ESCUELA LATINOAMERICANA DE REDES

UNIVERSIDAD DE LOS ANDES
MERIDA - VENEZUELA
(2 AL 20 NOVIEMBRE, 1992)

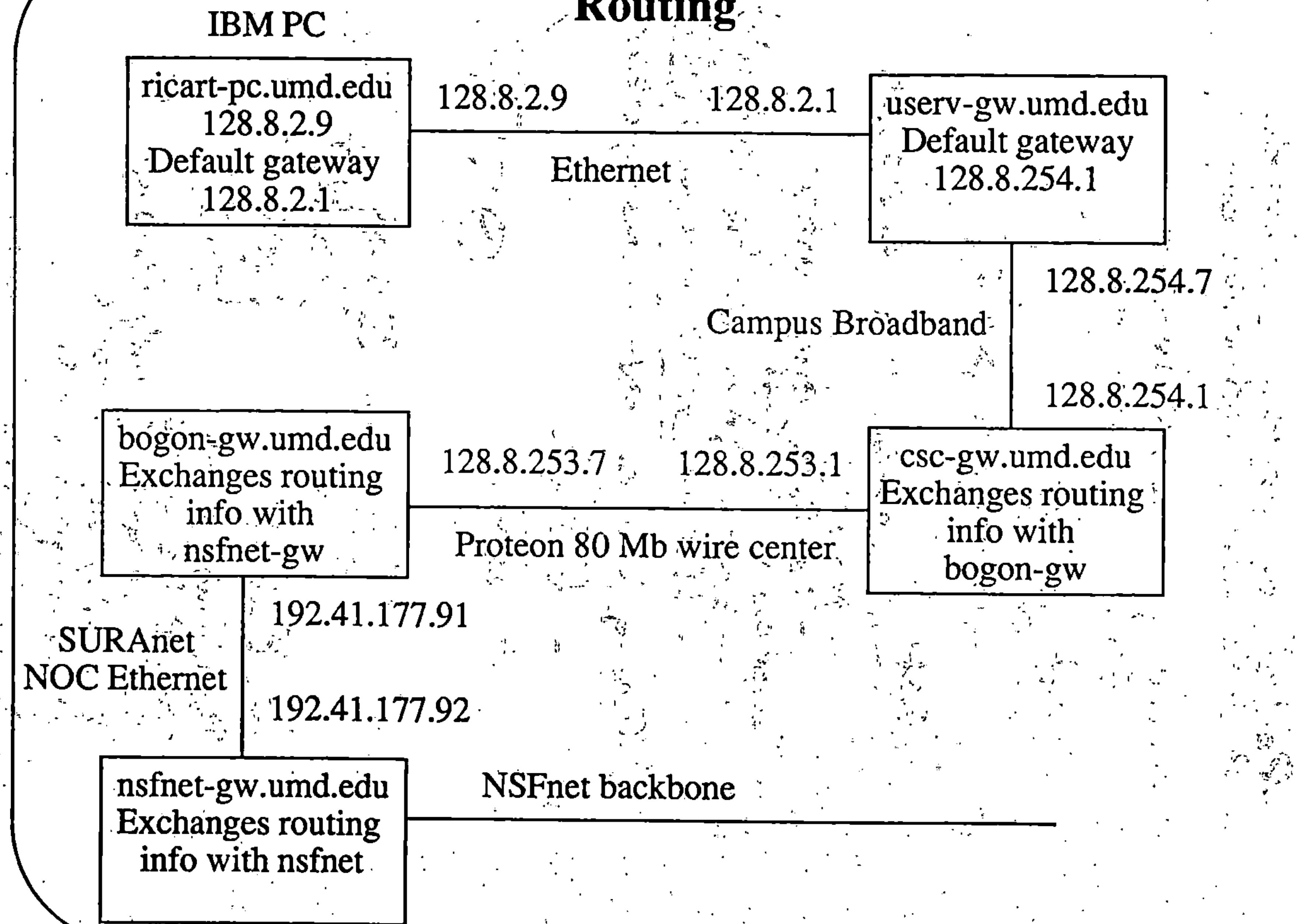
NC23

ENRUTADORES, PUENTES, CABLEADO Y VIDEO CONFERENCIA

GLENN RICART

SURANET - MARYLAND
USA

Routing


IBM PC
ricart-pc.umd.edu
128.8.2.9
Default gateway
128.8.2.1
128.8.2.9
128.8.2.1
Ethernet
userv-gw.umd.edu
Default gateway
128.8.254.1
128.8.254.7
Campus Broadband
128.8.254.1
bogon-gw.umd.edu
Exchanges routing
info with
nsfnet-gw
128.8.253.7
128.8.253.1
csc-gw.umd.edu
Exchanges routing
info with
bogon-gw
Proteon 80 Mb wire center
192.41.177.91
SURAnet
NOC Ethernet
192.41.177.92
nsfnet-gw.umd.edu
Exchanges routing
info with nsfnet
NSFnet backbone

IP Routing

- Packet by packet - survivable
- Packets source/destination only
- Route by network number
  examples ncart pc netstat
- Static routes
  - PCs
  - No alternate paths
- RIP
  - Advertises hop distance
  - Max 15
  - Identify end nodes
- Autonomous systems
  - Single administrative authority
  - Like vendor equipment / RIP
- Peering between autonomous systems
  - EGP
  - BGP

OSPF

Open Shortest Path First

Loops
Time-to-live
Believing routes
ICMP Re-directs
Routing updates & link throughput
Designing default routes
Asymmetrical routes
Policy routing
Multicast routing

```
% traceroute merlin.ciens.ula.ve
traceroute to merlin.ciens.ula.ve (150.185.128.1), 30 hops max, 40 byte packets
 1  csc2hub-gw (128.8.10.9)  10 ms  10 ms  20 ms
 2  sura8-umd-c1.sura.net (128.167.104.1)  10 ms  10 ms  0 ms
 3  nss-SURA-eth.sura.net (192.80.214.247)  20 ms  10 ms  10 ms
 4  nss-SURA-eth.sura.net (192.80.214.247)  10 ms !N  20 ms !N  20 ms !N
% man nslookup
```

```
traceroute to dino.conicit.ve (150.188.1.10), 30 hops max, 40 byte packets
 1  csc2hub-gw (128.8.10.9)  30 ms  0 ms  10 ms
 2  sura8-umd-c1.sura.net (128.167.104.1)  10 ms  30 ms  20 ms
 3  en-0.enss136.t3.nsf.net (192.80.214.248)  10 ms  10 ms  20 ms
 4  t3-1.cnss58.t3.nsf.net (140.222.58.2)  10 ms  20 ms  20 ms
 5  t3-3.cnss56.t3.nsf.net (140.222.56.4)  10 ms  10 ms  10 ms
 6  t3-0.cnss32.t3.nsf.net (140.222.32.1)  10 ms  20 ms  20 ms
 7  t3-0.cnss33.t3.nsf.net (140.222.33.1)  10 ms  10 ms  30 ms
 8  t3-0.enss137.t3.nsf.net (140.222.137.1)  30 ms  20 ms  20 ms
 9  pax-gateway.jvnc.net (192.12.211.75)  50 ms  30 ms  30 ms
10  * 150.188.2.1 (150.188.2.1)  5380 ms  5640 ms
11  * dino.conicit.ve (150.188.1.10)  4900 ms  3430 ms
% !!
```

```
% traceroute ivic.ivic.ve
traceroute to ivic.ivic.ve (150.188.4.2), 30 hops max, 40 byte packets
 1  csc2hub-gw (128.8.10.9)  10 ms  10 ms  10 ms
 2  sura8-umd-c1.sura.net (128.167.104.1)  10 ms  10 ms  10 ms
 3  en-0.enss136.t3.nsf.net (192.80.214.248)  10 ms  10 ms  10 ms
 4  t3-1.cnss58.t3.nsf.net (140.222.58.2)  10 ms  10 ms  20 ms
 5  t3-3.cnss56.t3.nsf.net (140.222.56.4)  10 ms  10 ms  10 ms
 6  t3-0.cnss32.t3.nsf.net (140.222.32.1)  20 ms  20 ms  10 ms
 7  t3-0.cnss33.t3.nsf.net (140.222.33.1)  10 ms  10 ms  10 ms
 8  t3-0.enss137.t3.nsf.net (140.222.137.1)  20 ms  20 ms  20 ms
 9  pax-gateway.jvnc.net (192.12.211.75)  30 ms  30 ms  30 ms
10  150.188.2.1 (150.188.2.1)  3070 ms  4150 ms  4620 ms
11  dino.conicit.ve (150.188.1.10)  4140 ms  3010 ms  2770 ms
12  * * *
13  * * *
14  * * *
15  * * *
16  * * *
17  * * *
18  * * *
19  * * *
20  150.188.4.2 (150.188.4.2)  3380 ms !  3230 ms !  3270 ms !
%
```

Bridges & Routers

		Creates
Repeater	level 1	one logical medium
Bridge	level 2	one logical IP-number network
Router	level 3	one internet

	Connects	Forwards	Latency
Repeater	Stars	Bits	Very Low
Bridge	Spanning trees	~~Packets~~ Frames	Low
Router	Arbitrary	Re-written packets	Medium

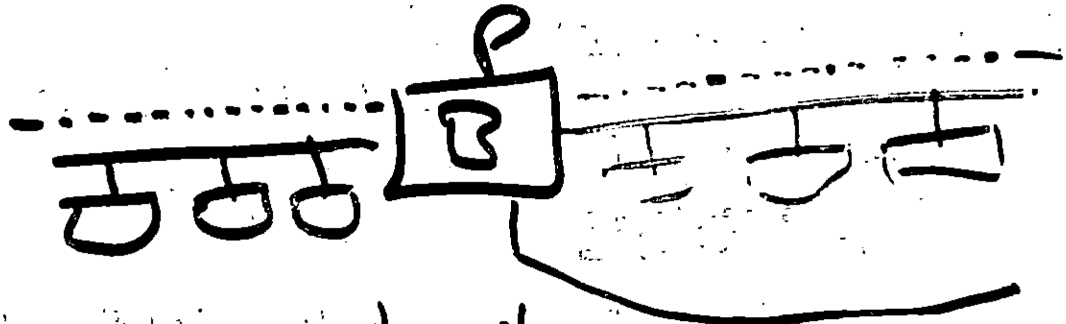
	Protocols	Firewall
Repeater	Any	None
Bridge	Framed packets	Filters
Router	Known protocols	Chks packets

Advantages

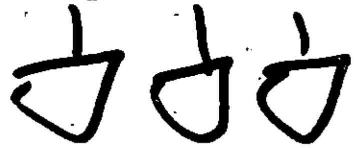
Bridges	Routers	Brouters
Fast IP + DECNET + LAT + ... Isolates traffic	Rich topology Minimizes wasted traffic Don't have to trust subnets	All except best of speed

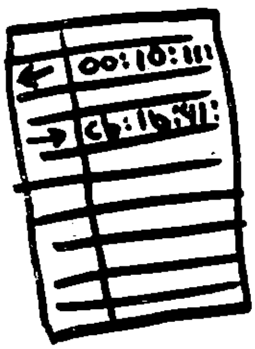
Bridges

- Extend networks beyond repeater limits or ~~switch~~ change media
- Filters traffic, increasing capacity

