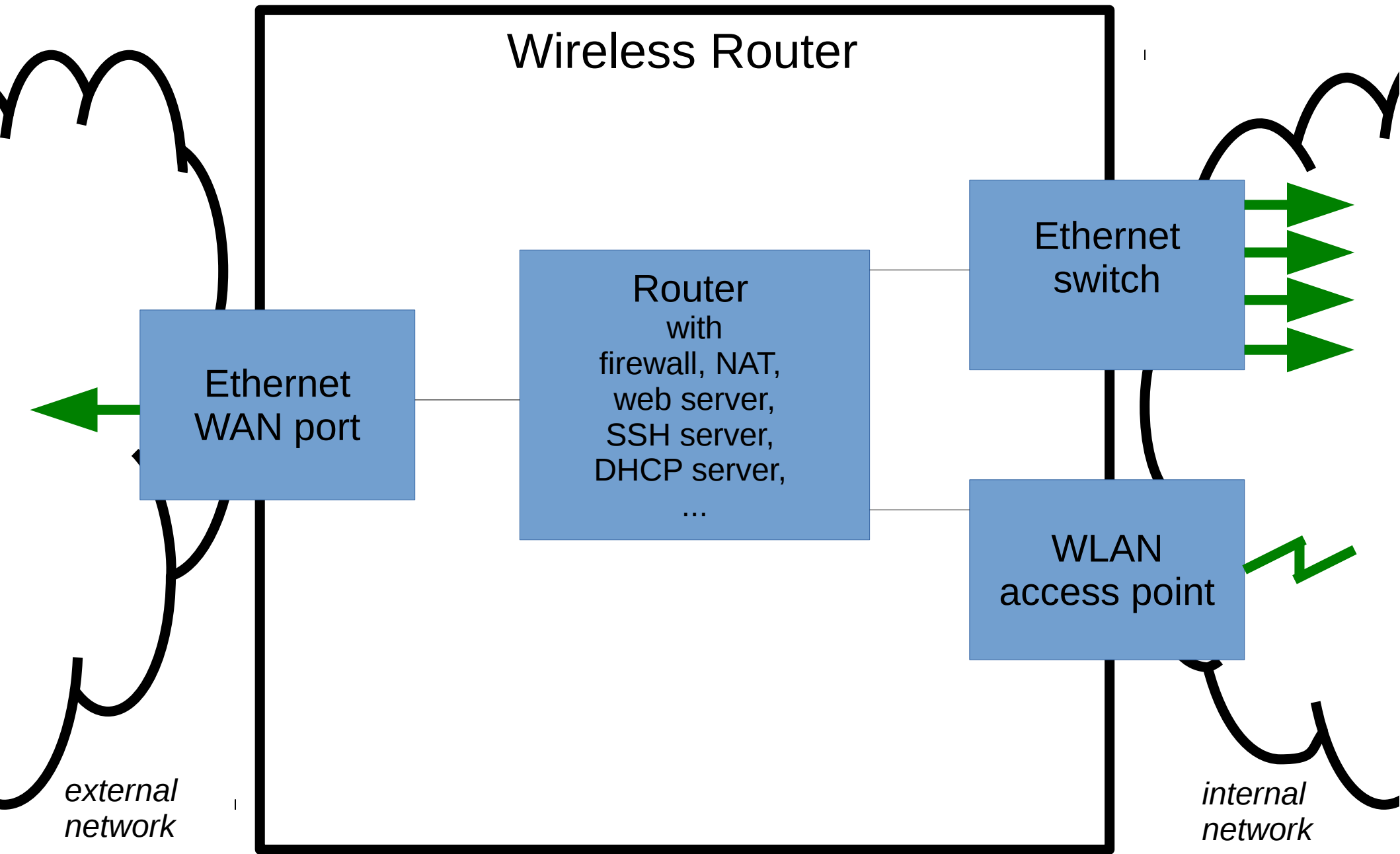


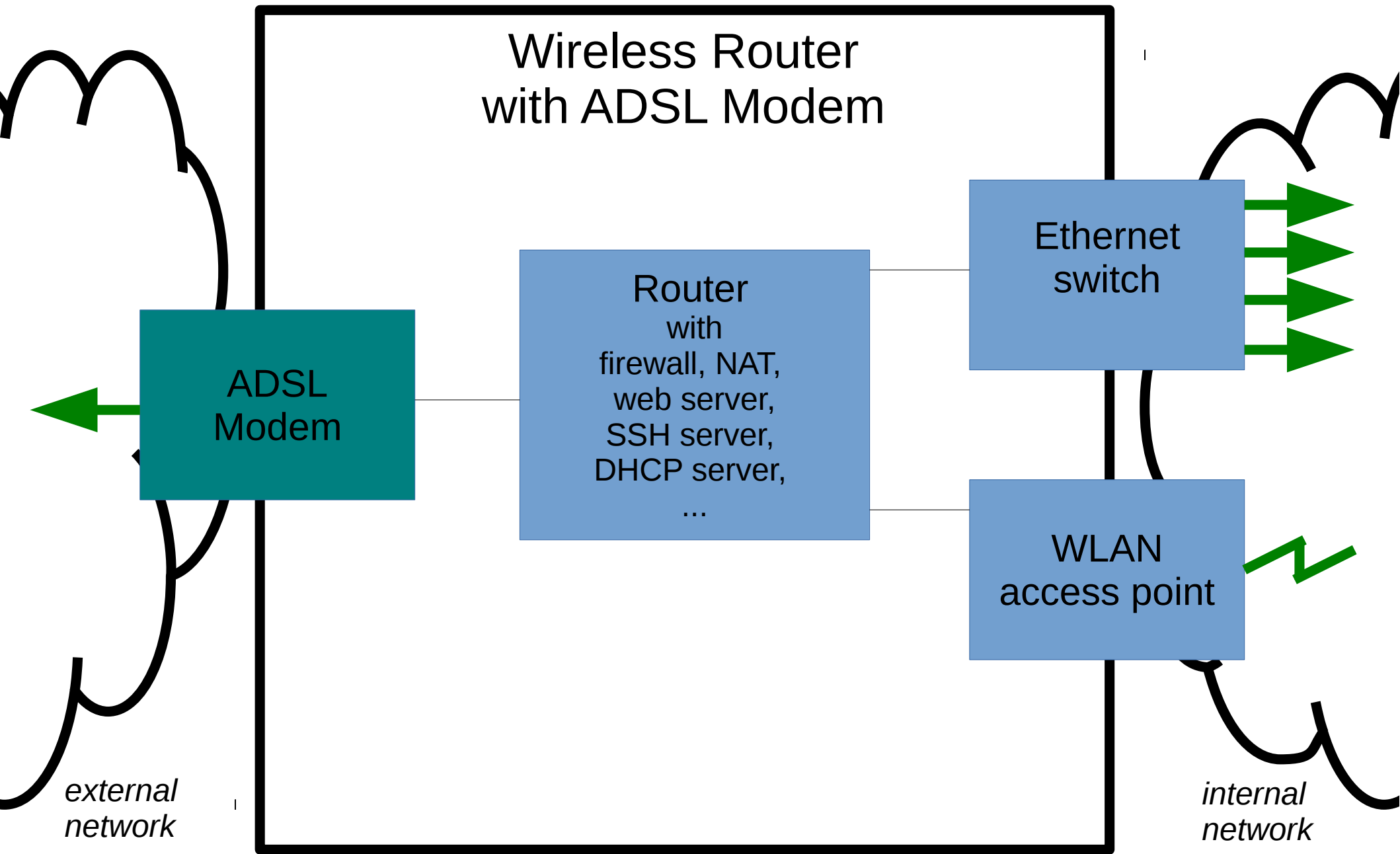
# Wireless All-in-one Router at Home

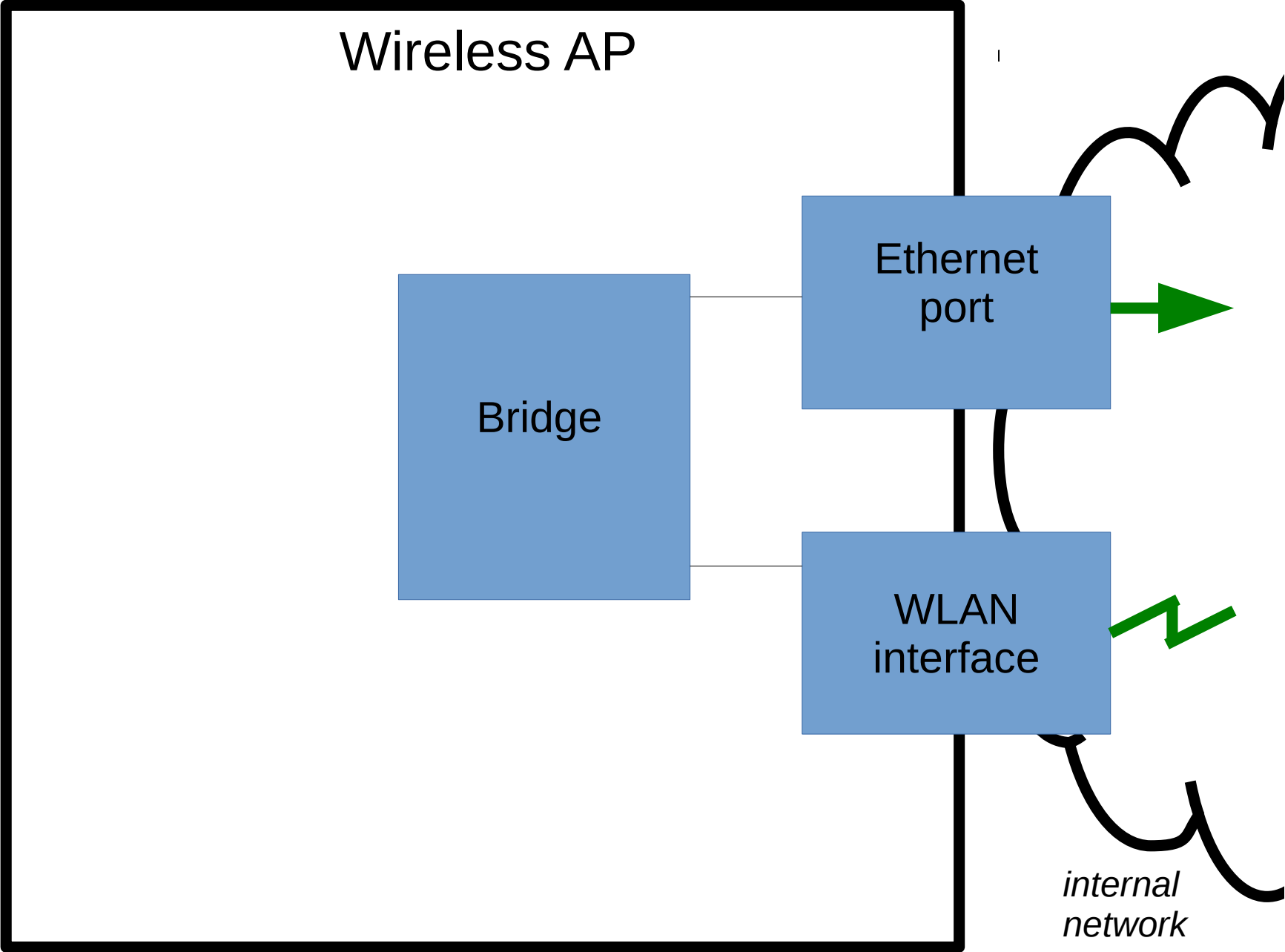


# Wireless LAN AP at SIIT









Wireless AP

Bridge

Ethernet  
port

WLAN  
interface

*internal  
network*

Router



All-in-one



