Internal Memorandum

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Subsidiary of SRI International

To	**Distribution**	Memo #	**SBN-900403**	Date	**April 3, 1990.**
From	**S. B. Ng**	Location	**W-333**	Telephone	**x3035**
Subject	**Digital Simulcast — Issues and Debate.**				

The following pages represent an attempt to capture the essence of on-going debates among some members from the three laboratories in the CE&IS division regarding a digital simulcast Advanced TV (ATV) system. To the extent possible, little or no effort has been made to defend any points of views — I am not impartial to all views myself. The issues mentioned here by no means constitute recommendations. They merely serve to bring together some concerns on the general question of what we should do and what we can do in response to the recent F.C.C. statement that "new developments" in HDTV transmission proposals would be considered as late as 1992.

TECHNICAL ISSUES

Image Compression

- Algorithm development/selection process must begin immediately.
- Need to define picture formats (number of pixels, lines, frame rate, etc.)
- Need to define target image quality and compression.
- Need for a sufficiently large data base of source materials.
- Satisfactory picture quality is doubtful at compression less than ~0.5 bpp.
- Compression to ~1bpp can conceivably result in SNR of ~35 dB.
- At ~35 dB SNR, some disagreement over whether the image quality is sufficient for HDTV.
- 35 dB HDTV pictures look better than 35 dB NTSC pictures. Can the same argument be applied for ATV versus NTSC when ATV has less resolution than HDTV?
- Motion compensation probably needed.

- Sub-pixel (down to 1/4 or 1/8) accuracy in motion compensation gives improvement at a reasonably small additional complexity. (Local interpolation, pyramid not necessary. This is akin to the sub-pixel deghosting currently designed into the deghoster chip.)

- Important to keep in mind that no statistical multiplexing effect can be expected because the scenario is a single, fixed-rate channel. Substantial time variation in compression (i.e., picture quality) is very likely. Adaptive compression schemes appear unavoidable.

- Different compression for static and for moving areas?

- A layered approach has been suggested in which a low resolution (NTSC-like) picture reaches receivers at the outer regions while those with good transmission SNR will recover more data to have an ATV picture. A less optimistic definition of the low resolution picture may be that of VHS quality and resolution.

Transmission

- In broadcast TV channels, the problems of digital transmission are probably as great as, if not greater than, the problems of image compression.

- Dominant channel impairment for the digital channel may turn out to be NTSC-induced interference. Even at UHF, the problem is non-trivial. Modem and/or channel coding effort should include a thorough study of this phenomenon.

- Is 20 Mbps for a 6 MHz bandwidth (20% excess bandwidth, and 4 bps/Hz) a practical limit? The disagreement over this question continues. While 30 Mbps has been suggested, we have yet to test the 20 Mbps modem in a real-world broadcast TV channel.

- Can clever schemes be devised to counter the interference problem? TV station synchronization may provide a solution to combating the known interfering TV signal. Other suggestions include lowering modem data rate during the known strong interference period (e.g., VBI of the interfering signals.)

- Typical broadcast TV transmission problems (multipath, airplane flutter) contribute significantly to the digital channel degradation, probably much more than in the NTSC environment. If there is a ghost of a chance (Schiff's pun!) that 30 Mbps can be sent in a 6 MHz channel, any ghosts had better be invisible to the modem.

- Is digital transmission the right approach for the broadcast environment, given the high seasonal as well as geographical variation of channel conditions so characteristic of the broadcast TV channels?

- Binary FEC (e.g., convolution codes) was designed primarily for bi-level amplitude modulation (QPSK included.) Multi-level modulation (16-QAM, 64-QAM, etc.) will benefit from multi-level FEC (e.g., trellis-coded modulation, Ungerboeck codes) instead of binary FEC.

- Can a modified constellation in the modem provide the desirable channel characteristics for a layered system?

- Does combined source coding and channel modulation, using modified constellation, for example, offer any advantage over the approach of the classical separation of the source coding and channel modulation?

- What about combined source and channel coding? To some extent, this approach is implicit in the layered approach in which portions of the compressed data (the low resolution image, the motion information, e.g.) are more important than others and therefore are put in a more robust sub-channel. The sub-channel can be either logical (using more error protection) or real (using modified constellation points.)