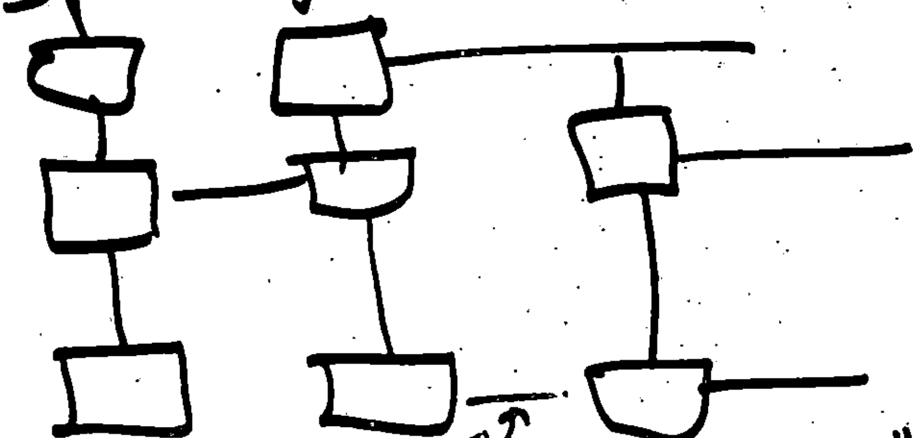


- Learning bridges





- Spanning trees



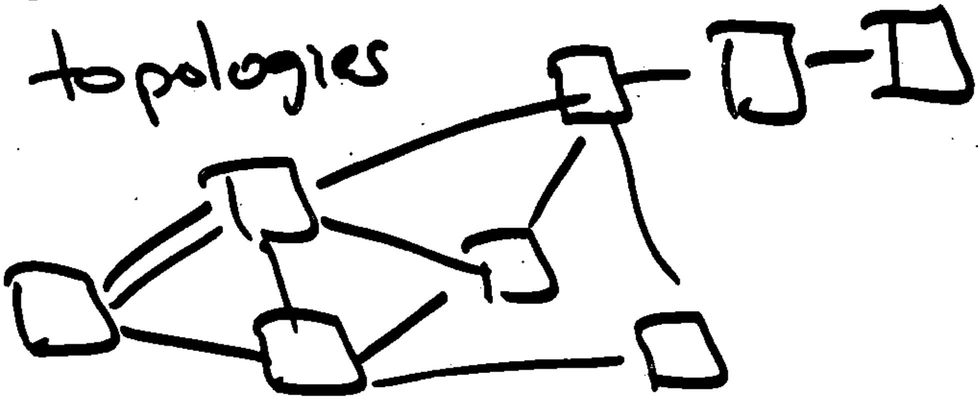
Backup link not normally used

Router interfaces

- Serial line
- Dial-up line
- SMDS (IEEE 802.6)
- Ethernet
- Token Ring (4Mb/s or 16Mb/s)
- FDDI
- ATM (Asynchronous transfer mode)
- FOIRL - Fiber Optic inter-repeater link

Routers

- Interconnect networks
- Routes, doesn't broadcast, unknown packets
- Does internal (~~to~~ in AS) or exterior (to another AS) routing using agreed-upon protocols
- Uses arbitrary, redundant topologies



- Configuring
  - Protocols
  - Interfaces
  - Buffer sizes
  - Password
  - Logging
  - Statistics

```
; Authority file for < ula.ve > zone
;
@        SOA     merlin.ciens.ula.ve.    hostmaster.merlin.ciens.ula.ve. (
                  9210280        ; Serial
                    86400        ; Refresh 1 day
                     3600        ; Retry 1 hour
                   432000        ; Expire 5 days
                    86400)       ; TTL
                 IN       NS     mozart.ing.ula.ve.
                 IN       NS     merlin.ciens.ula.ve.
                 IN       NS     dino.conicit.ve.

                 IN       MX     10 merlin.ciens.ula.ve.
                 IN       MX     50 dino.conicit.ve.
                 IN       MX     200 merlin.ciens.ula.ve.
;
; hosts listed alphabetically
;
adm              IN       NS     merlin.ciens.ula.ve.
ciens            IN       NS     merlin.ciens.ula.ve.
                 IN       MX     10 merlin.ciens.ula.ve.
                 IN       MX     50 dino.conicit.ve.
                 IN       MX     200 merlin.ciens.ula.ve.
ing              IN       NS     mozart.ing.ula.ve.
                 IN       NS     merlin.ciens.ula.ve.
faces            IN       NS     merlin.ciens.ula.ve.
med              IN       NS     merlin.ciens.ula.ve.
rector           IN       NS     merlin.ciens.ula.ve.
serbi            IN       NS     merlin.ciens.ula.ve.
```

```
> ls ula.ve
[merlin.ciens.ula.ve]
Host or domain name            Internet address
 ula.ve                         server = mozart.ing.ula.ve                  86400
 mozart.ing.ula.ve              150.185.146.1                     120
 ula.ve                         server = merlin.ciens.ula.ve                86400
 merlin.ciens.ula.ve            150.185.128.1                     86400
 ula.ve                         server = dino.conicit.ve                    86400
 dino.conicit.ve                150.188.1.10                      901
 ula.ve                         150.188.7.2                       901
 ciens.ula.ve                   server = merlin.ciens.ula.ve                86400
 merlin.ciens.ula.ve            150.185.128.1                     86400
 ing.ula.ve                     server = mozart.ing.ula.ve                  86400
 mozart.ing.ula.ve              150.185.146.1                     120
 ing.ula.ve                     server = merlin.ciens.ula.ve                86400
 merlin.ciens.ula.ve            150.185.128.1                     86400
 faces.ula.ve                   server = merlin.ciens.ula.ve                86400
 merlin.ciens.ula.ve            150.185.128.1                     86400
 serbi.ula.ve                   server = merlin.ciens.ula.ve                86400
 merlin.ciens.ula.ve            150.185.128.1                     86400
 med.ula.ve                     server = merlin.ciens.ula.ve                86400
 merlin.ciens.ula.ve            150.185.128.1                     86400
 rector.ula.ve                  server = merlin.ciens.ula.ve                86400
 merlin.ciens.ula.ve            150.185.128.1                     86400
 adm.ula.ve                     server = merlin.ciens.ula.ve                86400
 merlin.ciens.ula.ve            150.185.128.1                     86400
```

```
 dino.conicit.ve
erver:   merlin.ciens.ula.ve
ldress:   150.185.128.1

es_mkquery(0, dino.conicit.ve, 1, 1)
-----------
endRequest(), len 33
   HEADER:
       opcode = QUERY, id = 43, rcode = NOERROR
       header flags:  query, want recursion
       questions = 1,  answers = 0,  auth. records = 0,  additional = 0

   QUESTIONS:
       dino.conicit.ve, type = A, class = IN

-----------
-----------
ot answer (132 bytes):
   HEADER:
       opcode = QUERY, id = 43, rcode = NOERROR
       header flags:  response, want recursion, recursion avail.
       questions = 1,  answers = 1,  auth. records = 2,  additional = 2

   QUESTIONS:
       dino.conicit.ve, type = A, class = IN
   ANSWERS:
   ->  dino.conicit.ve
       type = A, class = IN, ttl = 538, dlen = 4
       inet address = 150.188.1.10
   AUTHORITY RECORDS:
   ->  conicit.ve
       type = NS, class = IN, ttl = 538, dlen = 2
       nameserver = dino.conicit.ve
   ->  conicit.ve
       type = NS, class = IN, ttl = 538, dlen = 15
       nameserver = nisc.jvnc.net
   ADDITIONAL RECORDS:
   ->  dino.conicit.ve
       type = A, class = IN, ttl = 538, dlen = 4
       inet address = 150.188.1.10
   ->  nisc.jvnc.net
       type = A, class = IN, ttl = 150623, dlen = 4
       inet address = 128.121.50.7

------------
Non-authoritative answer:
Name:    dino.conicit.ve
Address:  150.188.1.10
```

Network Management

- Each layer has its own diagnostics/information
- Network management stations
- Exception reporting
  - Timely
  - Can contribute to network failure
- Polling
  - Network management station determines relevance
- Management Information Base (MIB)
  - Definitions of available data

MIB Structure

Defined by SMI - Structure of Management Information
Definitions in Abstract Syntax Notation 1 - ASN.1
The database defined by the SMI is the MIB - Management Information Base
Names of objects look like

- 1.3.6.1.2.1.1.1
- ISO (1) Identified-organization (3) DoD (6) Internet (1) Management (2) Counter (1) ....

OSI Network Management Standards

10164-1 Object Management
10164-2 State Management (enabled/disabled, active/busy, locked/unlocked, etc.)
10164-3 Relationship Management (direct/indirect, symmetric/asymmetric)
10164-4 Error Reporting (critical, major, minor, warning, indeterminate)
10164-5 Management Service Control - filtering events
2886 Configuration Management
3312 Fault Management
3313 Performance Management
3338 Security and Audit Management
3314 Accounting Management
3309 Log Control Management

OSI Network Management (ISO 7498-4)

- Done at applications level
- Systems Management Application Entity (SMAE)
  - Exchanges Management application data units (MAPDUs) with other SMASEs (Systems Management Application Service Elements)
  - Communications may be via Common Management Information Service Element (CMISE)
  - CMISE relies on Remote Operations Service Element (ROSE) and Association Control Service Element (ACSE)
- Common Management Information Service (CMIS) (ISO 9595)
  - ASCE: Initialize, terminate, abort
  - ROSE: event-report, get, set, action, create, delete
- Common Management Information Protocol (CMIP) (ISO 9596)
  - Abstract Syntax Notation 1 - ASN.1 encoding of CMIS

Who Wires

- Do-it-yourself
  - Advantages
    - Inexpensive
    - Quick to do
  - Disadvantages
    - Violated standards may not be immediately apparent
    - Asbestos
    - Appearance
    - Fire and safety codes easily violated
- Professional installation
  - Advantages
    - Installation backed by installer
    - Avoid disadvantages listed above
  - Disadvantages
    - Cost
    - Time
    - Very few firms can do anything but twisted pair well