AP

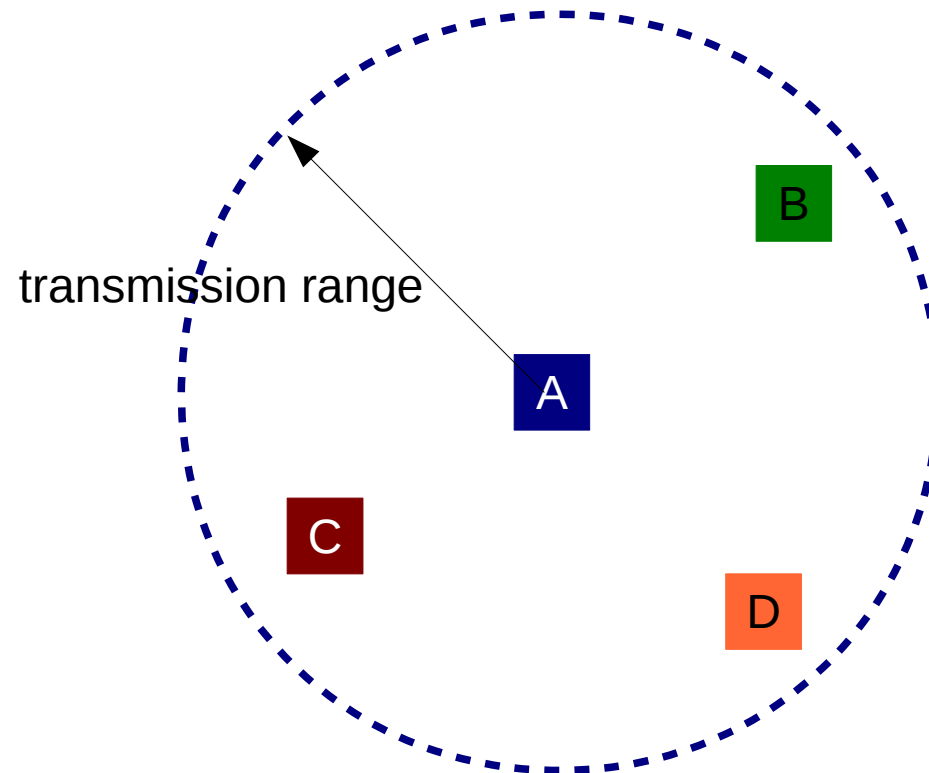


# Wireless LANs

- IEEE 802.11 (standards), WiFi (marketing)
- Aim: Provide equivalent functionality to wired Ethernet
- Advantages of wireless:
  - No wires
  - Mobility
- Disadvantages of wireless:
  - More errors, varying delay: hard to achieve same performance as wires