Hardware

- Currently we have no digital ATV compression hardware.

- Compression hardware design can only begin after many preliminary questions have been answered. This may require several months of intensive study and some political decisions to be made. The preliminary work must precede any hardware effort.

- To meet the deadline for the F.C.C. testing, any hardware prototype must be ready by early 1992, and defintely no later than late 1992. The resultant constraints on the hardware design should be assessed well ahead of time.

- Hugh's modem is designed as a 16-point QAM system. At symbol rate of 5 mega-symbol per sec, it gives 20 Mbps data rate. With a change of ROM, the modem can be made to produce a 64-point QAM constellation at 30 Mbps rate. The 20-Mbps modem testing and development work is still in progress.

- Does trellis-coded modulation (TCM) involve substantial modem hardware modification? There is a definite software change (actually a software addition) to accommodate the trellis code, or for that matter, any other channel coding scheme. The modem, as it stands, is a channel modulator. A classical digital chain comprises a source coder (video compression codec), a channel coder (for error protection in the channel,) and a channel modulator (typically a modem.) The channel coder is likely to play an important role in realizing the 20 Mbps (or perhaps even 30 Mbps) channel rate.

- Modification of the constellation pattern generally involves reporgramming a ROM in the modem. This appears to to be true even for non-uniformly spaced constellation points.

- If layered approach chosen, is it sufficient to demonstrate in hardware, only the low resolution layer, and supplement the demonstration with simulation of a complete ATV system with all layers?

POLITICAL ISSUES

- Sex appeal of an all-digital simulcast system. Given two systems with similar picture resolution, I believe the all-digital one will win.

- Step down from the hard-core HDTV definition of twice horizontal and twice vertical resolution. We can possibly send an all-digital ATV over a 6-MHz channel, but not an all-digital HDTV. Notice that almost all the current HDTV proposals do not meet the hard-core definition of HDTV. So let’s drop the HDTV and emphasize the ATV aspects.

- Picture resolution better than ACTV, close to other “HDTV” proposals (e.g., Zenith, MUSE, MIT.)

- Is a system with resolution performance *less* than the competition an acceptable system? If XYZ proposal has h pixels by v lines, for e.g., must our system handle $\geq h$ pixels and $\geq v$ lines?

- Construct a layered approach that fit into the broadband ISDN structure. Other media, such as home recording and pre-recorded materials, ought to be included in such a plan.

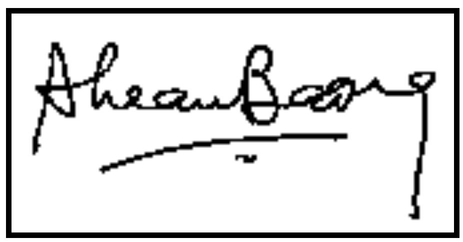
- Is it acceptable that the ATV coverage is less than the present NTSC coverage? The problem of coverage may be particularly severe in major markets such New York City and Los Angeles.

- Is directional transmitter antenna coupled with “fill-in” stations an acceptable solution to the coverage problem?

It is pre-mature to judge if an all-digital simulcast system is feasible, let alone picking out an algorithm for the compresion. The first order business for the digital simulcat project is to find an answer to that question, and possibly demonstrate the expected performance of any proposed algorithm(s).

The compression issues may very well depend on the definition of ATV resolution. I suggest the following as a reference model. The ATV system will deliver 960 pixels/line and 540 lines/frame at 60 Hz frame rate with progressive scan. and square pixel. The resolution of the image is 540 lph in both the vertical and the horizontal directions. The reference model for the low resolution picture can be, for example, 480 pixels by 270 lines (which is clearly less than NTSC but it lacks the NTSC artifacts.) For comparison, the Zenith proposal has, according to its earliest description, 612 lph horizontally and 720 lph vertically (1020 pixels/line and 720 lines/frame with 5:3 aspect ratio.) In moving areas, the resolution drops to 204 lph horizontally and 96 lph vertically. The ATRC estimates of Zenith's system, based on observations alone, are 500 lph horizontally and vertically in static areas and 450 lph in moving areas. (The analog simulcast proposal currently under consideration by the ATRC has 525 lph resolution vertically.) The 540 lph resolution proposed here certainly has the same resolution flavor as other "HDTV" proposals.

Your comments are sought.



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