Wiring the Network

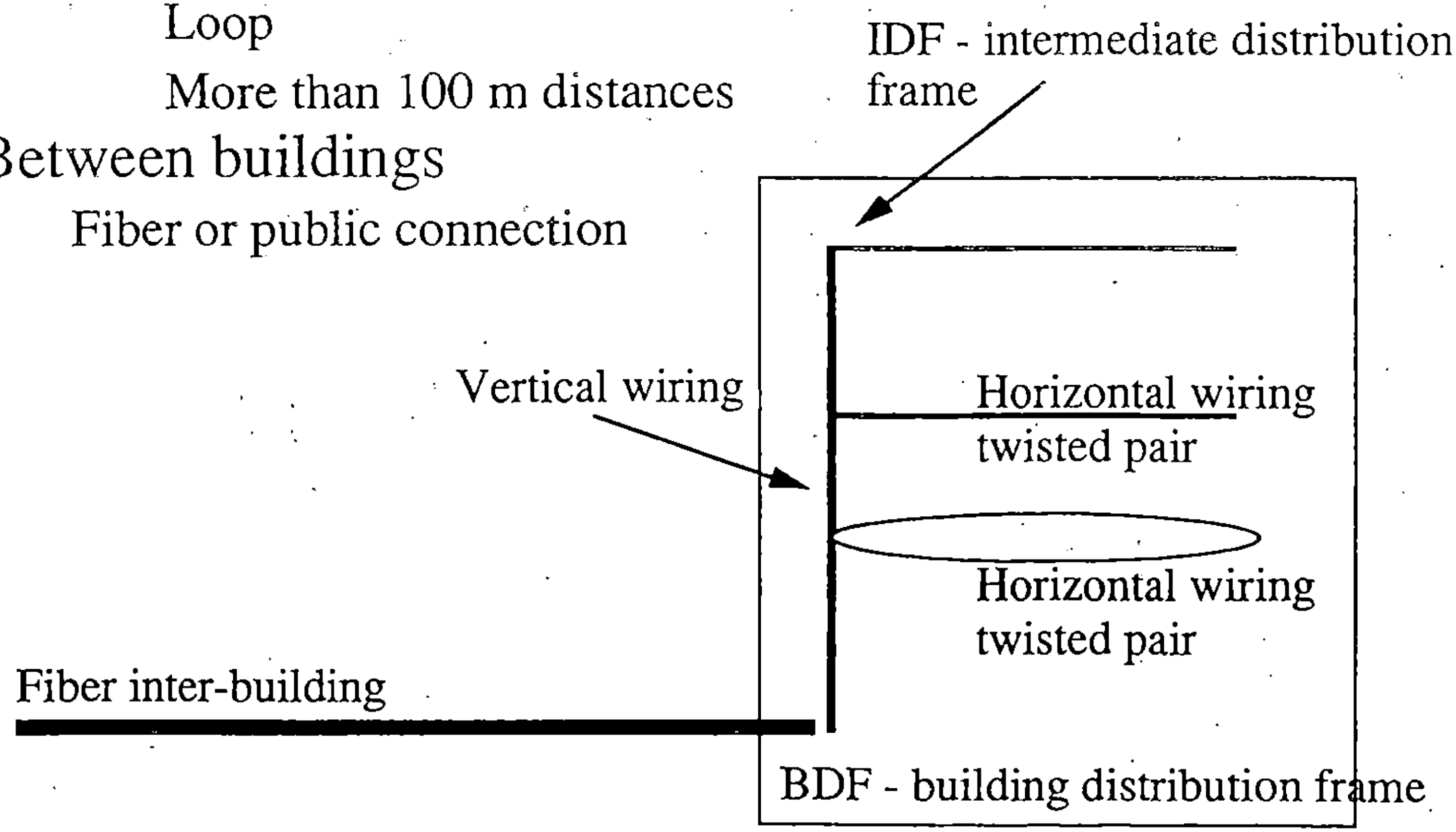
- Who wires
- Standards
- Topology
- Wireless LANS

Wiring Standards

Coaxial cable	500 + Mb/s	40 US cents/m	Costly to install
Sheielded twisted pair (STP) copper	200+Mb/s	25 US cents/m	IBM standard
Unshielded twisted pair (UTP) copper	100 Mb/s	15 US cents/m	Market leader Already installed
Fiber	10 Gb/s +	50 US cents/m	Expensive to terminate / interface

Wiring Topology

- Horizontal
  - Recommended: Home run - 100 m maximum with UTP
  - Also possible
    - Loop
    - More than 100 m distances
- Between buildings
  - Fiber or public connection



Wireless LANS

Capabilities

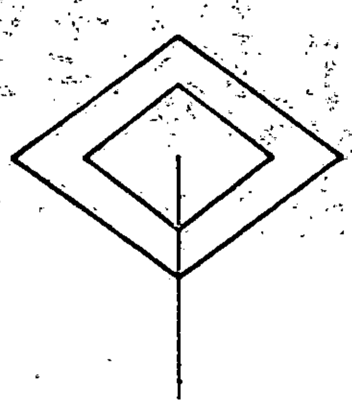
- 1-10 Mb/s for up to 16-32 stations

Advantages

- No building wiring changes necessary
- Ideal for temporary setups

Disadvantages

- Higher cost than fixed networking
- Limited distances
- Interference with other systems
- Easily intercepted



Video Teleconferencing

Applications
- Frequent meetings
- Travel time saved
- Education

Bandwidth / Quality Tradeoff

Classes
- High bit rate T1+
- Low bit rate 56 Kb/s - 384 Kb/s
- Telephone 14.4 Kb/s
- Packet

Components and arrangement

Switching

Standard H.261 = p x 64

CIF - Common Interchange Format

QCIF - Quarter CIF

Vendors

Compression Labs

PictureTel

Videotelecom

NEC

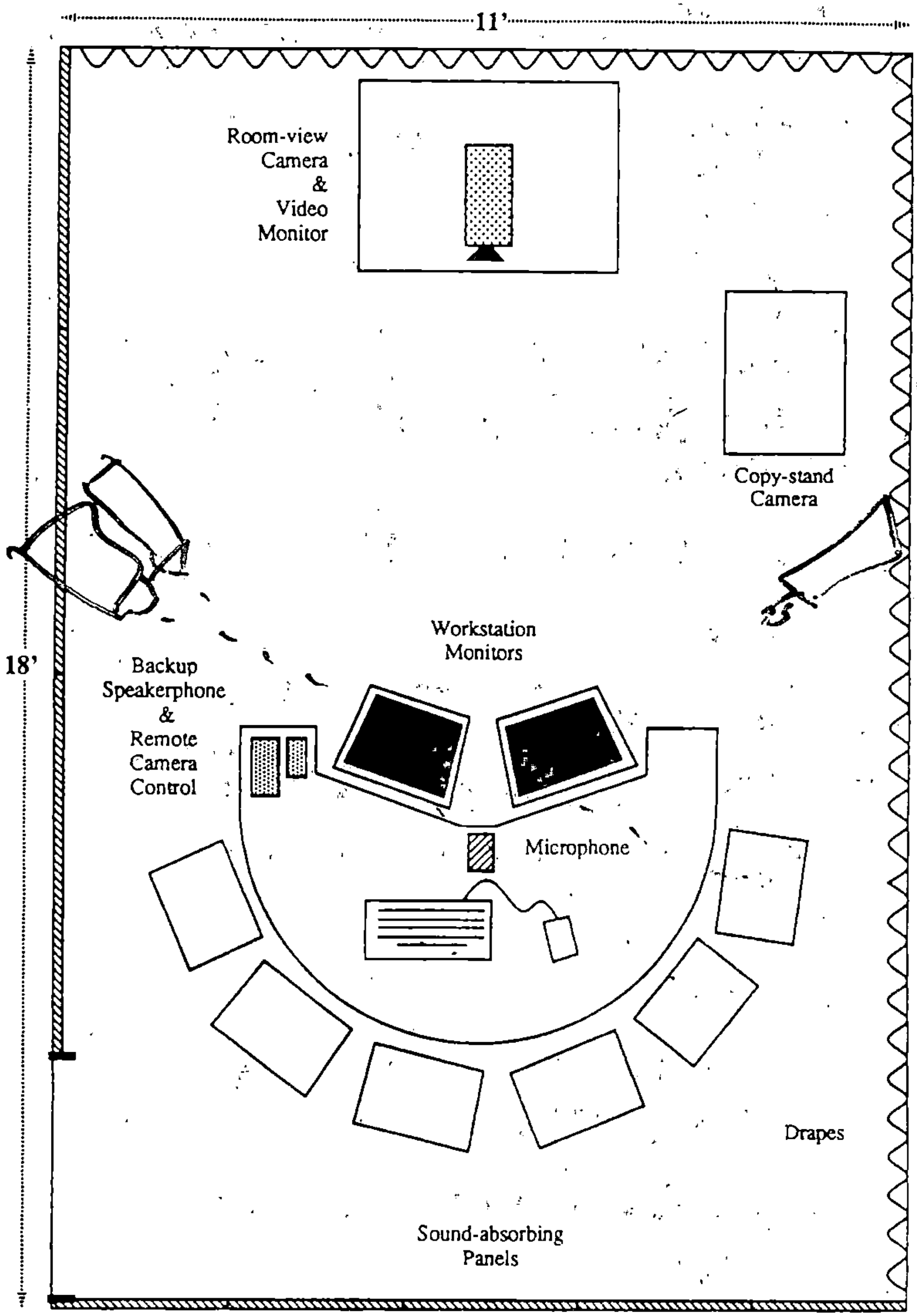
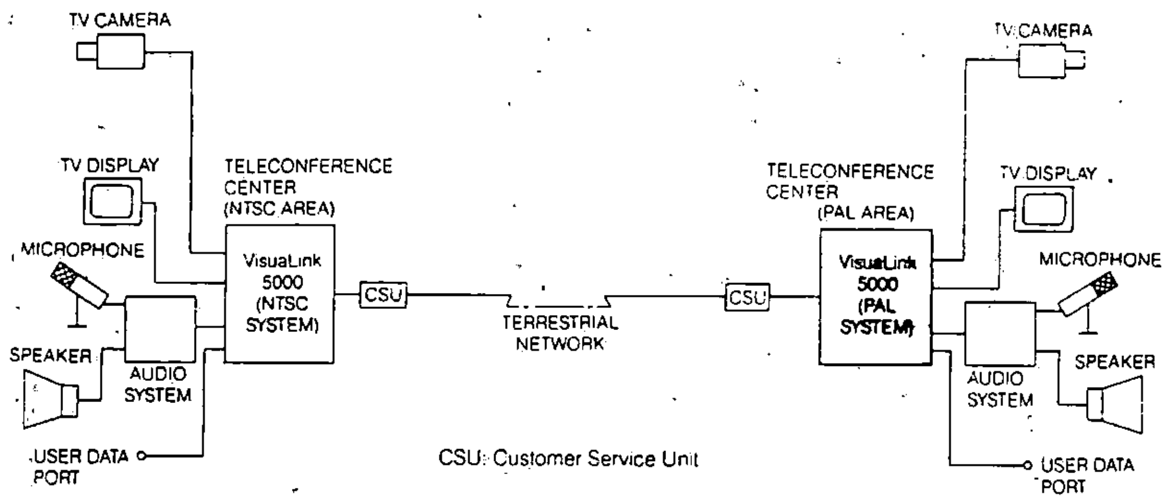


Figure 3. ISI Conference Room

A. International Teleconferencing (full duplex)

The illustration below demonstrates how users on different continents can hold a video conference. The VisuaLink 5000 digital television codec provides the required conversion between NTSC (National Television Standards Committee) and PAL (Phase Alternate Line) formats to enable international teleconferencing.



CSU: Customer Service Unit

B. Education Network System (simplex)

In this application, instructors can transmit audio and video to far away classrooms to provide remote education. The transmitting side requires the VisuaLink 5000 encoder, camera, and microphone for transmission; the receiving end uses the VisuaLink 5000 decoder, monitors and speakers. This application can easily be configured for duplex transmission between the instructor or main site and the remote facilities.

