DESIGN SPECIFICATION (Rev 1.2)

CVI BROADCAST VIDEO SYSTEM

Carlo Kopp, PHA Pty Ltd, 1995

1.Design Objectives

Produce a system capable of transmission and management of compressed broadcast video signals over low data rate serial channels. This system must support the following features:

- ability to accept PAL-B, SECAM and NTSC composite and RGB video signals

- ability to encode to an MPEG-4 or like format frame sequence with a frame rate of 25 fps, reduced colour resolution and 1/4 of broadcast television luminance resolution.

- ability to extensibly support a large number of user sessions across multiple user servers

- user sessions must have facilities to support user selection of services

- user services to include selection of video streams, and selection of previously stored video streams, freeze frame and other facilities TBD

- a central management facility must exist to enable, disable and profile user access.

- user interface to be menu driven on a PC hosted application

- all communications via BSD sockets over TCP/IP for absolute network transparency

- a recording facility must exist to store 48 hr of programming per continuous video channel

- user sessions must be capable of accessing and replaying recorded sessions

- system must have sufficient redundancy to protect from any single point failure downstream of the video stream generation which could disable the service to all users

2.Capability Timescales

Phase 1.

- simple menu driven user interface to select one of several video streams

- simple supervisor management utility to set user profile and disable/enable user accounts

- ability to support 1/4 decimated PAL resolution video over modem channel

Phase 2.

- enhanced user service selection to include playback of recorded video, highlight playback and other interactive services

- supervisor utility to include more sophisticated profiling and service accounting (charge per time per service type)

Phase 3.

- user service to support teleconferencing and videophone services

3.Implementation

3.1.User Front End / User Terminal

- the user front end shall run on a Windows host with PC based hardware

- the user front end software and PC platform shall be designated the User Terminal (UT)

- the user front end shall communicate with the User Server Host (USH) via BSD socket connections, implementation should be based upon a header compressed PPP channel to a modem rack / terminal server, with the terminal server communicating with the user server host over an Ethernet.

- three socket channels shall be used for communication between the User Server Host platform (USH) and User Terminal (UT). One channel shall carry a compressed video stream from the USH to the user terminal, and one each channel shall carry control traffic between the USH and the UT.

- the control channels shall utilise very little bandwidth, and a simple (eg curses and terminal emulator) based scheme shall be used for Unix debugging. A graphical pushbutton style interface shall be used on the UT Windows display.

3.2 User Session Process (USP)

- each UT shall communicate only with a single US Process running on its allocated USH host

- the US process will be responsible for user authentication and control of access rights

- the US process shall only ever run a captive shell which provides the debug menu interface under Unix, and a protocol engine to support the Windows pushbutton user interface on the UT

- each US shall have a home directory on the USH platform, which will contain a user profile file

- the user profile file shall contain a defintion of which services the user amy access, what charging rates the user is to be billed for

- each US shall have a home directory on the USH platform, which will contain a user accounting log file

- the user accounting log file shall retain a log of activity written by the USP, this file will be continuously appended to

- service messages from the USH supervisor such as broadcasts shall be transmitted via the menu display control panel (eg impending loss or restoration of service, impending closure of account etc)

- the USP shall have read-only access to one or more stream ring buffers each corresponding to one broadcast service, the Unix group mechanism shall be used to enforce access rights by users.

- the USP shall, upon selection of a service, read the compressed video stream in the ring and copy it over the video stream socket connection to the UT.

- the USP shall at any time respond to a menu command to start, stop, or freeze reading from the ring buffer

- reselection of broadcast service will cause the USP to read the corresponding ring buffer

3.3 Drive Daemon (DD) and Frame Ring Buffer (FRB)

- the FRB shall be a segment of System V style shared memory on a USH host platform

- the FRB shall be created by the DD at daemon start time, and destroyed at shutdown time

- only the DD will ever have write access to the FRB, USP may only ever read the FRB

- the FRB shall be divided into a circular stream buffer, and a status table

- the status table shall indicate the state of the buffer, and the tail frame position in the buffer

- the DD will accept a compressed video stream over a BSD socket connection, and write this stream in order into the FRB

- on completeing an FRB write, the DD will accordingly update the status table

- the status table is to prevent reading USPs from over-running the FRB and getting ahead of the DD

3.4 Topology Model

- each video source shall have an encoder/compressor engine which will provide multiple sockets for the reading of a compressed video stream

- two redundant master server hosts shall read a stream from each and every encoder/compressor engine, and maintain corresponding FRBs.

