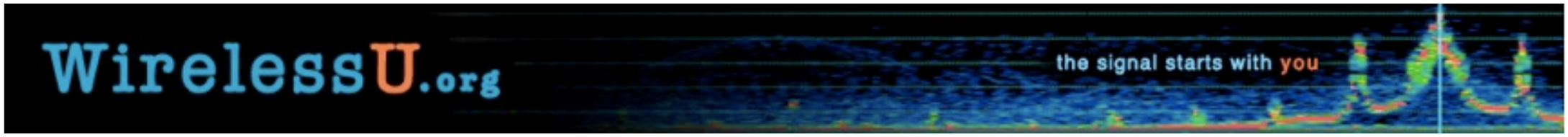
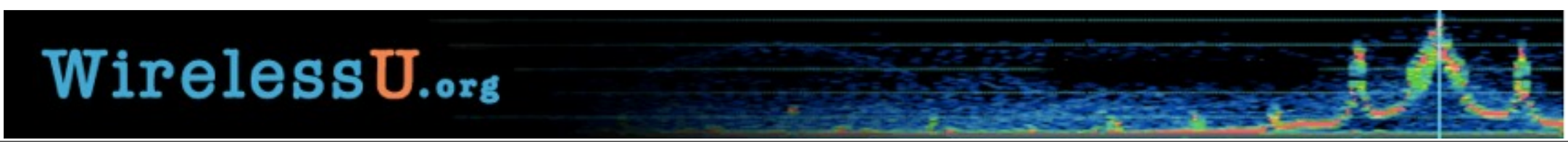



# Bandwidth usage of common networking applications

# Overview

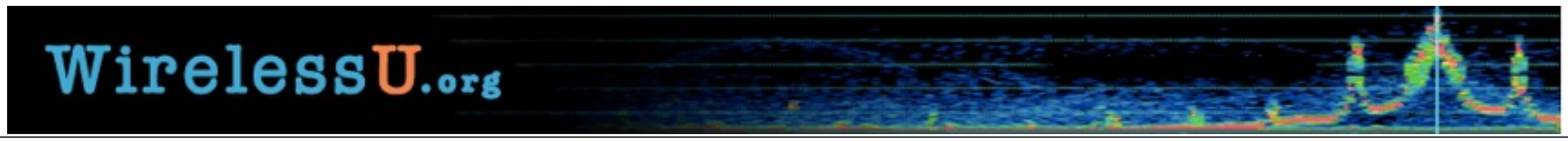
- Bandwidth vs. bandwidth
- Networking stack review
- Basic rules for calculating bandwidth usage
- Examples
  - Calculating bandwidth usage for VOIP
  - Calculating bandwidth usage for an scp session
  - Calculating bandwidth usage for an HTTP download
- Errors and error correction



# Bandwidth is finite

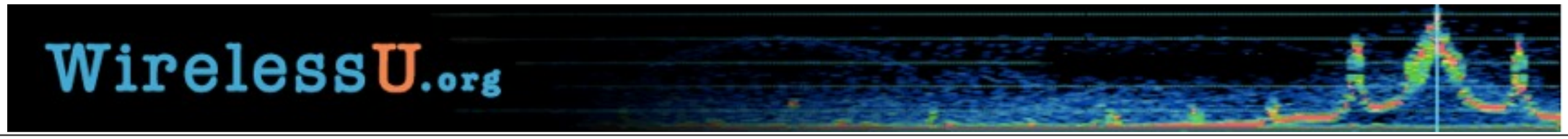
- Signal bandwidth is the difference or distance between the high and low cutoff frequencies in a channel.

- Like everything else, bandwidth is not infinite.
- Capacities of common networking media:
  - Ethernet via CAT5e/CAT6 cable - 1 Gbit/sec
  - Ethernet via CAT5 cable - 100Mbit/sec
  - 802.11G wireless 54Gbit/sec
  - T1 data line 1.54 Mbit/sec
  - GSM 64Kbit/sec(voice) 384Kbit/sec(data)
- These are all theoretical and not achievable in real-world situations.