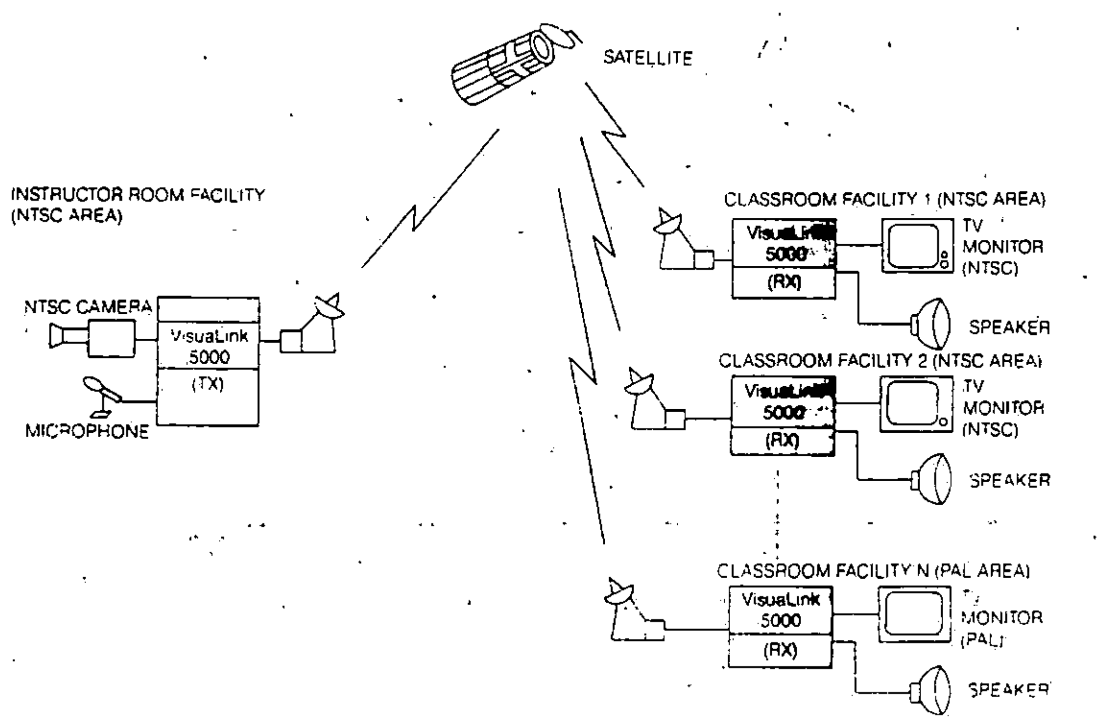


FIGURE 4.

Comparison of Picture Quality
(a) Original
(b) Coded Picture—Format: QCIF, frame rate: 15, bit rate 64 kbit/s
(c) Coded Picture—Format: CIF, frame rate: 10, bit rate: 64 kbit/s
(d) Coded Picture—Format: CIF, frame rate: 15, bit rate 320 kbit/s
(e) Coded Picture—Format: CIF, frame rate: 30, bit rate: 1,472 kbit/s

Video Coding Algorithm

The basic objective of video coding is to reduce the bit rate by removing redundant information. There are two major categories of coding schemes, i.e., source coding and entropy coding. Source coding deals with source material and yields results which are lossy, i.e., picture quality is degraded. Source coding can be further divided into intraframe and interframe coding. Intraframe coding is used for the first picture and for later pictures after a change of scene. Interframe coding is for sequences of similar pictures, including those containing moving objects. Intraframe coding removes only the spatial redundancy within a picture, whereas interframe coding removes also the temporal redundancy between pictures. Entropy coding achieves bit-rate reduction by using the statistical properties of the signals and, in theory, is lossless. The CCITT H.261 video coding algorithm uses both the intraframe and interframe coding schemes.

A block diagram of the CCITT H.261 source encoder is shown in Figure 2. It is a hybrid of DCT (Discrete Cosine Transform) and DPCM (Differential Pulse Code Modulation) schemes with motion estimation [6, 8]. In intraframe mode, the DPCM is not operative. Every 8×8 block in a picture frame is transformed into DCT coefficients, linearly quantized, and then sent to the video multiplex coder. The same picture frame is also recovered (through the inverse quantizer and inverse transform) and stored in the picture memory for interframe coding.

During the interframe coding mode, the DPCM is in operation. The prediction is based on motion estimation by comparing every Macro Block (luminance only) of the current frame with the Macro Blocks in the neighborhood of the corresponding Macro Block in the previous frame. If the difference between the current and the predicted Macro Blocks is less than a certain threshold, no data is transformed for that Macro Block. Otherwise, the difference is DCT transformed, linearly quantized, and then sent to the video multiplex coder together with motion vector information. A loop filter can be switched on and off to improve picture quality by removing high-frequency noise when needed. The step size of the linear quantizer can be adjusted depending on the fullness of the transmission buffer of an encoder. When the transmission buffer is close to full, the step size will be increased so that less information needs to be coded. This, of course, will result in a degraded picture. On the other hand, the step size will be decreased to improve picture quality when the transmission buffer is not full.

To further increase coding efficiency, variable word-length entropy coding is used in the video multiplex coder which immediately follows the source coder. There are five variable word-length coding tables for the quantized DCT coefficients and various side information. The output of the video multiplex coder is sent to a transmission buffer, which regulates the flow of video information to a constant bit rate by controlling the step size of the linear quantizer.

Video Data Structure

One of the most important aspects of a video coding standard is to define a data structure so that a decoder can decode the received bit stream without any ambiguity. A simplified hierarchical structure with four layers of video data is shown in Figure 3.

Data for each picture consists of a picture header followed by data for GOBs. The picture header includes a 20-bit picture start code and other information such as video format (CIF or QCIF), temporal reference (frame number), etc.

The GOB layer consists of a GOB header followed by data for MBs. The GOB header includes a 16-bit GOB start code and other information such as the position of the GOB, and quantizer information for the GOB until overridden by any subsequent MB quantizer information, etc.

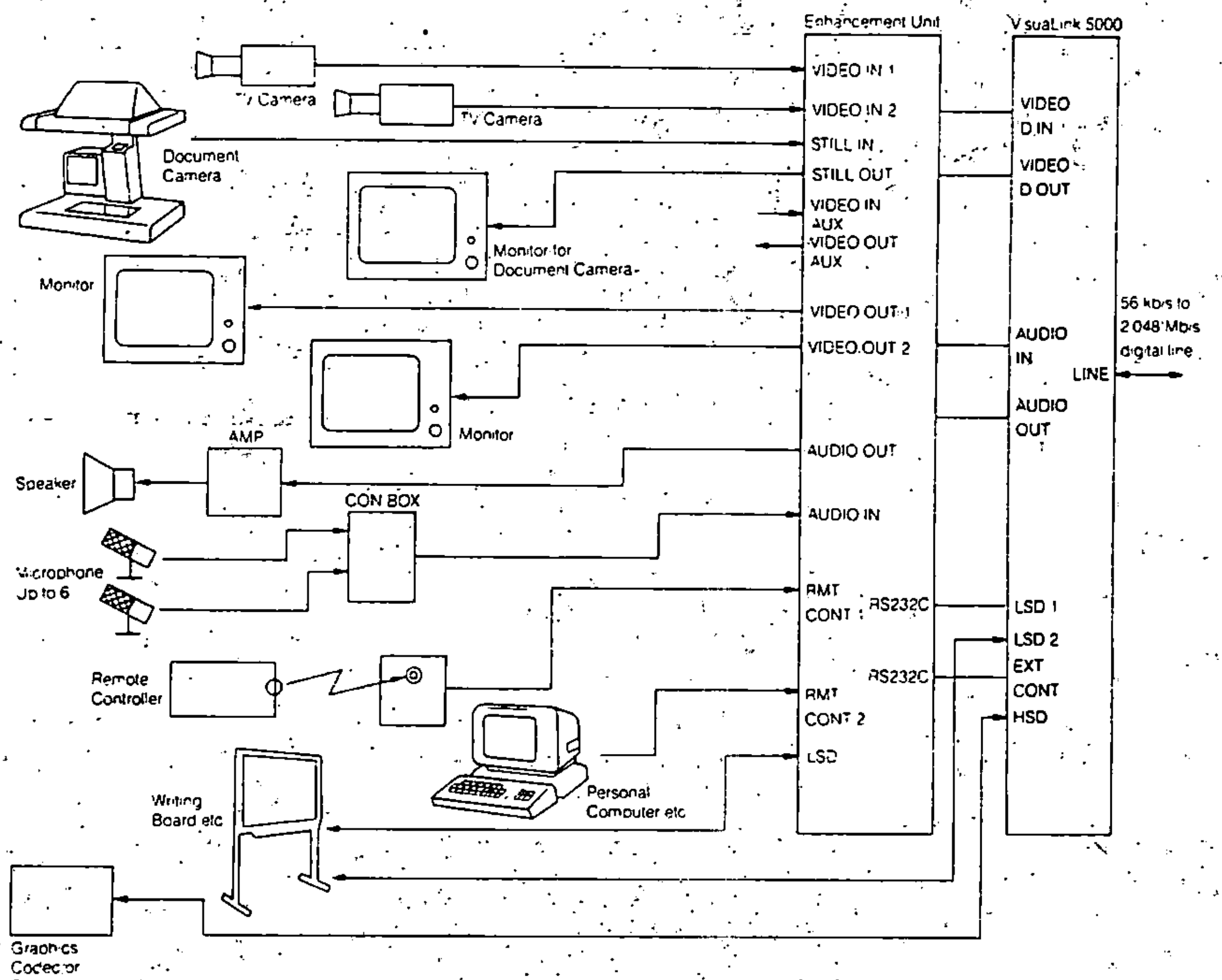
The MB layer consists of an MB header followed by data for Blocks. The MB header includes a variable length code (VLC) for the MB address. It is followed by a VLC for MB type indicating whether it is intraframe or interframe, with or without motion estimation and/or loop filter. Depending on a particular MB type, various combinations of video side information may follow. When motion estimation is accurate to within a given specification, no block data for DCT coefficients needs to be transmitted. It should also be noted that not every MB in a GOB needs to be

1000%

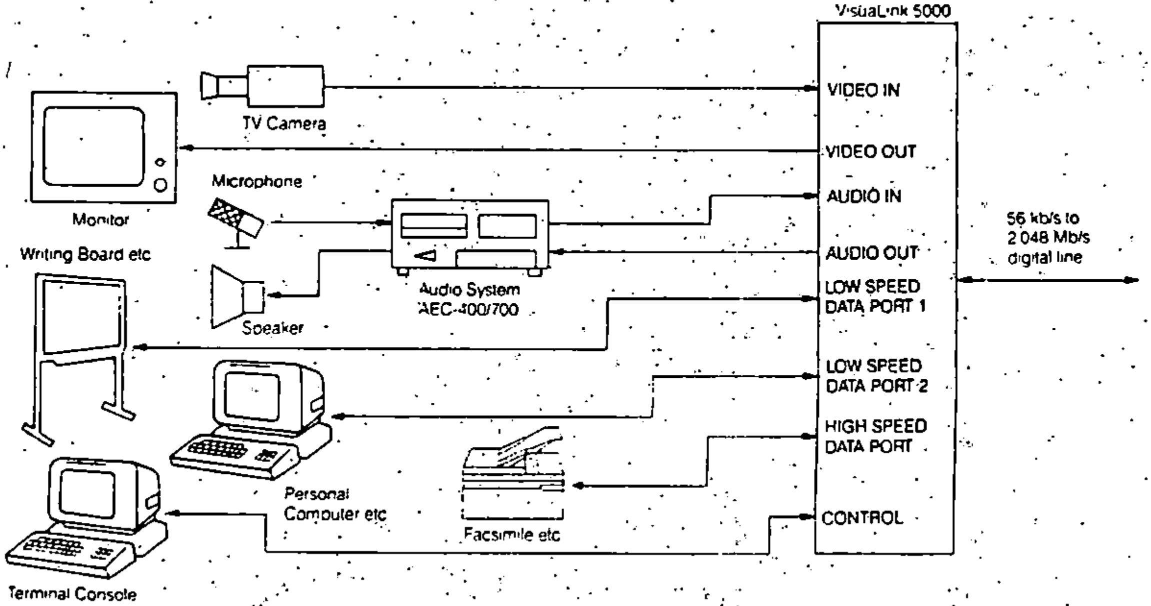
Fig. 13. Pictures representing the cases in Fig. 12. (a) The original. (b)-(e) show cases 1-4.