- one or more playback server hosts shall read multiple video streams from the encoder/compressor engines and record these to a RAID array

THROUGHPUT ANALYSIS (Rev 1.2)

CVI MPEG BROADCAST VIDEO SYSTEM

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1.Modem Throughput Constraints

Modem speed range between 28.8 kbps and 42.3 kbps

Compression assumed between 100% and 167%

Throughput at 24 frames/sec MPEG (41.66 msec/frame):

Modem	bytes/sec	bytes/frame	bytes/packet(1)	bytes/packet(2)
28800	3600	150	190	155
38400	4800	200	240	205
42300	5287.5	220.31	260.31	225.31
28800 compress	6000	250	290	255
38400 compress	8000	333.3	373.3	338.3
42300 compress	8812.5	367.2	407.2	372.2

(1) TCP/IP over Ethernet, 1 frame/packet
(2) PPP Header Compressed (RFC1144) serial - MTU is ˜1 frame

Conclusions:

Worst Case Frame Size = 150 bytes/frame
Best Case Frame Size = 367 bytes/frame

2.Host Interface Constraints

STANDARD ETHERNET:

10 MHz Ethernet Interface Throughput Limit is:

10 Mbps @ 80% = 8 Mbps = 1 Mbyte/s

Host Interface Performance Limit:

10 Mbps @ 80% = 8 Mbps = 1 Mbyte/s @ MTU = ˜1500 bytes => 666 packets/sec
10 Mbps @ 80% = 8 Mbps = 1 Mbyte/s @ 0.5 MTU = ˜750 bytes => 1333 packets/sec

A single Unix host Ethernet interface will saturate at about 1000 packets/sec, this is consistent with an MTU for Ethernet 1492 bytes and an achieved throughput of 80% of the Ethernet maximum.

Worst Case Frame Size (150 bytes/frame)/Best Case Ethernet Load

1000 packets/host/sec
N frames/packet

24 frames/user/sec
40 bytes per TCP/IP packet
26 bytes per Ethernet packet
interpacket gaps ignored

N	IP-packet	Ethernet-packet	users/interface	Ethernet [%]
1	190	216	41.6	21.6
2	340	366	83.2	36.6
4	640	626	163.4	62.6
9.9/MTU	1492	1518	411.8	151.8 (!)

Best Case Frame Size (367 bytes/frame)/Worst Case Ethernet Load

1000 packets/host/sec
N frames/packet
24 frames/user/sec
40 bytes per TCP/IP packet
26 bytes per Ethernet packet
interpacket gaps ignored

N	IP-packet	Ethernet-packet	users/interface	Ethernet [%]
1	407	433	41.6	43.3
2	774	800	83.6	80.0
3	1141	1167	124.8	116.7 (!)

Conclusions:

A single 10 MHz Ethernet interface will limit the system to about 90 users for large average video frame sizes, and to about 180 users for small average video frame sizes.

FAST ETHERNET:

100 MHz Ethernet Interface Throughput Limit is:

100 Mbps @ 80% = 80 Mbps = 10 Mbyte/s

Host Interface Performance Limit:

100 Mbps @ 50% = 50 Mbps = 6.25 Mbyte/s @ MTU = ˜1500 bytes => 4200 packets/sec
100 Mbps @ 50% = 50 Mbps = 6.25 Mbyte/s @ 0.5 MTU = ˜750 bytes => 8400 packets/sec

A single Unix host Fast Ethernet interface will saturate at about 4000 packets/sec, this is consistent with an MTU for Fast Ethernet 1492 bytes and an achieved throughput of 50% of the Fast Ethernet maximum.