  - Spectrum/frequencies available is limited: cannot just add more wires
  - Radio transmissions are broadcast: No “physical” security



# Wireless LANs: Broadcast Radio



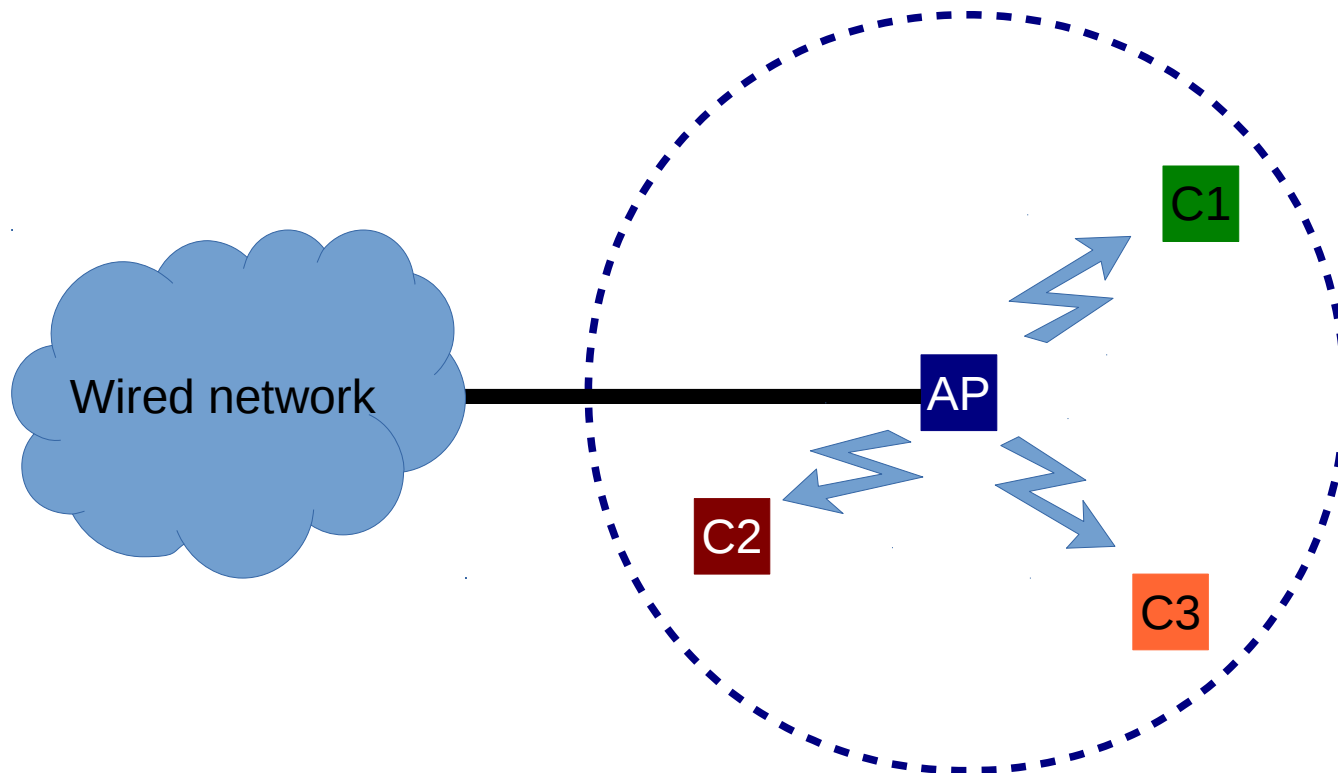
- Transmit signal at center **frequency**  $f$ , with **bandwidth**  $BW$
- Devices with receives tuned to frequency  $f$  will receive the signal (if it has strong enough power)
- “Strong enough power”: depends on transmit power, receiver characteristics, antennas, frequency, obstructions
- Assume maximum distance some signal can be transmitted is **range**