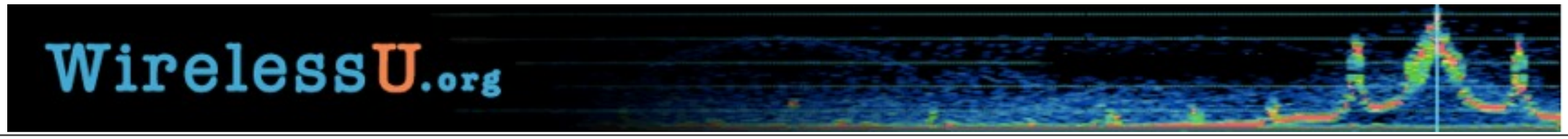


# What's eating our lunch ?

- Overhead is everywhere
- Structural overhead
  - "The cost of doing business"
  - Physical layer -ethernet frame header, PPP headers, ATM, VSAT protocols
    - Network and transport layer - IP headers
    - Application -Encapsulation and Application-specific headers
- Errors eat capacity too
  - Retransmission
  - Back-off/sync-ing messages, etc.
  - inefficient recovery
  - interference (wireless)



# Basic bandwidth calculation:TCP/IP over Ethernet



# Applications: VOIP Bandwidth Usage

Roughly, the bandwidth required for a VOIP call is

Codec bandwidth =(sample frequency/1000)*codec sample rate

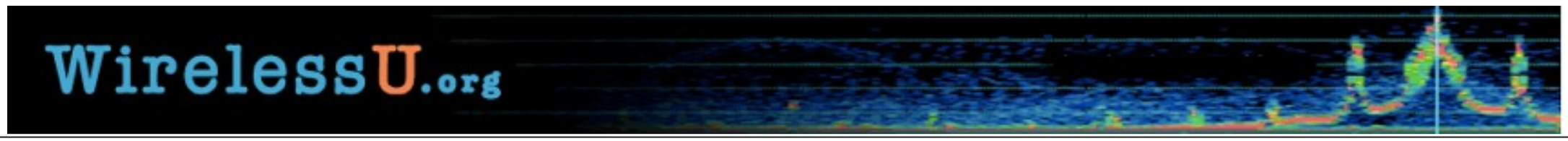
((Codec bandwidth)+((network overhead)+(media overhead)) - VAD**

=

Total Network Bandwidth required*
(usually given in Kbits/sec)

*Not including add'l Layer 2/3 headers like HDLC, MPLS, etc.

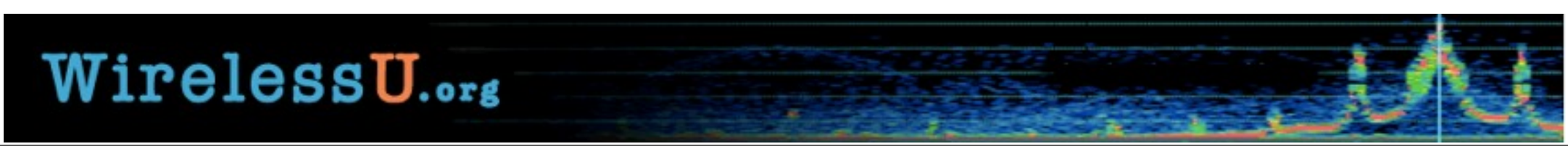
**Also called "silence suppression"



# Some common VOIP codecs

| | Data Rate(Kbit/sec) | Codec Sample interval (in msec) | Codec sample size(bytes) | Voice sample rate(msec) | Voice payload(bytes) | payload packets/sec |
|---|---|---|---|---|---|---|
| G.711 | 64 | 10 | 80 | 20 | 160 | 50 |
| G.726 | 32* | 5 | 20 | 20 | 80 | 50 |
| G.723.1 | 6.3 | 30 | 24 | 30 | 24 | 34 |
| G.723.1 | 5.3 | 30 | 20 | 30 | 20 | 34 |
| G.729A | 8 | 10 | 10 | 20 | 20 | 50 |