Worst Case Frame Size (150 bytes/frame)/Best Case Fast Ethernet Load

4000 packets/host/sec
N frames/packet
24 frames/user/sec
40 bytes per TCP/IP packet
26 bytes per Ethernet packet
interpacket gaps ignored

N	IP-packet	Ethernet-packet	users/interface	Fast Ethernet [%]
1	190	216	166.7	8.6
2	340	366	333.3	14.6
4	640	626	666.7	25.0
9.9/MTU	1492	1518	1650.3	60.7

Best Case Frame Size (367 bytes/frame)/Worst Case Fast Ethernet Load

4000 packets/host/sec
N frames/packet
24 frames/user/sec
40 bytes per TCP/IP packet
26 bytes per Ethernet packet
interpacket gaps ignored

N	IP-packet	Ethernet-packet	users/interface	Fast Ethernet [%]
1	407	433	166.7	17.3
2	774	800	333.3	32.0
3	1141	1167	500.1	46.7

Conclusions:

The use of Fast 100 MHz Ethernet of FDDI will not introduce any throughput limits on a workstation class host (eg SS10) for the MPEG frame sizes under consideration.

3.Host Memory Constraints

Memory Estimate per MPEG FRB Buffer =

64k-128k buffer for 14-18 sec latency for 150-370 byte frame sizes

Memory Estimate for 10 Service Channels (MPEG Streams) = 1.3 MBytes

Operating System = 20 MB
Buffers = 10 MB

User Session est 2 MB

Reader Process est 0.5 MB

Total per User 2.5 MB

SPARCStation 10/20 M/B 512 MB => Limit is 192 Users

Conclusions:

A system with 512 MB main memory will support between 150 and 200 users before memory is exhausted, given user process size estimates.

