EVALUATION OF ISDN VIDEO TRANSMISSION TO A TRAFFIC OPERATIONS CENTER

by

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Final Project Report

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Project Objectives

The objective of this project is to perform evaluation tests related to the transmission of digitized video signals over ISDN lines between a video traffic reporting camera and a traffic management center. The quality of the received video signals can be used to effectively monitor existing and developing traffic conditions.

An evaluation plan was developed with the concurrence of NJDOT (sponsor of the project) consisting of: a) market survey of current video-transmission options, b) the hardware specifications for the ISDN connections, and c) the description of the tests performed.

This final report summarizes the findings of our work and is delivered to the participating agencies (UTRC and NJDOT).

Project Environment

A typical video-transmission over a public ISDN network involves the following steps:

1. The analog audio/visual signal is digitized by a frame grabber. A device subsequently compresses the digitized AN signal using in most cases a hardware-assisted compression scheme.
2. The remote computer's processor transmits this signal to the ISDN-transceiver which codes it appropriately.
3. The digitized video-frame is transmitted through the public ISDN-network.
4. The reverse process occurs at the computer at the Traffic Management Center (TMC), where a hardware device decompresses in real-time the received digital AN signal and feeds the video-board for further display either at a computer monitor or a commercial TV-set.

Figure 1 depicts the experimental setup used in this project to test the feasibility of traffic-related video scenes over ISDN-lines.

The video quality is influenced at the following points:

1. The video grabber can capture video frames at a certain rate (fps) and resolution. The higher the rate and the resolution the better the quality of the transmitted signal. Typical resolutions and frame rates for the used video grabber are 325x288 (CIF) and 176x144 (QCIF) at either 15 fps or 30 fps.
2. The quality of the digitized signal is designated by the depth of colors supported by the frame grabber. The used color depth in this project is 65,536 (16-bit).
3. The codec-device is capable in compressing in real-time the digitized signal without the need of increasing the load on the home-computer. The compression typically results in a signal where the video stream is reduced by approximately 90 percent, at the expense of a lossy compression which detracts from capture quality. In this project the compression was carried out in hardware. The used compression format with the agreement of NJDOT was the H.261 standard which defines two video-resolutions 352 x 288 (CIF - Common Intermediate Format) and 176 x 144 (QCIF - Quarter CIF).
4. The video transmission rate is constrained by the available bandwidth of the ISDN line. In this project, we used Basic Rate Interface (BRI) ISDN connections which provided a maximum bandwidth of 128 Kbits/sec. An ISDN line is broken down into two B channels (which carry data) and a D channel (for routing and handling information). By barring one B channel and allocating 35.2 Kbits/sec for audio and data transmission, we emulated the video transmission option over Plain Old Telephone System (POTS). The allocated bandwidth for this test was approximately 28.8 Kbits/sec (i.e., equivalent to that of a typical modem).

All the above (video capture board, compression standard, communication link(s)) were selected with the agreement of NJDOT after an extensive market survey. NJDOT asked for this survey in the initial phase of this project so that the team selects the optimum compression standard and broadband communication link (based on a cost/benefit analysis).

The used compression boards were the Zydacron Z350 PCI Video Conferencing Codec (at http://www.zydacron.com), attached to a Motorola NT-1 ISDN Adapter. These boards were placed at two Pentium II (rated at 400 MHz) computers running Windows NT ver. 4.0. The specifications of these boards appear in Appendix A.

Project Settings

NJDOT supplied one video tape (VHS-format) with representative video traffic scenery. The quality of the received video signals is assessed for effectively monitoring the traffic conditions.

The experimental procedure consisted of the following phases (as shown in the context of Figure 1):