System Application

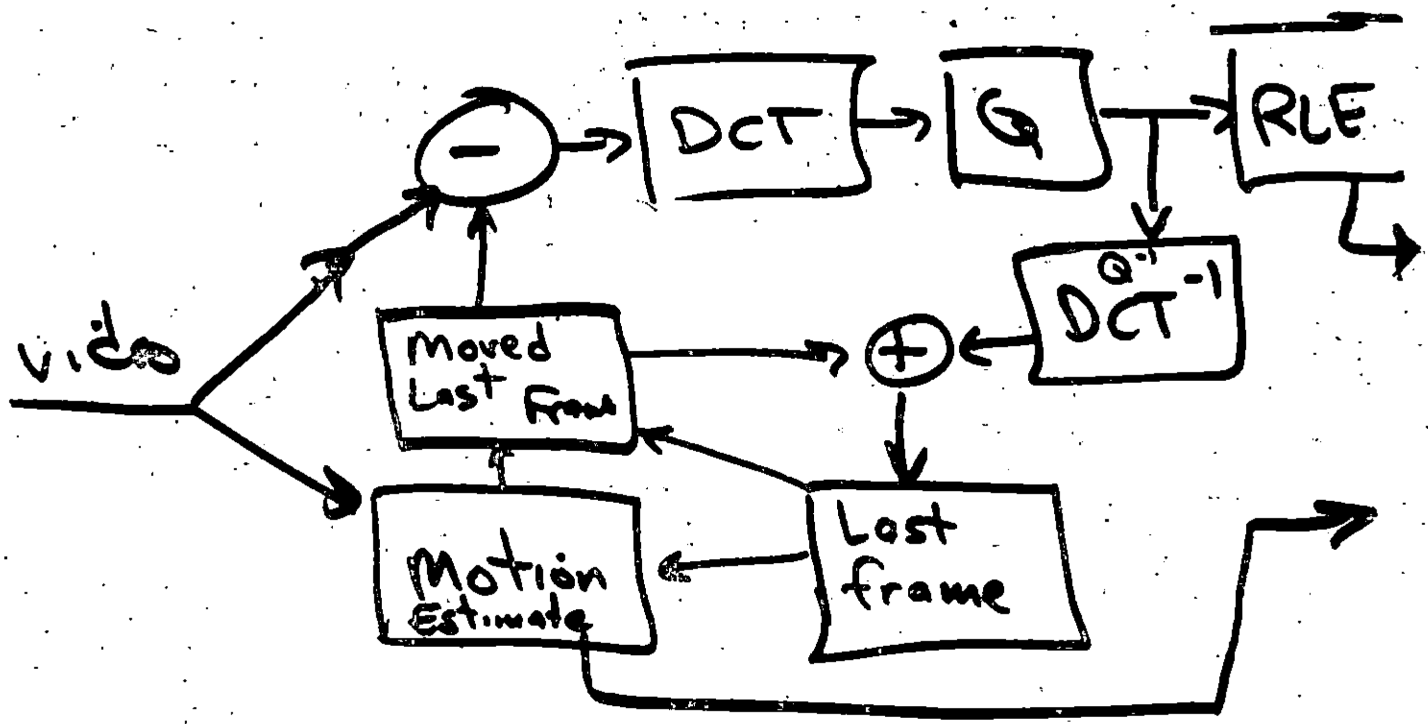
The VisuaLink 5000 simultaneously transmits motion video, audio (using NEC's AEC-400 or AEC-700 audio systems) and data signals such as facsimile over a 56 kb/s to 2.048 Mb/s digital transmission line. The figures below illustrate how the basic codec can be enhanced through simple software upgrades or module replacement to provide additional capabilities. These upgrades include graphics, audio echo canceller, encryption, and a multitude of other features. When integrated with NEC's advanced facsimile and audio systems, the VisuaLink 5000 efficiently transmits full-feature simultaneous video teleconferences, domestically or internationally.

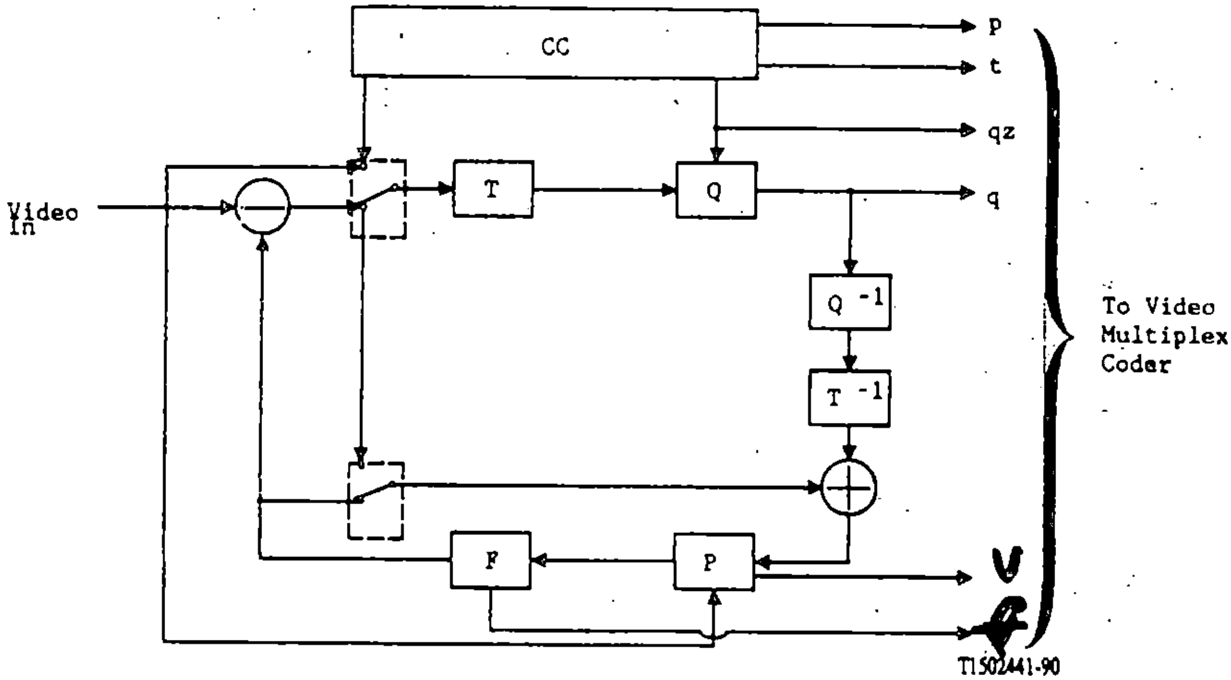


VisuaLink 5000 System Application with Enhancement Options



VisuaLink 5000 System Application without Enhancement Options


video
DCT
Q
RLE
Q^{-1}
DCT^{-1}
Moved
Last Frame
Motion
Estimate
Last
frame



T: Transform
Q: Quantizer
P: Picture Memory with motion compensated variable delay
F: Loop filter
CC: Coding control

p: Flag for INTRA/INTER
t: Flag for transmitted or not
qz: Quantizer indication
q: Quantizing index for transform coefficients
v: Motion vector
f: Switching on/off of the loop filter

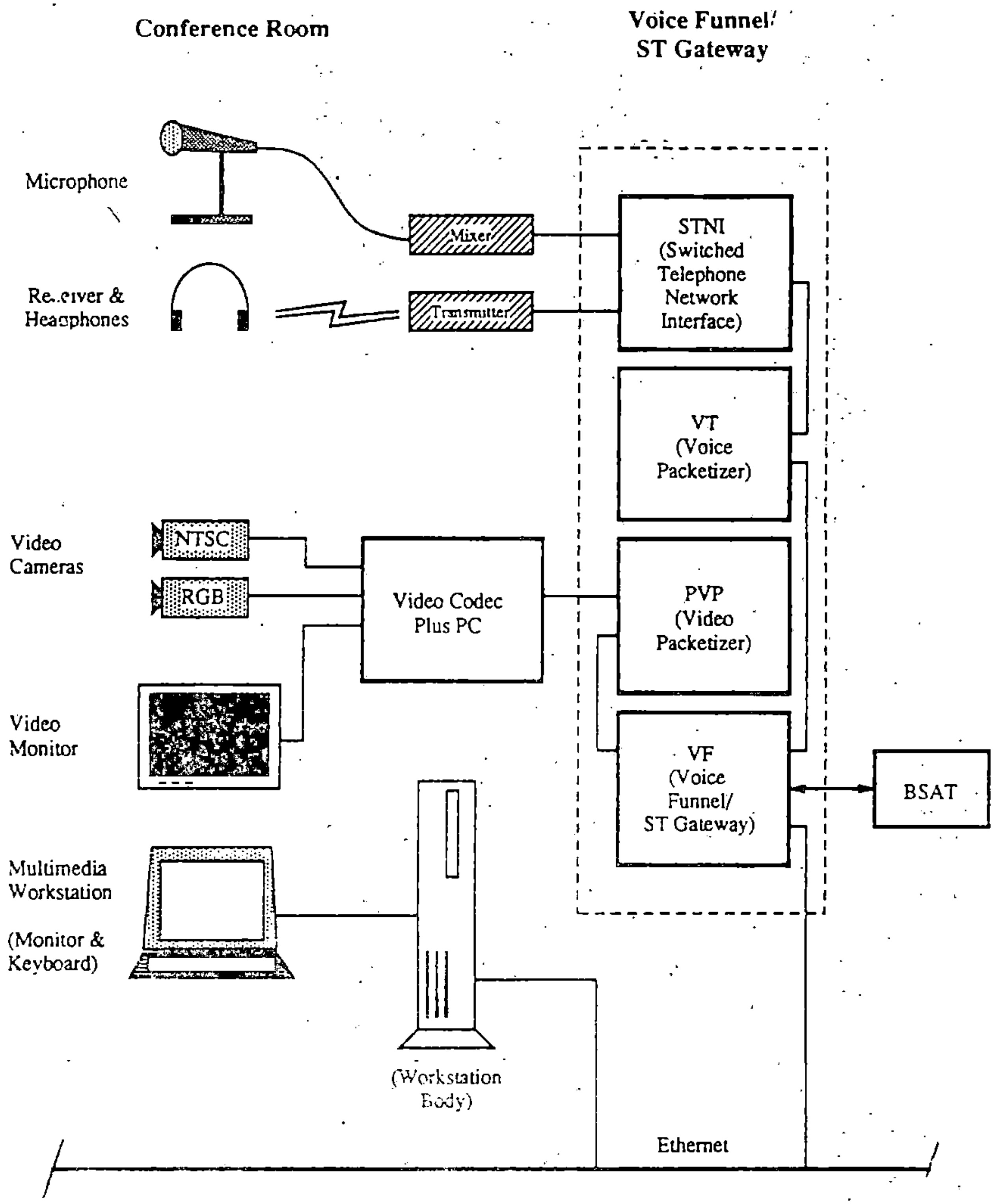
FIGURE 3/H.261

Source coder

3.2.2 Motion compensation

Motion compensation (MC) is optional in the encoder. The decoder will accept one vector per macroblock. Both horizontal and vertical components of these motion vectors have integer values not exceeding ± 15 The vector is used for all four luminance blocks in the macroblock. The motion vector for both colour difference blocks is derived by halving the component values of the macroblock vector and truncating the magnitude parts towards zero to yield integer components.