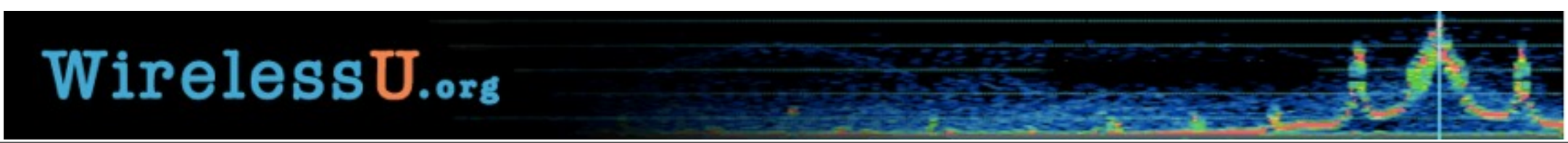
*can also be used at 16 & 24 Kbit/sec



# G.711 over 802.3 Ethernet

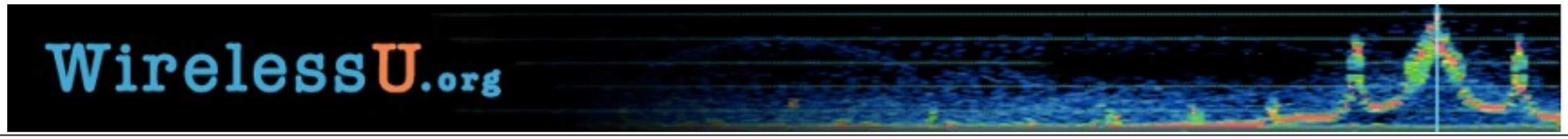
- Codec characteristics: G.711 - 64Kbit/sec codec
  - 20 msec(160 bytes or 1280 bits) sample payload
  - 50 Payload Packets/Sec(PPS) * 1280=64Kbit/sec
- Overhead components:
  - Ethernet frame header: 18 bytes (14 bytes +4 byte CRC)*8 =144 bits
  - RTP:12 bytes(96 bits)
  - IP header: 20 bytes(160 bits)
  - UDP header: 12 bytes(96 bits)

144+96+160+96=496 bits overhead *per packet*
50(payload packets/sec)*496=24,800 bits total overhead/sec
+64,000=
88,800Kbit/sec total bandwidth required



# In addition

- Additional Layer2/3 protocols can add an additional 1-4 bytes-per-packet overhead
- Compression(cRTP, etc.) can remove 40+bytes/packet of overhead
- Silence Suppresion (VAD) can reduce this even further

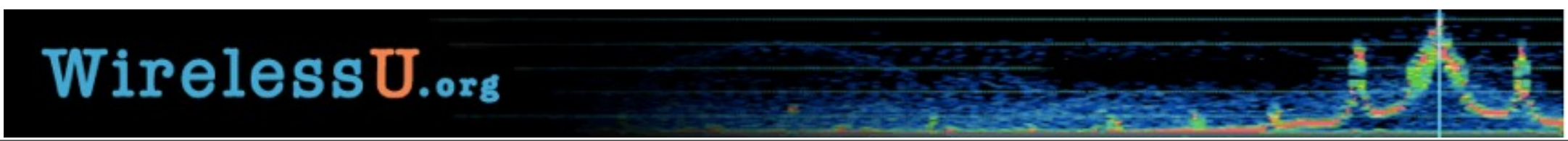


# SSH Protocol Overhead

- Encrypted protocol with it's own internal transport, connection and authentication layers.
- Adds random(4-255 bytes) of padding to each packets
- Actual bandwidth consumption depends on channel type, transport, compression, etc.
- For an ssh "tunnel" the worst-case additional overhead is:
  4 bytes - ssh packet length
  1 byte - random padding length(in bytes)
  1-255 bytes - padding
  ~20 bytes for MAC (depends on MAC algorithm)
  66 bytes IP encapsulation <----don't forget this!!