# Wireless LANs: Broadcast Radio

- Everyone within range of transmitter receives the signal
- If two (or more) signals received at same time, then neither can be understood
  - Interference, a “collision” occurs
- IEEE 802.11 MAC protocol aims to ensure only one device transmits at a time
  - Good: No (or few) collisions
  - Bad: Each device must wait for other devices before it can send
    - Shared medium: divide the data rate by number of devices wanting to share

# IEEE 802.11 Wireless LANs

- **Access Point (AP)**: acts as a bridge between wireless segment (WiFi) and wired segment (Ethernet)
- **Client**: wireless communications to AP



# IEEE 802.11 Wireless LANs

- Physical (**PHY**) Layer:
  - Defines how to send wireless signals between devices
  - Data rate, frequency, bandwidth, power, modulation, ...
  - Different standards: 802.11a, 802.11b, 802.11g, ...
- Medium Access Control (**MAC**) Layer:
  - Defines how to efficiently send data between devices while sharing the medium
  - Common across different PHY standards

# Wireless LAN PHY Characteristics

**TABLE I**

**THE EVOLUTION OF THE 802.11 STANDARDS**

<i>Protocol</i>	<i>Year Introduced</i>	<i>Maximum Data Transfer Speed</i>	<i>Frequency</i>	<i>Highest Order Modulation</i>	<i>Channel Bandwidth</i>	<i>Antenna Configurations</i>
802.11a	1999	54 Mbps	5 GHz	64 QAM	20 MHz	1×1 SISO
802.11b	1999	11 Mbps	2.4 GHz	11 CCK	20 MHz	1×1 SISO
802.11g	2003	54 Mbps	2.4 GHz	64 QAM	20 MHz	1×1 SISO
802.11n	2009	65 to 600 Mbps	2.4 or 5 GHz	64 QAM	20 and 40 MHz	Up to 4×4 MIMO
802.11ac	2012	78 Mbps to 3.2 Gbps	5 GHz	256 QAM	20, 40, 80 and 160 MHz	Up to 8×8 MIMO; MU-MIMO

# Wireless LANs: Key Points

- Data Rate
  - Speed at which data sent between 2 devices
  - Varies according to PHY and distance
- Throughput:
  - MAC Overheads, e.g. headers, ACKs: 20-40%
    - 54 Mb/s - 25% overhead = 4 Mb/s
  - Waiting for others: divide by number of users
    - 10 users associated with AP: 4 Mb/s per user

# Wireless LANs: Key Points

- Frequency Bands:
  - 2.4 GHz: supported by all devices; crowded
  - 5 GHz: not all APs, clients support; shorter range; less interference
- Channels:
  - Important when many nearby APs
  - 2 APs, 20 clients split amongst the APs
  - APs use same channel: 2 Mb/s per user
  - APs use non-overlapping channels: 4 Mb/s per user
  - 2.4 GHz band: channels 1, 6 and 11 (and 14)
  - 5 GHz band: 8 non-overlapping channels

# Wireless LANs: Key Points

- Security:
  - None: no authentication or encryption
  - WEP: shared secret key, flawed
  - WPA: shared secret key (client and AP)
  - WPA Enterprise: authentication performed between client and separate server, encryption between client and AP



# Wireless Router Firmware

- All wireless routers come with manufacturer provided firmware
  - Based on Linux and other embedded OS
- 3<sup>rd</sup> party firmware projects, usually Linux-based
  - **OpenWRT**: configurable with latest developments, free, open source software
  - **DD-WRT**: based on OpenWRT, ready-to-use, includes proprietary components
  - **Tomato**: ready-to-use, includes proprietary components
  - and others

# Naming, Acronyms, etc.

- AP - access point
- BSSID - basic SSID *identifies AP*
- CTS - clear to send
- ESSID - extended SSID *identifies network (also SSID)*
- LAN - local area network
- MAC - medium access control (layer) *defines how to share channel with others*
- NAT - network address translation *allows private addressing in internal network*
- PHY - physical (layer) *defines data rate, channels, power, signals, ...*
- RTS - request to send
- SSID - service set identifier
- WAN - wide area network
- WEP - wired equivalent privacy *insecure encryption*
- WLAN - wireless LAN *also WiFi, IEEE 802.11*
- WMM - wireless multimedia mode *priority for voice, video packets*
- WPA - WiFi protected access *secure encryption*
- WRT - wireless router