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High-definition Media Transport System

Installation Guide (v.1.2)

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Contents

Chapter 1

Specifications

This product includes software developed by the University of Southern California/Information Sciences Institute and by the University of Glasgow, by the Computer Science Department at University College London, by the Computer Systems Engineering Group at Lawrence Berkeley Laboratory, by the Laboratory of Advanced Networking Technologies at CESNET/Masaryk University, and by Akimichi OGAWA.

This product uses the RSA Data Security, Inc. MD5 Message-Digest Algorithm.

Software available at `http://www.gloriad-kr.org/hdtv`

1.1 Overview

One of our design goals is to make the transport system cost-effective. Not only hardware but also software architecture holds the design goal. Features of `uv-0.3.9.4` and the transport system are like these.

- It supports 1080i video operating at 29.97, 30.00, 59.94, and 60.00 fps. At this moment, 720p video can not be displayed over the system. However, applying 720p to the system would not be difficult.
- It supports 10-bit YCbCr('v210'), 8-bit YCbCr('UYVY') or 8-bit RGBA (for DXT1 compression).
- 24-bit 48KHz audio frames are carried by a separate RTP session. Audio signal can be captured from either SDI or AES input.
- `uv-0.3.9.4` works only with HD-SDI interfaces carried by AJA Video Systems. There is a working group trying to merge a number of HD-SDI interfaces (Centaurus and AJA) into `ultragrid`. Googling with the keyword "UltraGrid TODO".
- `uv-0.3.9.4` is able to control multiple XENA HS cards and networked streams. Also, embedded user interface makes it easy to operate our software.

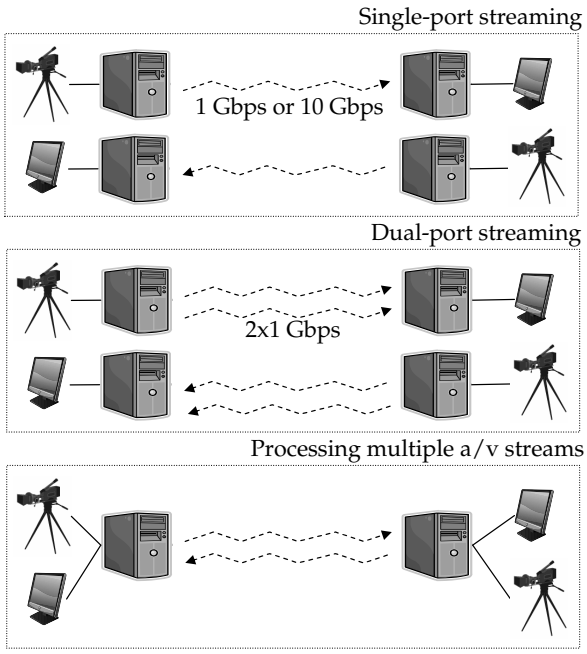

Figure 1.1: Single-port streaming (top), dual-port streaming (mid), and multiple A/V processing (bottom).

- `uv-0.3.9.4` includes a software module for disk-read (see `disk.c` and `disk.h`). However currently, we disabled the function due to the maintenance problems of RAID array. We'll touch disk I/O issues in near horizon.
- Network interface should be one of the followings: 1 Gbps (`single-port streaming`), 2x1 Gbps (`dual-port streaming`), or 10 Gbps (`single-port streaming`). As for under 1 Gbps solution, we applied image cropping (slicing out a small portion of video frames).
- `uv-0.3.9.4` supports XENA_HS, xVideo, dxt, and SDL for video display. In addition, XENA_HS (SDI or AES out) or Linux ALSA (using sound cards) gives an option for audio playout.

1.2 System and Peripheral Devices

You MUST take into deep consideration choosing server boards. Some of them, particularly applying Intel's chipset architecture, have a bottleneck point between north- and south-bridges, and they make peripheral devices share a system bus together. You are recommended to get a board which has at least 2 PCI-X expansion slots, 1 PCI-express ($\times 8$ or $\times 16$) slot, and a dual-port (onboard) network interface.

You should pay attention while placing peripheral devices on PCI-X expansion slots, if you have a number of PCI-Xs. Mainboards armed by Intel's chipset

are likely to share a system bus with multiple PCI-X slots. In this case, the performance of peripheral devices will be drastically downing. For instance that 2 PCI-Xs share a system bus, a 133Mhz device would operate at 66Mhz or less if the other running at 66Mhz took a slot which shares the same bus.