A positive value of the horizontal or vertical component of the motion vector signifies that the prediction is formed from pels in the previous picture which are spatially to the right or below the pels being predicted.



. re 1. Multimedia Conferencing System

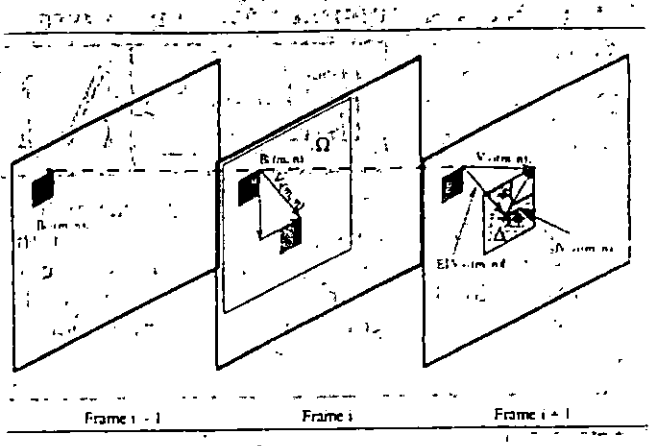


Figure 1: Inter-frame predictive block pattern searching scheme

Combined inter-block/inter-frame predictive searching can also be used to further reduce the searching complexity. In this case, the motion vectors of the refreshed frame are estimated by inter-block prediction scheme proposed in [3] and the motion vectors of subsequent frames are estimated by inter-frame prediction.

3. Inter-frame Predictive Motion Compensated Compression System

The inter-frame motion prediction scheme is tested for a "CAR" sequence. The video compression system we use for testing the proposed motion estimation scheme is shown in Figure 2. It is basically an inter-frame hybrid DPCM/DCT compression scheme. Due to its robustness and good performance, this scheme has been used in the CCITT H.261 codec for video telephony [1], in the CCITT MPEG video compressor for full-motion video [2], and in the General Instrument's Digicipher video codec for HDTV compression simulation [7]. The motion compensator is defined to be block-based, the specific motion searching scheme and error criterion are left open to implementors in the proposed draft standards. In most simulation studies, a full motion searching scheme is employed. In this paper, the proposed inter-frame predictive searching scheme is implemented and compared with the "optimal" full search scheme.

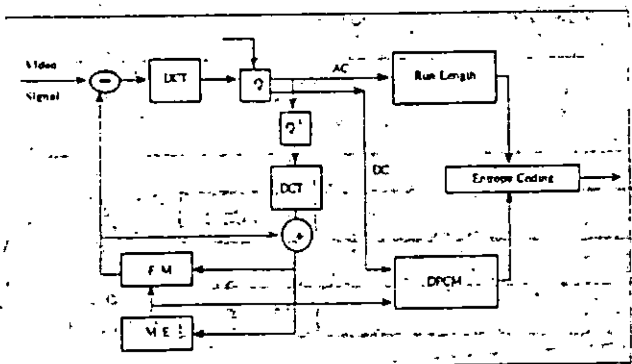


Figure 2: Block Diagram of Inter-frame motion-compensated hybrid DCT/DPCM video compression scheme

After motion compensation, the displaced difference frame is block DCT transformed and uniformly quantized. The quantization process takes advantage of human visual characteristics and coefficients are weighted prior to the uniform quantization. Then, the AC coefficients are zig-zag scanned and run-length coded. The DC coefficients of adjacent blocks are further DPCM coded to reduce the inter-block redundancy. Motion vectors are noiselessly coded and transmitted. All quantities are entropy-coded prior to transmission.

The "CAR" is a full-motion color video sequence in CCIR 601 format with 720 by 480 per frame, 16 bits per pixel in YUV format (or 24 bits in RGB format) and 60 fields interlaced per second. It is basically a fast camera panning sequence which is ideal for testing different motion compensation algorithms. Motion estimation is only implemented for the Y component, assuming that the U and V components have the same motion activity.

4. Experimental Results

Motion activities in both vertical and horizontal directions for the sequence "CAR", which are measured by the full-motion search scheme and the minimum absolute difference matching criterion, are shown from Figure 3(a) and 3(b) respectively. A block size of 8 by 8 and searching area of 16 by 16 are used for the measurement.

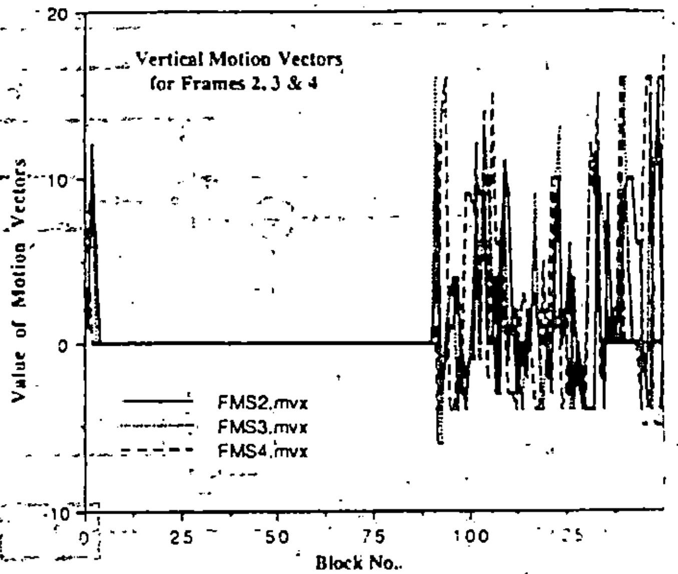


Figure 3(a): Motion Activities in the vertical direction for frame 2, 3 & 4 measured by full search.

It can be easily observed from Figure 3(a) & 3(b) that there is very slight motion in the vertical direction and very heavy motion associated with the horizontal direction. This is consistent with the actual video observation. The measurement results also indicate that consecutive video frames tend to have similar motion activities. In another word, the motion activity in one frame can be well predicted from the previous frame, which is the motivation for our inter-frame predictive motion estimation scheme.

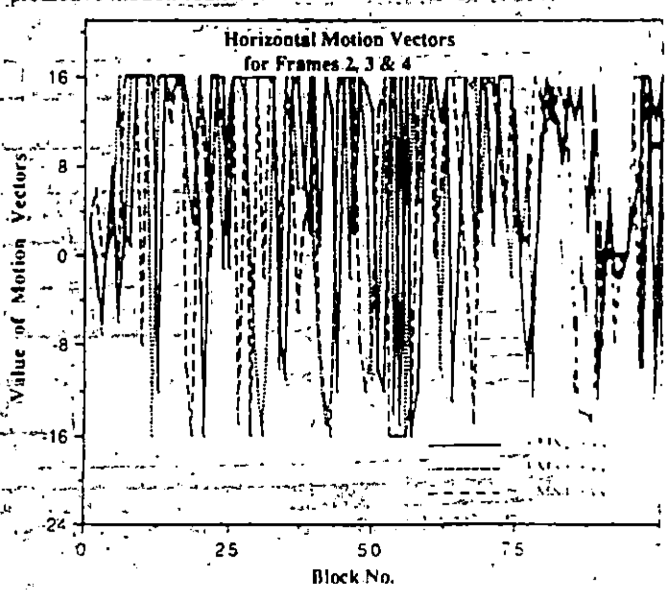


Figure 3(b): Motion Activities in the horizontal direction for video frame 2, 3 & 4 measured by full search

For $p \geq 6$, CIF may be used since there are more bits available to code a picture. Due to its increased resolution, CIF is more appropriate for videoconferencing applications.

For the video coding algorithm recommended by the CCITT, the CIF and QCIF are divided into a hierarchical block structure consisting of Pictures, Groups of Blocks (GOBs), Macro Blocks (MB), and Blocks. The composition of a Macro Block is shown in Figure 1. Each Macro Block is composed of four 8 × 8 luminance (Y) Blocks and two 8 × 8 chrominance (C_B and C_R) Blocks. A Group of Blocks is composed of 3 × 11 Macro Blocks. A QCIF Picture has 3 GOBs while CIF has four times that number. This elaborate hierarchical block structure is essential for the high-compression video coding algorithm which will be briefly described in the following section.

