

ECE 8873
Data Compression and Modeling

Lecture 14:
Data Compression in Communication Systems

School of Electrical and Computer Engineering
Georgia Institute of Technology
Spring, 2004

Outline

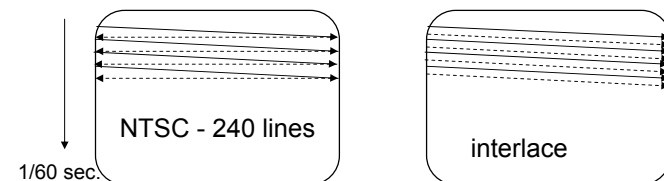
- Video signals and coding issues
- Telephony and networks
- Broadcasting and networks
- New dimensions in data compression – embedded and layered coding

NTSC Video Representation

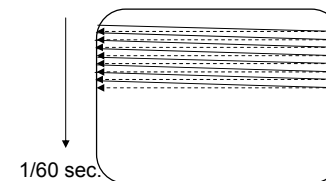
- 525 scan lines per frame, 30 frames per second (actually 29.97 fps, 33.37 ms/frame) on CRT
- Interlaced, each frame divided into 2 fields, 262.5 lines/field
- 20 lines reserved for control information at the beginning of each field
- maximum visible data of 485 lines
- Laserdisc and S-VHS have resolution ~420 lines; ordinary TV ~320 lines
- Each line takes 63.5 microseconds to scan. Horizontal retrace takes 10 microseconds (with 5 microseconds horizontal synch pulse embedded); active line carrying video is 53.5 microseconds

Video Signal Representation

CRT (Cathode Ray Tube) for display of video images



HDTV-ready TVs, or LCD display



Color Video

- **Component video** – each primary color (e.g., R,G,B) is sent as a separate video signal
 - Best color reproduction but requires more bandwidth and good synchronization of the three components
- **Composite video** – color (chrominance) and luminance signals are mixed into a single carrier wave (see next slide)
- **S-Video** (Separated video) – Transformation of RGB into separate luminance and chrominance signals (e.g., YIQ, YUV)
 - a compromise between component analog video and the composite video. It uses two separate “channels,” one for luminance and the other for composite chrominance signal
- **Digital component video** – luminance and color difference video; $Y = .299*R + .587*G + .114*B$ just as in NTSC and $Cr = R-Y$, $Cb = B-Y$, 8 bits/sample.

Composite Video

- Seven elements:
 - horizontal line sync pulse
 - color reference burst: 3.58 MHz 0-phase sine wave, 8 to 9 cycles before the picture information on each scan line
 - reference black level
 - picture luminance information
 - color saturation information
 - color hue information
 - vertical sync pulse
- Composite video signals between equipment are connected with a single 75 ohm coax cable, usually with RCA connectors. Composite video signals can also be modulated onto an RF carrier for TV broadcast, or transmitted on coax cable in cable TV distribution systems.

Luminance & Composite Chrominance

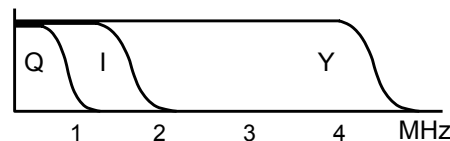
Y (luminance)

I & Q (color difference)

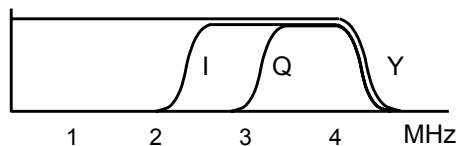
$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.274 & -0.322 \\ 0.212 & -0.523 & 0.311 \end{bmatrix} \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix}$$

$[R' \ G' \ B']$ Gamma corrected RGB

$Cr = R' - Y$, $Cb = B' - Y$



NTSC Composite Video Spectrum



ATSC (HDTV) Video Format

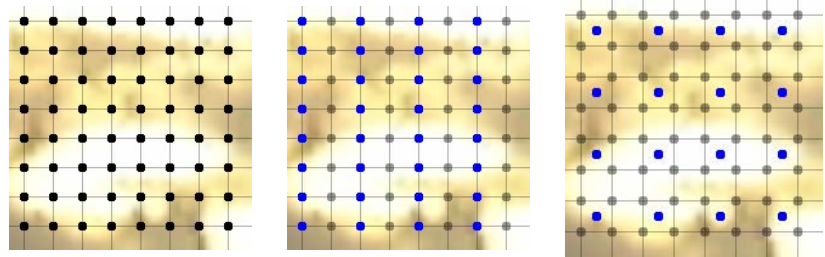
Video Format

The video scanning formats supported by the ATSC Digital Television Standard are shown in the following table.