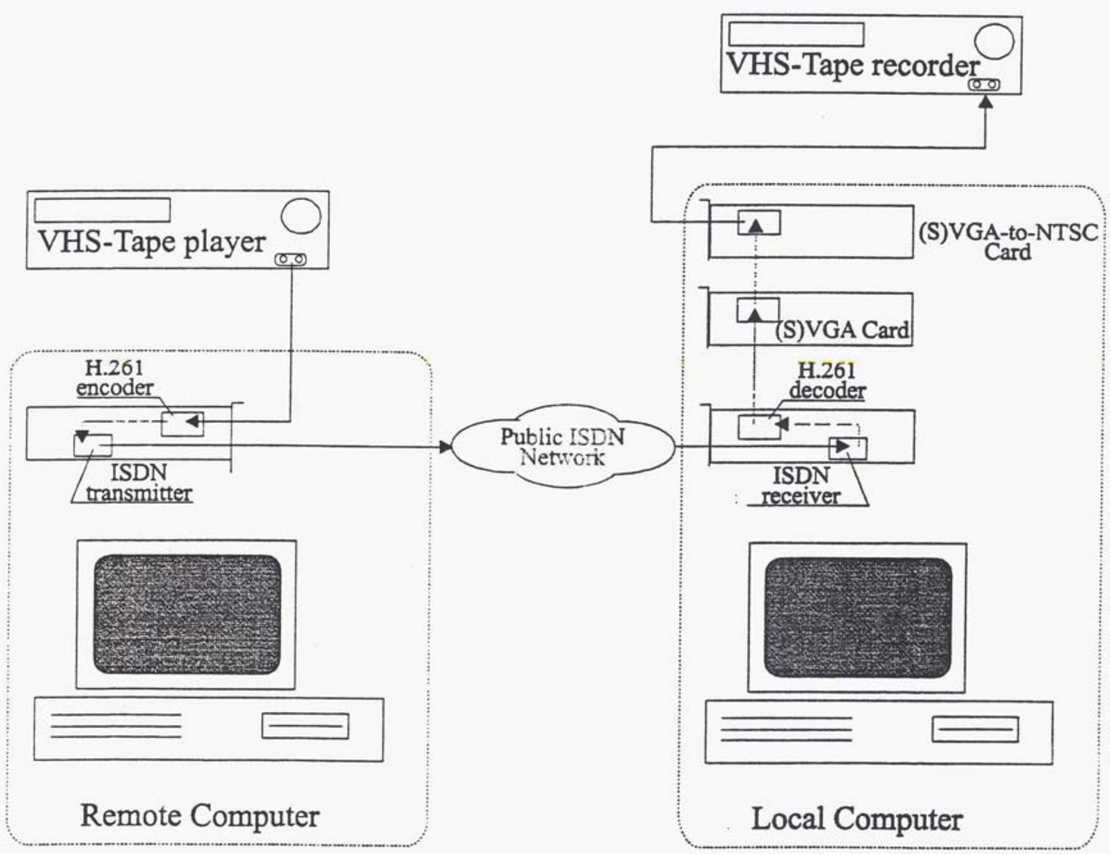


Figure 1: Video Transmission Experimental Environment

a) A VHS-Tape player transmitted the video stream from NJDOT's video-tape to the H.261'encoder',
b) The H.261 encoder captured the frames of the video-stream and digitized them based on the selected resolution (CIF 352x288 vs. QCIF 176x144) according to our settings. To use the maximum bandwidth we disabled any audio and data transmission from the H.261 codec while the transmission between the remote and local computers was unidirectional.
c) The digitized and properly condensed image was sent to the ISDN-modem which adjusted its bandwidth according to our settings (either 2B-channels at 128kbit/sec or 1B-channel at 64kbit/sec). The ISDN transmitter subsequently transmitted the compressed H.26 1 -compliant video-stream through the ISDN-public network to the localcomputer.
d) The ISDN modem/receiver at the local computer receives the video-stream and directs it to the H.261 decoder.
e) The H.261 decoder decodes the video stream and transmits it to the video-memory of the local computer.
f) The video-card processes the contents of the video-memory and based on the card/monitor resolution (either VGA 640x480, or SVGA 800x600) displays the uncompressed transmitted video-stream. The aspect ratio during the display is one while the displayed image always occupies an area of 352x288 pixels. For the CIF-case (352x288 pixels) there is a one-to-one correspondence, while for the QCIF-case (176x144 pixels) one pixel of the transmitted image is copied to its four neighboring one followed by a proper smoothing algorithm for better display.
g) To record the contents of the monitor's screen, we direct the monitor visual data stream to a converter for NTSC output. During this phase, there is significant degradation of the signal caused by this conversion.
h) The NTSC-compliant signal is then sent to a VHS-tape recorder for recording purposes.

Project Results

We have sent to NJDOT two videotapes (VHS-format) resulting from our tests. We selected from the NJDOT-provided videotape several video segments with:

different traffic patterns including day and night scenes, and

cases where the camera observing the traffic was steady or/panning/tilting.

A representative 15-minute interval was used for all video-transmission cases. To investigate the effects of bandwidth (128Kbit/sec vs. 64Kbit/sec) and resolution of the digitized image (CIF vs. QCIF), we selected distinct scenarios; the results from these tests are highlighted in the first videotape. This videotape contains the reconstructed video-stream on the remote computer after the compression (using the H.261 protocol) and transmission over the ISDN-public network.