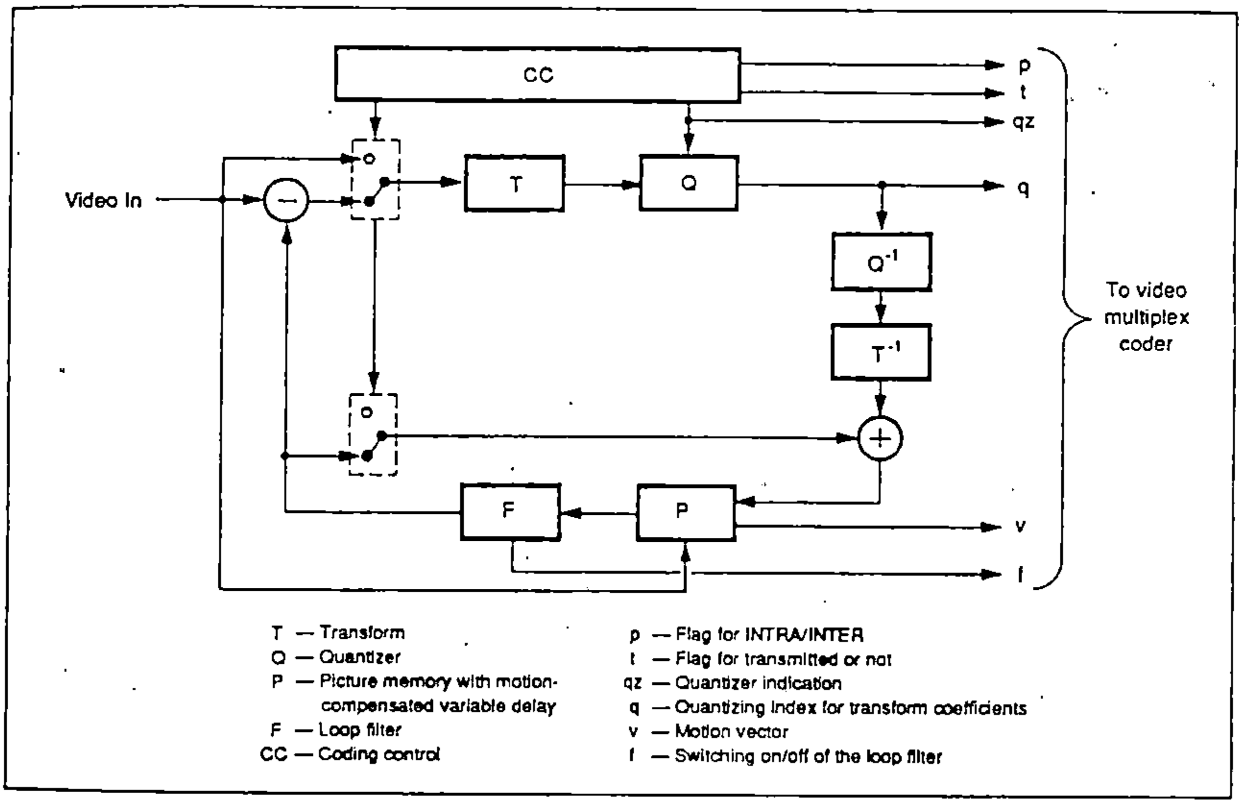


FIGURE 2.
Block Diagram of the Source Coder

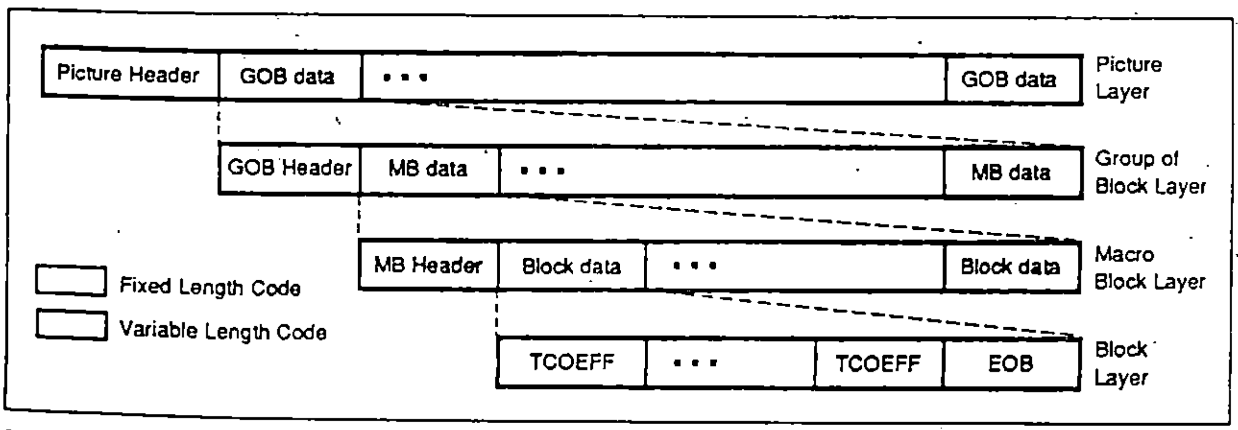
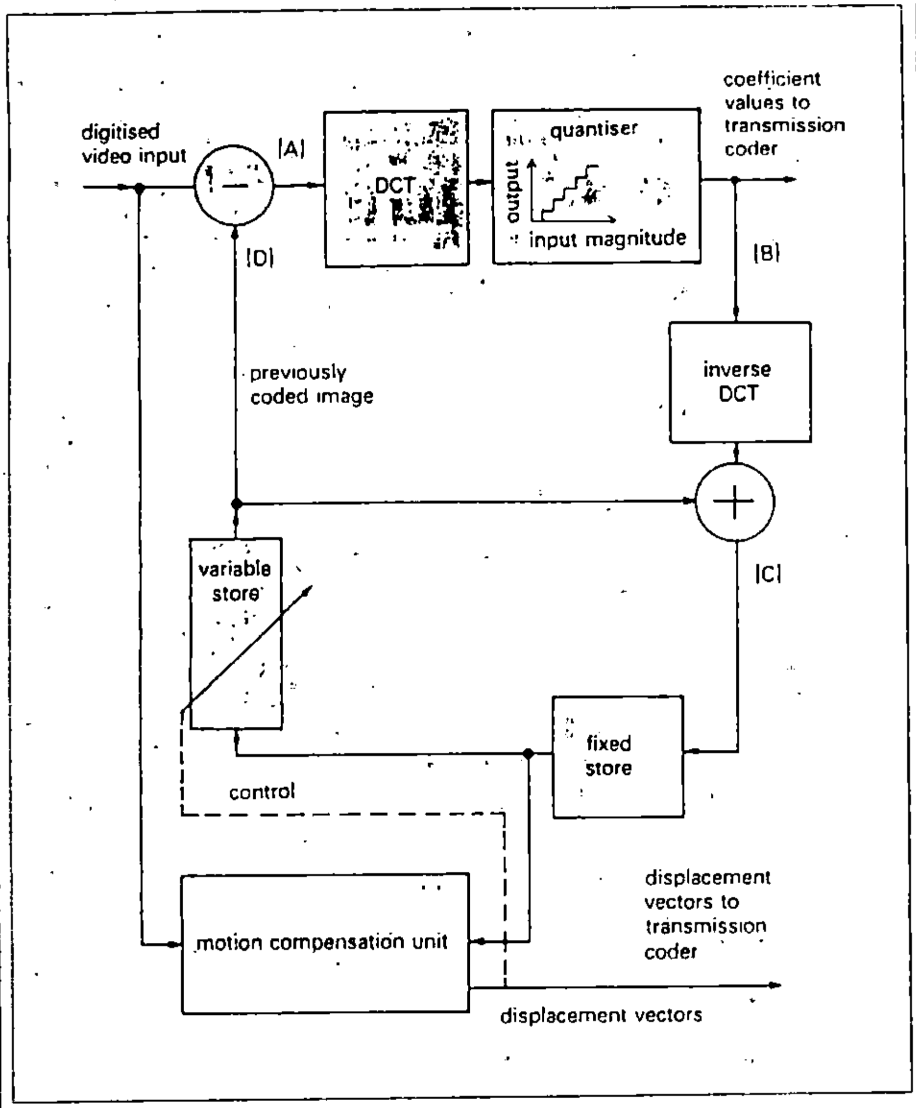


FIGURE 3.
A Simplified Data Structure of the Video Multiplex Coder



2 Basic block diagram of hybrid DPCM/DCT encoding scheme

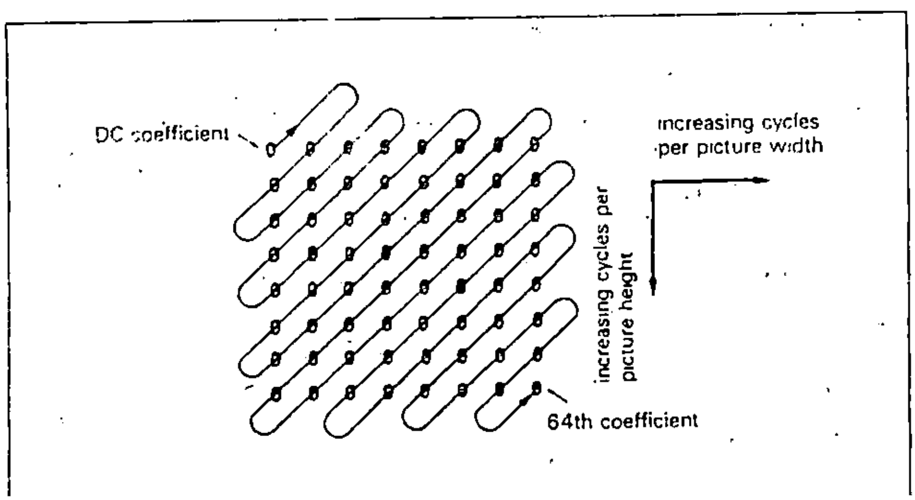
codecs to 'proprietary' specifications and thus effectively became locked-in to a single manufacturer. The lesson learnt from this less-than-ideal situation led to virtually all telecommunications operators and manufacturers of videoconference codec equipment coming together within the framework of a CCITT SGXV/1 Specialists Group.[2]

This Specialists Group, under Nippon Telegraph and Telephone Corporation (NTT) chairmanship, initially concentrated on achieving a standard for worldwide videoconferencing at 384 kbit/s and its multiples up to almost 2 Mbit/s. The target date for this standard was late 1988. The Group would have followed this with a standard for codecs at 1 and 2 · 64 kbit/s for ISDN applications. In the event, it was judged important to have the same algorithm for both bit rate ranges, so after a delay of one year a single $p \cdot 64$ kbit/s draft CCITT recommendation has resulted which covers all bit rates from 64 kbit/s up to 2 Mbit/s. It is expected that this draft CCITT standard H.261 will become a full recommendation by an accelerated procedure during July 1990. This article will consider the H.261 standard in more detail and describe equipment which will enable a range of new audio-visual services to become established.

2 The H.261 algorithm

During the five years of CCITT international collaboration to form the new standard H.261, many alternative picture coding algorithms were explored. Algorithms based on differential pulse code modulation (DPCM), vector quantisation, hierarchical techniques, discrete cosine transform (DCT) and hybrid DPCM/DCT techniques were all evaluated. An overview of these techniques can be found elsewhere.[3] All of these picture coding algorithms are quite complex and it would have been a mammoth task to build real-time hardware for all of them to allow comparison of the various algorithm performances. For this reason, most of the active parties in the international collaboration built up flexible computer-based simulation systems.

A video coding simulation system consists of a real-time digital storage medium in association with a mainframe computer and typically includes sufficient storage to store a 30-second long real-time digitally sampled video sequence. The real-time storage, usually random access memory (RAM) or high-speed parallel transfer discs (PTDs), is first used to capture a moving sequence from a digitised real-time video source. This data is then transferred at a relatively low speed to the mainframe computer. Various computer programs designed to simulate the desired picture coding algorithm are then executed on the mainframe computer and the data subsequently returned to the storage medium. This whole process typically takes several hours for each video sequence. However, after this process it is possible to view the resultant



Technology
SYSTEM 261 Video Codecs utilise some of the most advanced technology available. Large scale integrated circuits, including custom designed ASICs (Application Specific Integrated Circuits) are used extensively alongside surface mount components used to increase packing density. SYSTEM 261 Video Codecs are designed w[illegible] ATE (Automatic Test Equipme[illegible] [illegible]onally and self test facilities, co[illegible] with the high priorities of reliability and [illegible]ability.

Compatibility
SYSTEM 261 Video Codecs are guaranteed to operate with any other video codec conforming to the relevant CCITT recommendations. It must be noted however that connecting a SYSTEM 261 Video Codec to a basic H.261 video codec will degrade the video and the audio performance of SYSTEM 261.
All SYSTEM 261 Video Codecs are mechanically designed to allow replacement of existing GPT video codecs in the field.

Enhancement Options
The following list covers some of the enhancement options that will be available for SYSTEM 261 Video Codecs.

Additional video input modules
Additional video output modules
Split screen
Simultaneous graphics display
Encryption
Echo cancellation
16kbps audio
ISDN and other channel interfaces
System controllers
Audio processing functions

Plus many more planned.

