

# Digital Simulcast

## Discussion with Bellcore

Glenn A. Reitmeier

May 23, 1990

**David Sarnoff Research Center  
Information Systems Research Laboratory  
Princeton, NJ**

# Outline

- **Digital Simulcast strategy**
- **Digital RF Transmission**
- **Data Compression**
- **Discussion**

# Digital Simulcast Strategy

## **Political Situation in the U.S.**

- **The FCC plays a key role in establishing U.S. video standards**
- **The FCC has advocated a simulcast approach for HDTV using a single 6 MHz channel**
- **In the long term, we believe that all-digital HDTV is the right approach...**
- **We must find a solution which accomodates terrestrial broadcast**
- **It is highly desirable for every broadcaster to be able to obtain a simulcast HDTV channel**

## Technical Challenges

- **Design a digital transmission system for terrestrial broadcast that can co-exist with existing NTSC**
- **Design a digital transmission system with adequate capacity, robustness, and coverage area for HDTV**
- **Increase the data rate that can be transmitted in a 6 MHz terrestrial broadcast channel to >30 Mbps**
- **Obtain “HDTV-quality” data compression at less than 0.5 bits/pixel**
- **Meet the FCC timetable with an “acceptable” demo**

## Strategic Challenges

- **Understanding the FCC's (unofficial) view of the future (and the importance of other delivery media)**
  - fiber and cable
  - tape and other mass storage media
  - is terrestrial broadcast their *only* concern?
- **Specsmanship (resolution, S/N, etc.):**
  - Equal to Zenith?
  - Must HDTV have 1000 lines?
  - How many points do we get for being *digital*?
- **Determine what level of demonstration we need:**
  - Hardware modem and simulations of compression
  - A full real-time hardware system
  - Modem transmission of compressed data with non-real-time decompression

## A Plan for FCC Demonstrations

- **Demonstrate hardware for digital RF transmission**
- **Show simulations of data compression**
- **Demonstrate overall system performance:**
  - **store results of non-real-time compression**
  - **transmit compressed bit stream over the channel**
  - **capture received bit stream**
  - **decompress in non-real-time and display results**
- **Can Bellcore help ATRC? Can ATRC help Bellcore?**
  - **simulation**
  - **hardware**
  - **convince the industry and the FCC that digital HDTV is the right approach!**

# Digital RF Transmission



## RF Transmission

- **In order for every broadcaster to obtain a simulcast channel, co-channel spacing must be greatly reduced**
  - this may not be feasible...
  - but the FCC has been advised that it will work
- **Digital simulcast signals must not interfere with the existing NTSC station, therefore they must be lower power**
- **This means that the existing NTSC is a high-power interference to the digital simulcast channel**
- **There are complex tradeoffs to be made among:**
  - Power
  - Coverage area
  - Modulation technique
  - Interference characteristics
  - Data rate
  - Bit error rate and characteristics
  - Receiver complexity and cost

## Transmission Options

- **QAM**
  - **reasonable performance and low cost**
  - **currently working on high-speed hardware for 16/64/256 QAM (to send 20, 30, or 40 Mbps)**
  - **modified QAM approaches may increase robustness**
- **Multiple carrier techniques**
  - **512/1024 OFDM (LEREA Rennes)**
  - **8/16 carriers may allow spectral shaping to reduce interference with NTSC (K. Jonnalagadda)**
- **Hybrid approaches**

## Transmission System Issues

- Will the FCC change their “mode of operation”?
  - will they relax current blanket rules?
  - will they allow local solutions?
  - will they consider cellular approaches?
- Is it *really* necessary to provide every current broadcaster with an HDTV channel?
  - the biggest problem is the few top markets
  - e.g., Los Angeles currently has 25 channels
- It appears possible to double the number of channels received by half of the U.S. population
  - they receive less than 10 of the 68 channels
  - relaxing one taboo rule, every household in the U.S. could theoretically receive 28 channels
- Is reduced HDTV broadcast coverage supplemented by fiber/cable a solution for the top markets?
- Directional antennas and fill-in slave stations are tools to achieve local solutions for broadcast

# Data Compression

## Data Compression

- **Digital HDTV has a high data rate:**
  - **1 Mpix/frame x 60 fps = 60 Mpix/sec (just for Y)**
- **Transmission in a 6 MHz channel (20-30 Mbps) requires compression to less than 0.5 bits/pixel**
- **Several compression techniques produce good quality at >1bit/pixel**
- **True “HDTV quality” has not yet been demonstrated at rates below 1bit/pixel**
- **Digital Hierarchy concept further requires transcodability for delivery over other channels**

## Data Compression Options

- **DCT/block-match motion**
  - practical hardware with current technology
  - JPEG/MPEG path
  - can this achieve “HDTV quality” below 1 bpp?
- **Motion-compensated QMF**
  - good motion compensation is a powerful concept
  - showed that transcodability can be achieved without significant impact on picture quality
  - simulations using this approach are starting to produce good results at 0.5 bpp (roughly 30 Mbps)
- **3-D Transforms (QMF, Sub-bands, DCT, etc.)**
  - temporal artifacts?
  - relationship to motion-compensated approaches?
- **3-D Vector Quantization**
  - simple hardware in the receiver
  - how to perform 3-D mapping of vectors?
  - can a satisfactory codebook be designed?

# Discussion

## Possible Collaboration

- **HDTV parameters**
  - number of pixels and lines
  - frame rate
  - compatibility with NTSC?
  - compatibility with computing and telecom?
- **Data compression**
  - share source material
  - demonstrate compression results
  - agree to examine complimentary approaches
  - joint technical effort
- **Hierarchy concepts**
  - terrestrial broadcast
  - fiber
  - tape and other storage media



## Possible Collaboration, cont'd

- **Lower-level system design**
  - error management strategy and robustness
  - integrated approach to source and channel coding
  - sync, audio, and video budgets and error strategy
  - extend hierarchy concept to audio, signal formats, error correcting codes, etc.
- **RF system issues**
  - Zenith's strong suit
  - need to better understand interference issues
  - need to develop a "frequency allocation" plan that is politically acceptable
- **Develop a plan for industry and the FCC -- show how digital HDTV will create new opportunities and economies of scale in:**
  - Computing
  - Communications
  - Movie/Video Production
  - Broadcasting
  - Consumer electronics