Vertical Lines	Horizontal Pixels	Aspect Ratio	Picture Rate
1080	1920	16:9	60I 30P 24P
720	1280	16:9	60P 30P 24P
480	704	16:9 & 4:3	60I 60P 30P 24P
480	640	4:3	60I 60P 30P 24P

Chroma Subsampling

- Color information for a frame is sampled at a lower spatial resolution than the luma information



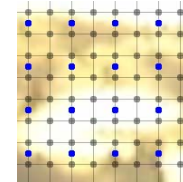
4:4:4

4:2:2

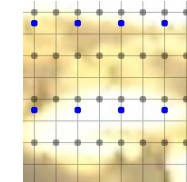
4:2:0
JPEG/MPEG-1/MJPEG

Chroma Subsampling (4:2:0)

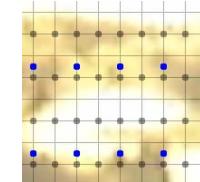
MPEG2



Full frame

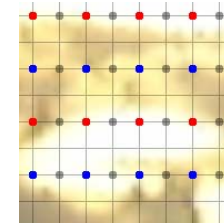


Top field

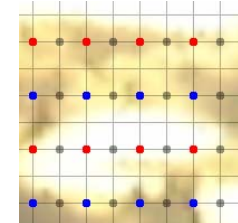


Bottom field

SMPTE DV-PAL



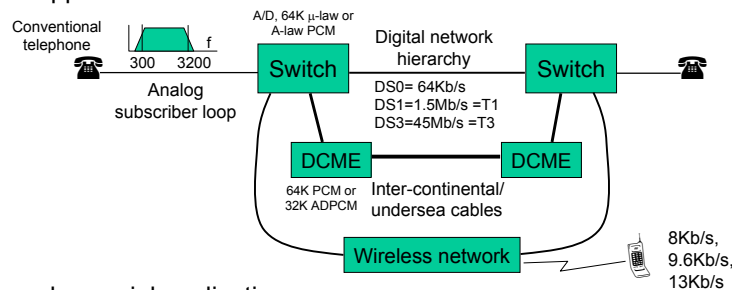
Top field



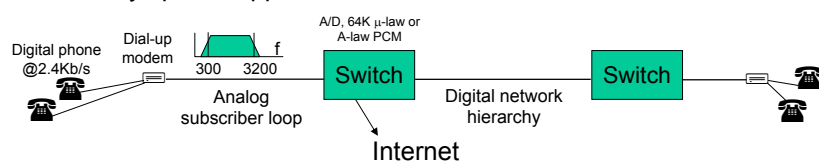
Bottom field

Digital Voice & Telephone Networks

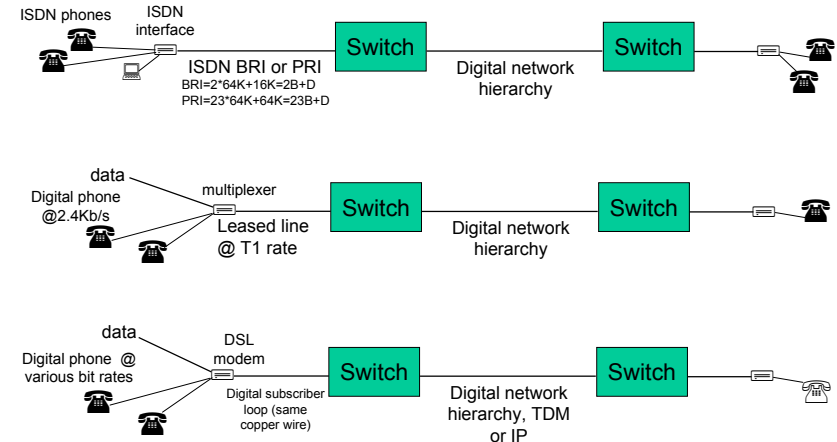
Typical applications



Some early special applications



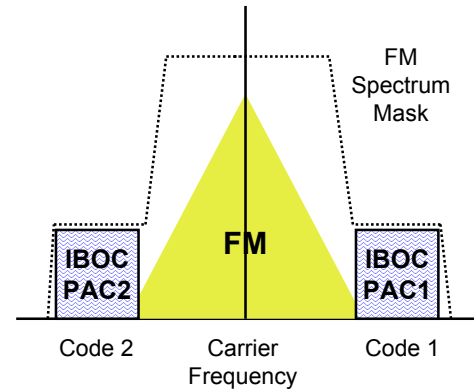
Digital Voice & Networks



Digital Sound Distribution or Broadcasting

- **Terrestrial Broadcasting**
 - In-Band-On-Channel (IBOC) for FM & AM
 - CD-like quality over FM channel
 - FM-like quality over AM channel
- **Satellite Broadcasting**
 - S-Band (Sirius, XM)
 - Subscription based service
 - Up to 130 national-syndicated program channels
 - Small disc-antenna; digital receiver
- **Digital Music Download from Internet**
 - Audio streaming
 - Solid-state audio player