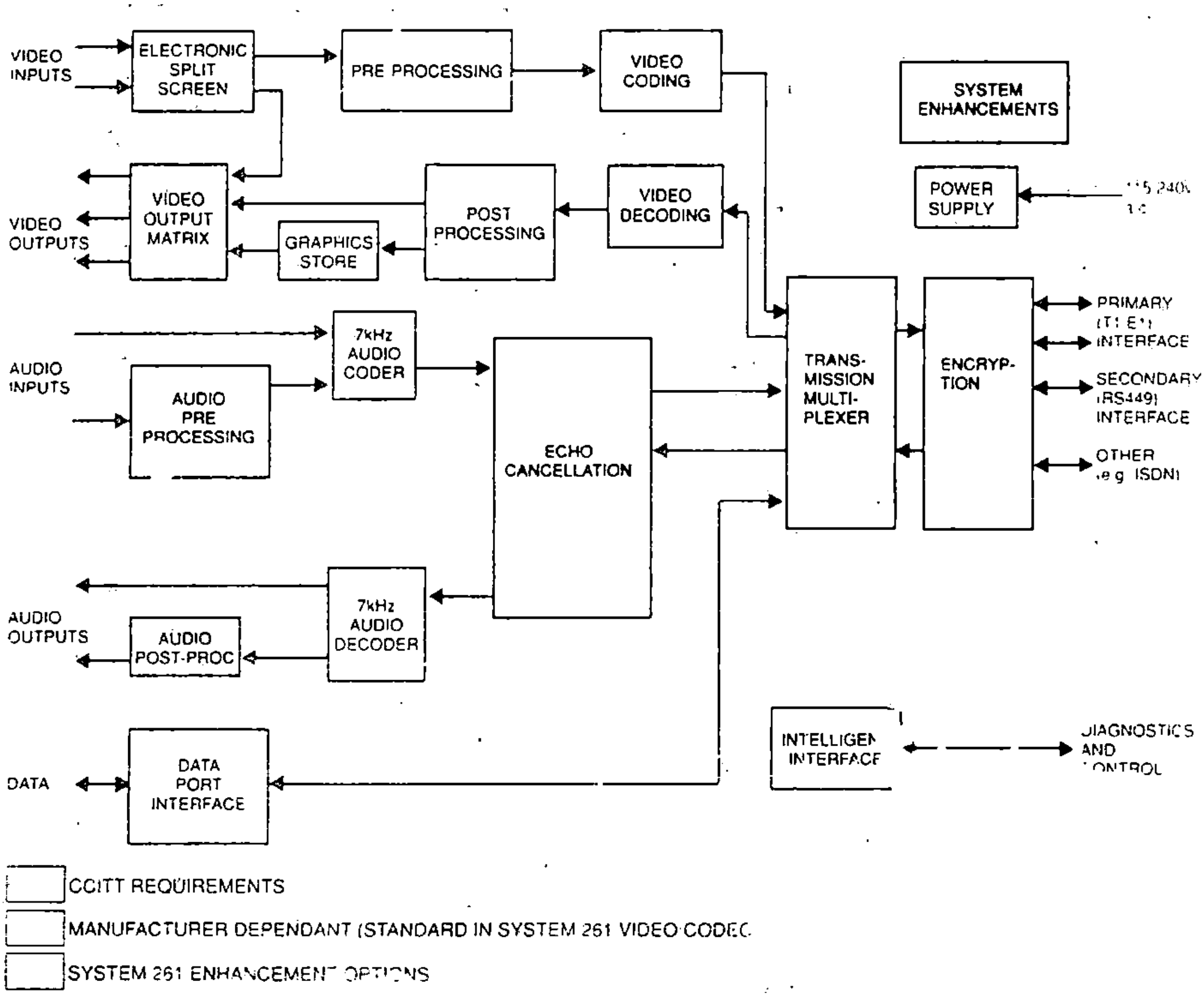


FIGURE 2. SYSTEM 261 VIDEO CODEC BLOCK DIAGRAM

Satellite Transmission

Characteristics

- Infrastructure independent
- Relocatable
- Transmission delay 230-240 msec.
- Very stable and reliable
  except can be "jammed" by
  enemies

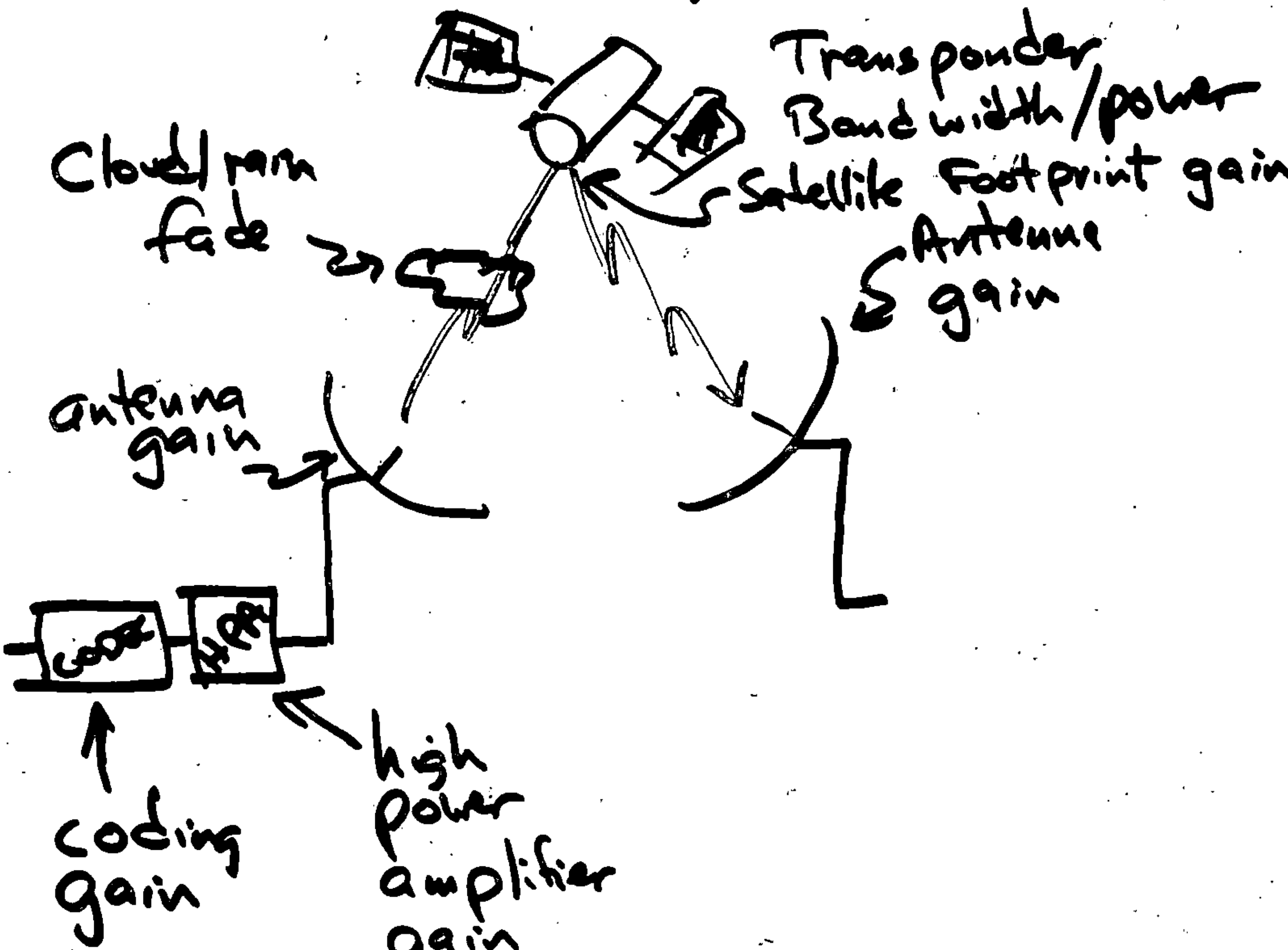
Issues

- Link Budget
- Forward error correction
- Frequency Band
  - C
  - K, Ka, Ku
    - Higher frequency
    - High gain with smaller antenna
    - Rain fade
- Sun outages

Adaptation:
- change power to compensate
- increase coding (lower bit rate)

Link Budget

— to maintain signal-to-noise ratio

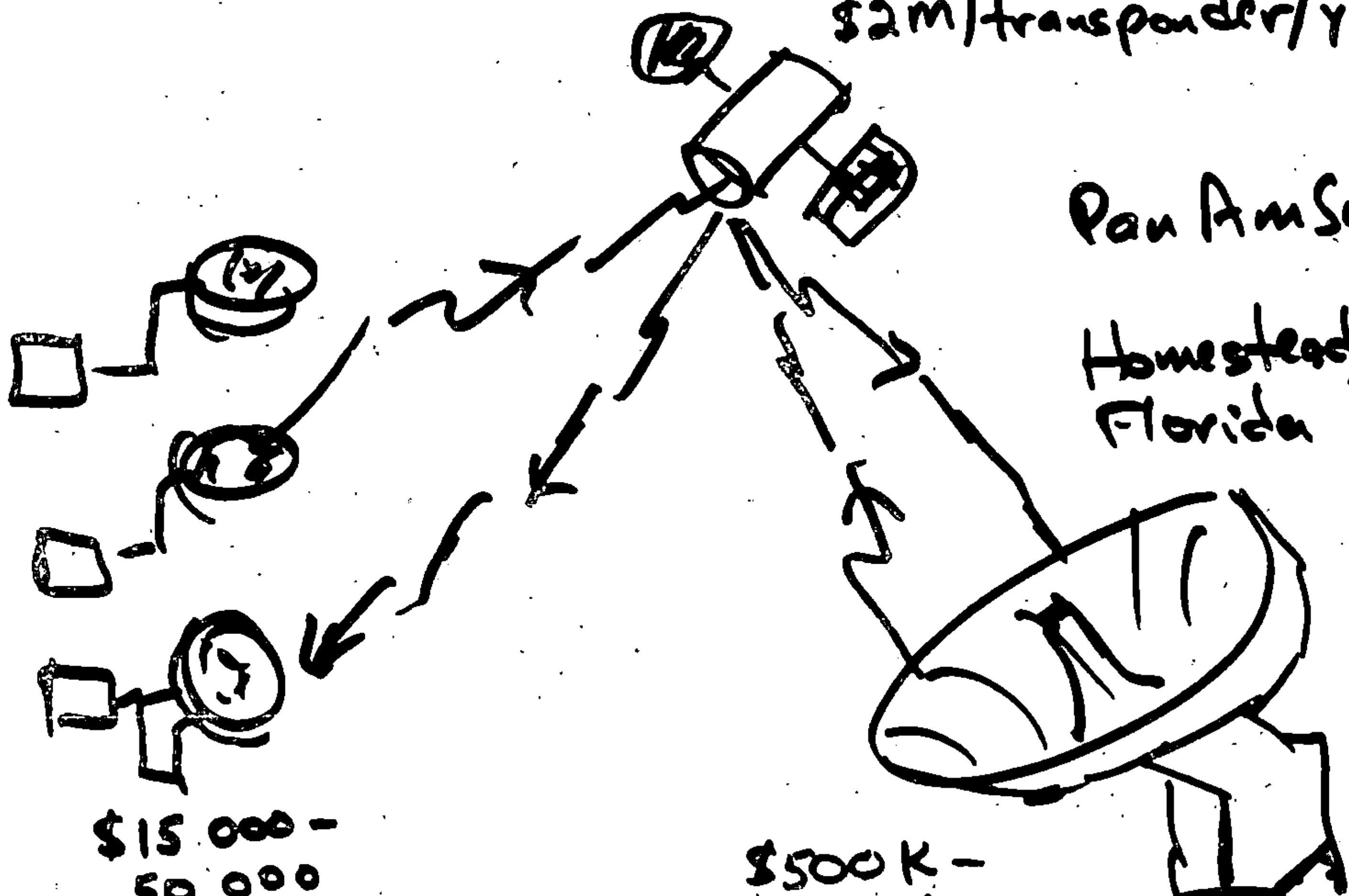


Solid-state up to about 10W
Power sometimes programmable
to compensate for rain
fade

Hubbing

VSAT

Very Small Aperature Terminal



License
Placement

Hub

VSAT to VSAT = twice the delay