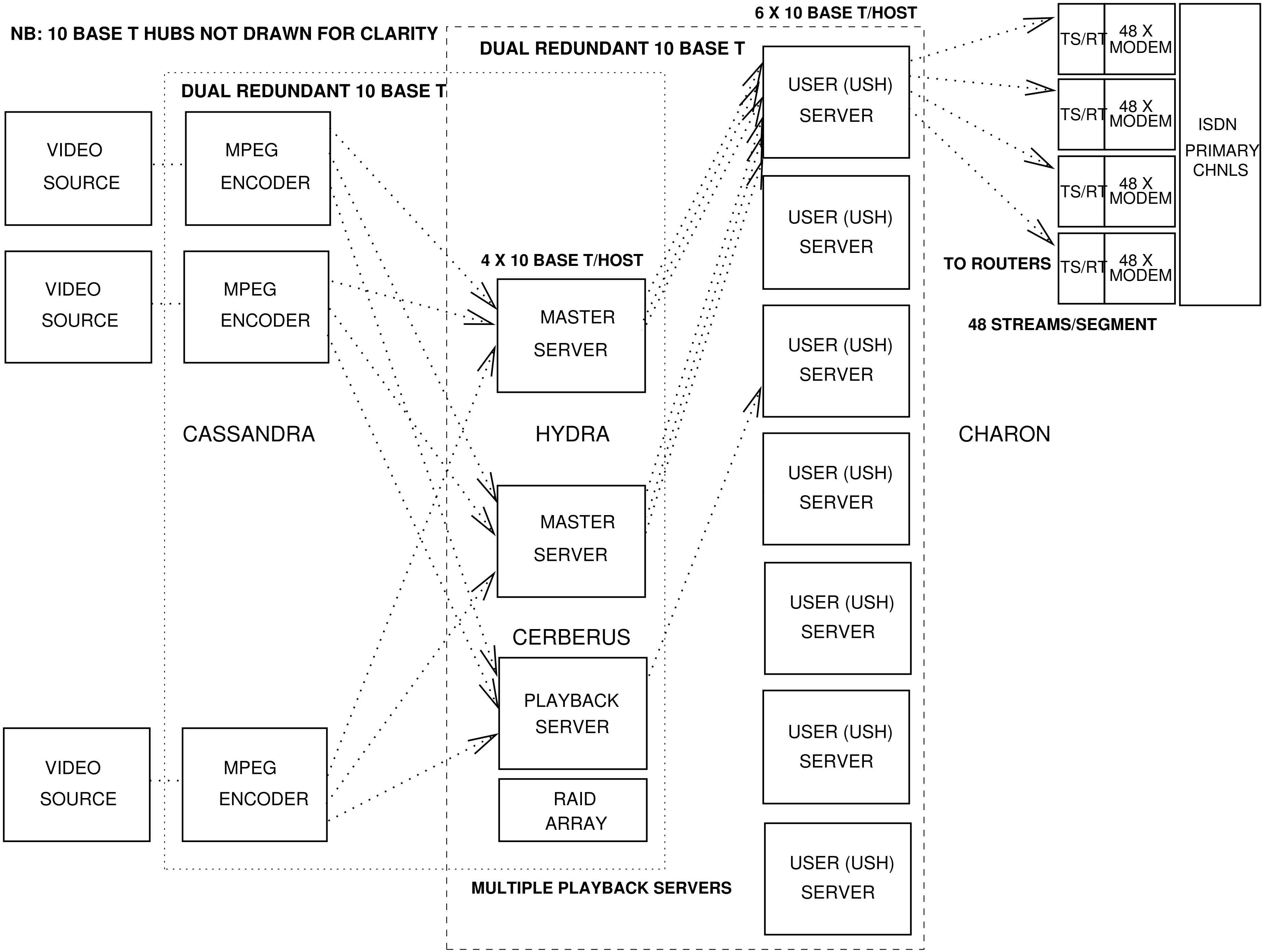

Figure 4.Redundant Compressed Video Stream Fanout Strategy – CVI Network (REV 1.4/6–10–95)

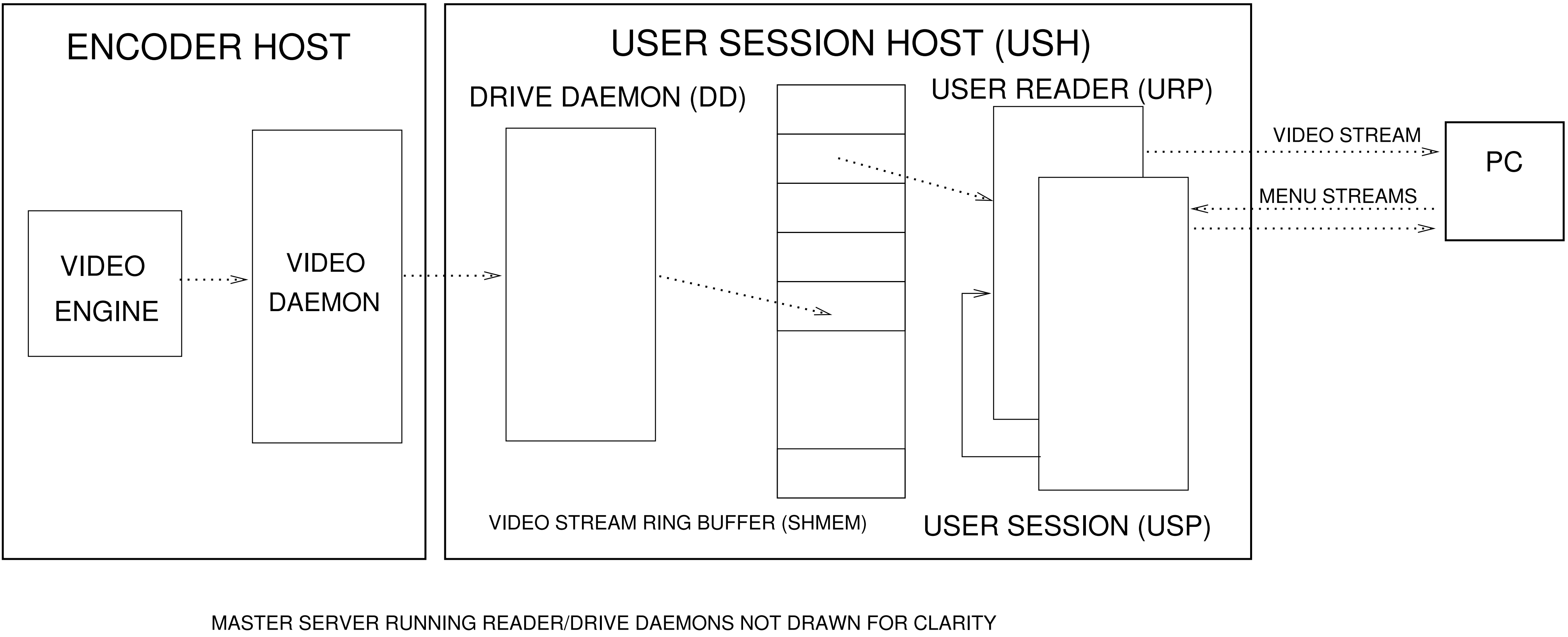

Figure 2. Data / Control Flow Model (Single Stage) – CVI System (Rev 1.3/2–10–95)