Tape 1 contains the following scenarios:

Case #	Bandwidth (Kbits/sec)	Resolution (CIF: 352x288, QCIF 176x144)	Monitor Resolution (VGA:640x480, VGA:800x600)
A.1.1	128	CIF	VGA
A.1.2	128	CIF	SVGA
A.2.1	128	QCIF	VGA
A.2.2	128	QCIF	SVGA
B.1.1	64	CIF	VGA
B.1.2	64	CIF	SVGA
B.2.1	64	QCIF	VGA
B.2.2	64	QCIF	SVGA

In addition to this evaluation, we emulated the transmission over a 'Plain Analog Transmission System' (POTS) at a rated speed of 28.8Kbit/sec. The obtained results are highlighted in the second videotape. Rather than using the 15 minutes intervals, we opted for a shorter duration (5 minutes) as it became apparent that transmission over POTS would offer poor results. We should point out that we used only CIF resolution. The

QCIF resolution was regarded unnecessary, as the quality of the video will further deteriorate.

Tape 2 contains the following scenarios:

Case #	Bandwidth (Kbits/sec)	Resolution (CIF: 352x288, QCIF 176x144)	Monitor Resolution (VGA:640x480, VGA:800x600)
C.1	28.8	CIF	VGA
C.2	64	CIF	VGA
C.3	128	CIF	VGA

The overall results indicate that:

- The video-transmission over POTS for a rapidly changing video-signal (e.g., cars moving, background varying due to the camera panning) is unacceptable. The typical frame rates when the camera was moving were 0.5 to 2 frames/second and the overall video-stream deteriorated significantly.
- The video-transmission over one 1-B channel (64Kbit/sec) of an ISDN-line exhibited significant deterioration for both CIF and QCIF resolutions. Typical frame rates were 2 to 3 frames/second for the case where the camera is stand-still and the cars were moving. The generated video-stream during night conditions is even worse and the number of cars in each frame can barely be determined.
- The video-transmission over the entire bandwidth of the ISDN-line (128Kbit/sec) produced the best results. The be-rates achieved for a CIF and a QCIF resolution were 3-to-IO fps and 3-to-I5 fps, respectively; this indicates that migrating to a QCIF resolution does not increase significantly the frame rate and therefore the signal quality. The deterioration for a QCIF-resolution is apparent during the night intervals, where the lack of adequate quantization (1/4 th of CIF's resolution) worsens the system's performance. The cost of using 2B-channels (128kbit/sec) vs. 1B-channel (64kbit/sec) is tripled. Despite this disproportionate cost, it appears that if one would like to maintain some level of quality in the transmitted video stream, then the 2B option should be used.

Overall Recommendation

Our overall recommendation is in line with the results above: we suggest that 2B-channels of the ISDN-line is a feasible option for the transmission of NJDOT video signals. We believe that CIF is preferable over QCIF sinceit results in higher frame resolution. At the same time CIF achieves comparable frame rates with that of QCIF.

Proposed Follow-Up Project

We would like to point out that we are still of the opinion that MPEG-based compression schemes would provide better results for the ISDN-level bandwidth (128 Kbit/sec). In addition, the rapidly changing video suggests that the MPEG-based schemes would work in a better manner than H.261. The latter was mostly designed for slowly changing video streams typically found in videoconferencing applications.

We therefore suggest that we proceed with experimenting with an MPEG-based video compression for traffic-scenes video transmission.

Appendix A

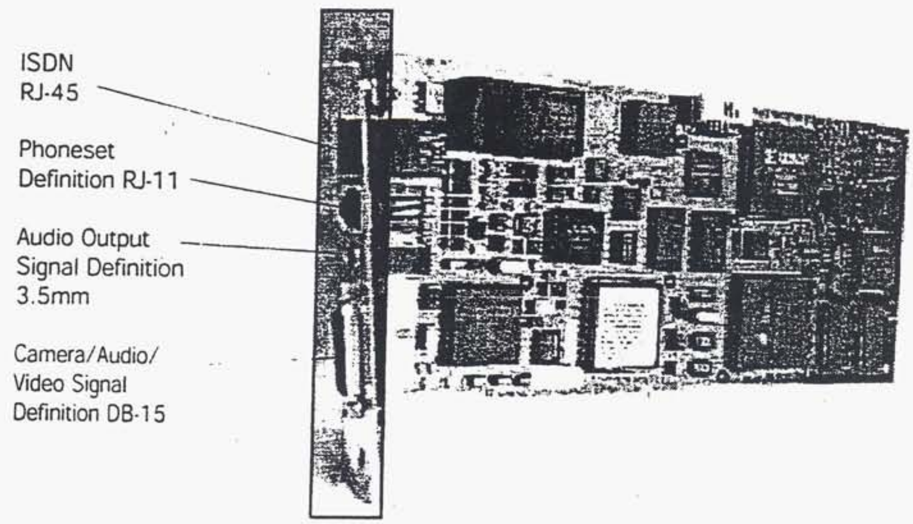
Video Codec and ISDN-line communication link

UP TO 30 FRAMES PER SECOND CIF

ZYDACRON, INC

Z350 for Windows NT

Single PCI Board for ISDN & LAN Videoconferencing



FEATURES:

- H.320 and H.323 standards compliant
- Up to 30 fps
- Single board, PCI-based codec
- On-board ISDN communications with S/T interface up to 128kbps
- Call size up to 384kbps with triple BRI add-in board
- Built-in ISDN analyzer software
- Microsoft NetMeeting™ integration for T.120 support
- MCU support
- End-user diagnostics
- User-friendly desktop videoconferencing application software

BENEFITS:

- Easy to use interface
- Low-cost, robust desktop videoconferencing for ISDN and corporate networks
- Easy troubleshooting self diagnostic capabilities
- Group conferencing ready

A single, PC-based board requiring just one PCI slot, the Z350 for Windows NT offers exceptional H.320 and H.323 compatible videoconferencing at up to 30 frames per second, with T.120 support for data collaboration via full Microsoft NetMeeting integration. The Z350 enables integration with PC hardware to deliver "plug and play" videoconferencing over ISDN via the on-board BRI or over the LAN via the PC's NIC.

The Z350 software includes built-in system configuration, an integrated ISDN analyzer and video overlay that works over the PCI bus to most PCI VGA controllers. It includes 384 Kbps Tri-BRI support and H.323 support.

High quality at a low cost makes the Z350 ideal for OEMs, VARs and System Integrators. Zydacron's core codec technology makes this codec a winner for business, government and educational institutions requiring robust PC-based videoconferencing. It's a must for users who need high quality video, low-delay audio and quick and reliable connections.

The Z350 is a breakthrough desktop videoconferencing technology that provides simplicity, flexibility and quality at value pricing.

Z350 for Windows NT Specifications

Z350 FOR NT STANDARD PACKAGE
- Z350 Codec board
- Software:
  - Z350 for NT application
  - Microsoft NetMeeting™
  - DirectX
  - Microsoft® Internet Explorer 4.0
- User manual
- Connectors:
  - 3.5mm headset
  - Line Input
  - S-Video
  - S-Video to RCA
  - Soundcard connector
  - ISDN

SYSTEM REQUIREMENTS
- 166 MHz or higher Pentium PC*
- 32 MB RAM*
- 1 Free PCI slot
- 30 MB available hard drive space

* Note: 300 MHz Pentium with 64 MB RAM suggested for NT version when used with ZC206 Tri BRI add-in card.

BOARD DIMENSION
- 8.70" x 4.20" (22.1cm x 10.67cm)

Z350 FOR NT APPLICATION FEATURES
- Drag & drop file transfer
- Far-end camera control
- Self-view picture-in-picture (PIP)
- Chat feature
- Customizable toolbar
- Phone handset pop-up dialing menu
- Netmeeting for application collaboration and whiteboard
- Video capture and display snapshot

OPTIONS
- Speakers
- Headset with microphone
- Pan-tilt-zoom camera
- Telephone handset

VIDEO
- H.261
- H.263 (H.323 only)

AUDIO
- G.728
- G.711 (a-law and law)
- G.722
- G.723

DATA
- T.120

OTHER STANDARDS
- H.225
- ISDN Q.931
- H.221
- H.281 (H.320 only)

REGULATORY APPROVALS
EMI Compliance CE
- US FCC Class B compliant
- Europe EN55022 Class B
- Australia EMI (AS3548)

Safety
- US UL 1950
- Canada CSA 225
- Europe EN60950
  EN41003 ISDN

EMC
- Europe EN50082-1

Operating Temperature
- 0 to 50 degrees C.

Power
- +5v +/- 5% 2.0 Amps (Max)
- +12v +/- 5% 250 mA (Max)
- -12v +/- 5% 250 mA (Max).

Includes Microsoft Internet Explorer

Featuring AVP™ Technology From microelectronics group Lucent Technologies

BACKPLATE CONNECTIONS

Phoneset Definition RJ-11

Pin#	Signal	Description
2	TIP1	Telephone Supply
3	RING1	Phone Return/Signal

Audio Output Signal Definition 3.5mm

Pin#	Signal	Description
TIP	AUDIO_OUT_R	Line level or Speaker output
RING	AUDIO_OUT_L	Line level or Speaker output

Camera/Audio/Video Signal Definition DB-15

Pin#	Signal	Description
1	CAMERA_POWER5	+5V @500 mA current limited
2	GND	
3	CAMERA MIC IN	LINE LEVEL
4	Y/COMPOSITE_IN1	Composite or S-video input
5	CHROMA_IN2	S-video chroma input
6	HEADSET_SPK	Headset speaker
7	LINE_IN	Line-level audio input
8	HEADSET_MIC	Headset mic
9	CAMERA_POWER12	+12V @500 mA current limited
10	GND	
11	CHROMA_IN1	S-video chroma input
12	GND	
13	Y/COMPOSITE_IN2	Composite or S-video input
14	GND	
15	GND	

FIGURE: View of Z350 Backplate connections

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