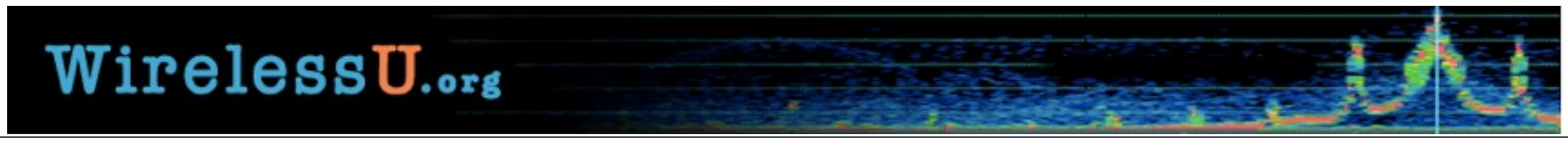
---

346 bytes



# Summary

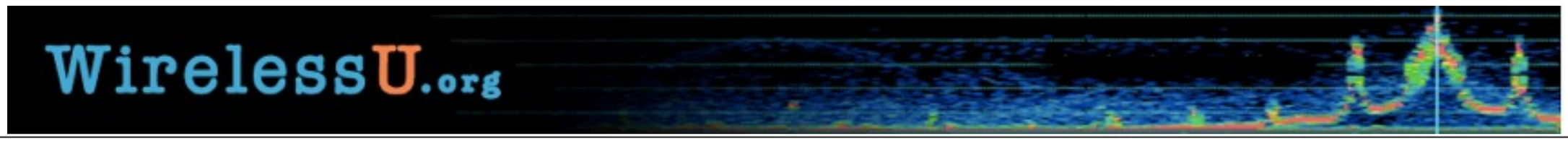
- When calculating network bandwidth needed for network applications, we must account for overhead used by the various network and transport layers carrying our data payload
- Some of this overhead is constant, some is variable.
- Some of this can’t be fully accounted for(errors, layer 2&3 routing protocols in intermediate routers, etc.), so we can really only make close estimates.
- The only way to know for sure how much bandwidth an application will use is to to try it out. First get it working, then optimize



# Exercises

- Calculate bandwidth needed for:
  - G.711 VOIP call over 802.11G

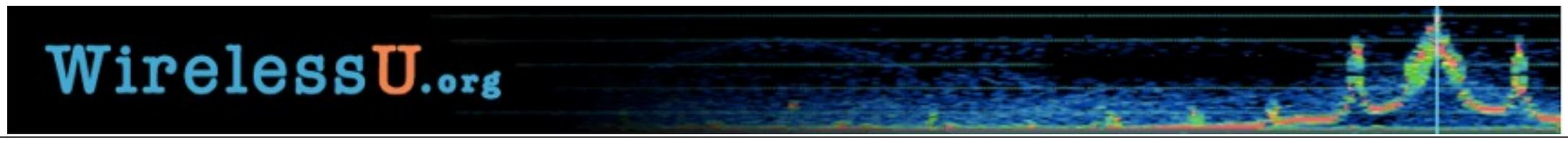
- Lab Practice
  - use iperf to measure:
    scp download of a Linux image or other file over Ethernet
    vs.
    ftp download of the same file.
  - use tcpdump to look at and identify/compare protocols



# Exercise: G.711 over 802.11G

- Codec characteristics: G.711 - 64Kbit/sec codec
  - 20 msec(160 bytes or 1280 bits) sample payload
  - 50 Payload Packets/Sec(PPS) * 1280=64Kbit/sec
- Characteristics for 802.11G
  - 54 Mbit/sec 2.4Ghz wireless protocol
  - Overhead :
    2 bytes frame-control 2 bytes Duration, 12-24 bytes of address space,
    2 bytes Sequence Control, 4-bytes CRC

- Compute estimated bandwidth required
- Hint: Things might go easier if you convert to bits



# G.711 over 802.11G

- Codec characteristics: G.711 - 64Kbit/sec codec
  - 20 msec(160 bytes or 1280 bits) sample payload
  - 50 Payload Packets/Sec(PPS) * 1280=64Kbit/sec
- Overhead components:
  2-byte frame-control
  +2-byte Duration
  +12-24 bytes of address space
  +2 bytes Sequence Control
  +4-bytes CRC(trailing)

  _____

  22-34 byte header or 176-272 bits of overhead per packet

  _____

  +RTP+IP+UDP=528-624 bits per packet
  26400-31200 +64000=90.4-95.2Kbit/sec