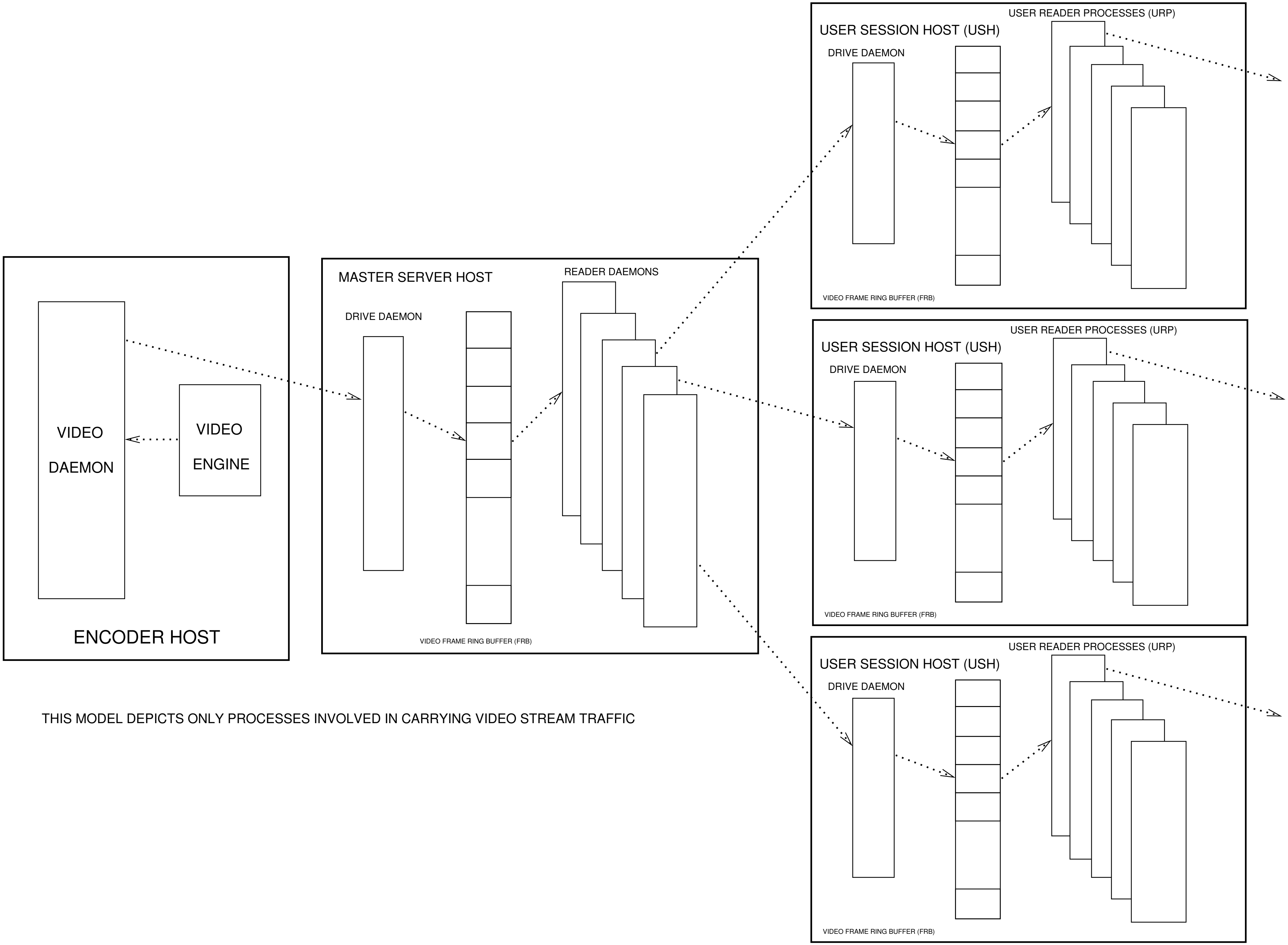

Figure 1. System Topology/Dataflow Model – CVI VIDEO Network (REV 1.3/2–10–95)