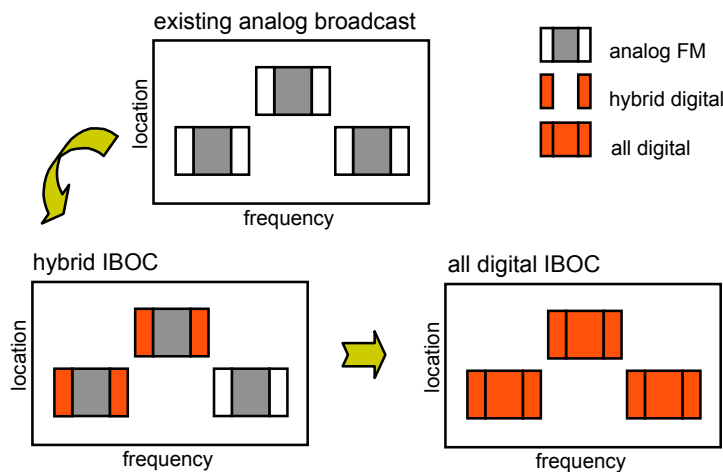
In-Band-On-Channel - FM



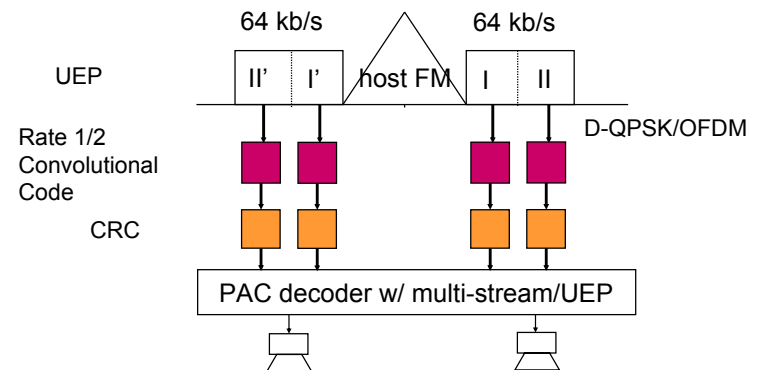
Challenges

- efficient source coding
- robust channel coding
- efficient modulation
- adjacent channel interference suppression
- error resilient transmission
- coverage
- RF amplification

In-Band-On-Channel DAB

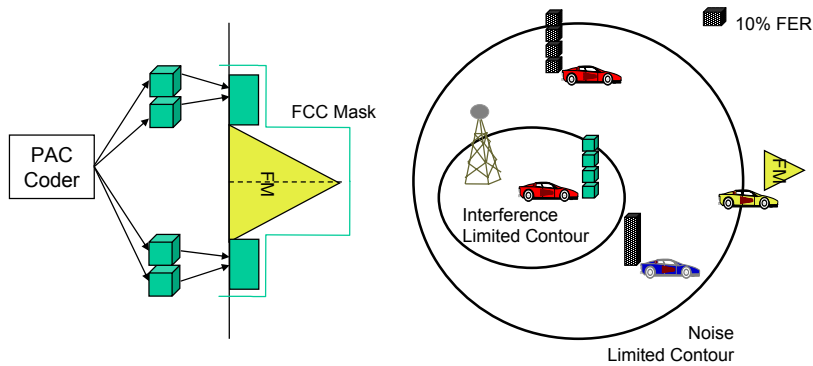


IBOC FM with Multi-stream Coding

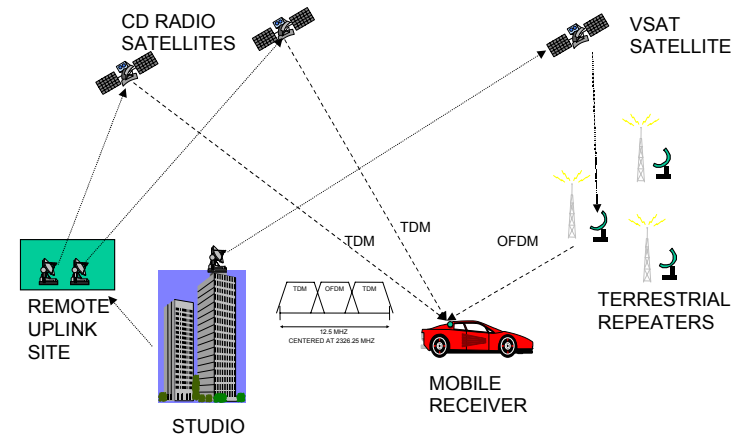


- source coding diversity; simpler decoder and combiner design
- digital program can be different from analog program, offering new datacasting services (e.g. weather, stock, traffic, messaging)

Multi-Stream (Diversity) Coding

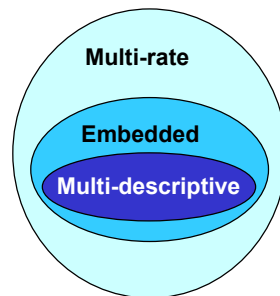


S-DAR System Operation Concept



Embedded/Layered Coding

- A subset of variable rate or multi-rate coding
- Embedded layers can be removed *after* encoding at any point during transmission
 - for added channel error protection
 - to minimize traffic congestion
 - to cope with heterogeneous networks
- Reduces need for trans-coding
- Allows one bit stream to feed multiple applications or servers
- Imperative in Voice over IP



Embedded and Layered Coding