There are a number of commercially available `one-size-fits-all` boxes for analog-digital and digital-to-analog signal conversion. They simplify interconnections among small devices to prevent messes on the floor. Googling will enlighten your insight.

1. **Mainboard**
   SuperMicro C2SBX. Mainboard MUST have at least two 64-bit PCI-X slots. Opteron server may work too. As a single CPU option, combination of Intel Core2Quad CPU and SuperMicro PDSM4+ would be possible. SuperMicro X6DHE-XG2 & G also functions.

2. **CPU**
   Core2Quad (Q6600). Intel Dual-Xeon 3.0 with FSB 800Mhz, Dual-core single CPU system may work but the performance of single-core system would be very poor.
   NOTE! When use C Wrapper for DXT1 compression in uv-0.3.9.4 (build24042008), you need more powerful CPU than Q6600. Exploiting SSE2 (newer one than build24042008) mitigates CPU load (Preliminary implementation shows 25*4% over Q6600 while 80*4% with C Wrapper)).

3. **Memory**
   PC3200 DDRII/400Mhz REG/ECC 2GB (at the mercy of motherboards)

4. **Graphics**
   NVIDIA Geforce 8600GT 512MB(PCI-Express×16). 6600GT or 7600GT possible. SHOULD support xVideo extension.

5. **ALSA Sound(Optional)** Realtek on-board (2channel 16-bit 48KHz).

6. **Network Interface Cards**, Chelsio N210 (Optional), Dual-port (2×1 Gbps) NIC, or at least a single-port(1 Gbps) NIC. MUST support Jumbo frame.

7. **HD(V) Camera**, Sony HVR-Z1N

8. **HD-SDI**, AJA XENA HS

9. **Audio A/D/A Converter**, FlyingCow 24bit, or AJA ADA4

10. **Video A/D Converter**, AJA HD10A

11. **HD-SDI and SDI D/A Converter**, AJA HD10C2, or AJA HDP

12. **Target Operating System of this manual** Fedora Core 5 (kernel 2.6.17-1.2139, 32-bit over x86 platform).

1.3 Operating System

Due to the kernel dependency of AJA XENA_HS, you MUST install the right kernel versions that we've thoroughly tested. The kernel sources you installed MUST contain `QT` and `xorg-x11-devel` packages. To make matters easy, take use of Fedora Core 5.

NOTE that what it really matters is KERNEL VERSIONs rather than LINUX DISTRIBUTIONs. Validated Linux dist.(kernel ver.)s are Mandrake 10.1 (kernel 2.6.11.3) and Fedora Core 5 (kernel 2.6.17-1.2139smp). Fedora Core 5 with kernel 2.6.16-1.2133 should work, too.

1.3.1 Fedora Core 5 with 2.6.17-1.2139

1. Download and install Fedora Core 5 as usual (Recommend full package installation - manual selection of all individual packages). Packages regarding to `xorg-x11-devel` and `QT (qt-devel)` MUST be in proper place.

   `INFO.` Unfortunately, Fedora Core 5 contains no `xorg-x11-devel` packages. Instead, `mesa-libGLU-devel` packages do the same function.

2. Get `kernel-2.6.17-1.2139_FC5.src.rpm`. Googling!! .

3. Install `kernel-2.6.17-1.2139_FC5.src.rpm`
   `rpm -Uvh kernel-2.6.17-1.2139_FC5.src.rpm`. You may face a lot of Warning messages. Just ignore it.

4. Let's install the kernel source
   `rpmbuild -bp --target=$(uname -m) /usr/src/redhat/SPECS/kernel-2.6.spec`
   The kernel source will take a place in
   `/usr/src/redhat/BUILD/kernel-2.6.17/linux-2.6.17.i686/`

5. Go to `/usr/src/redhat/BUILD/kernel-2.6.17/linux-2.6.17.i686/`

6. Now, Will patch `bigphysarea`. Prior to make patch,
   download `bigphysarea-2.6.17.tar.gz` from http://www.gloraid-kr.org/hdtv/
   and extract it to an arbitrary directory.
   `patch -p1 < [path]/bigphysarea-2.6.17.diff`

7. If you're trying to use bigphysarea other than 2.6.17 version, you'll get errors in 2 Makefiles.
   open `/usr/src/redhat/BUILD/kernel-2.6.17/linux-2.6.17.i686/Makefile`
   and set `EXTRAVERSION=.3-bigphys-v2p`. (**IMPORTANT!!**: Make sure that you MUST set the EXTRAVERSION name to .3-bigphys-v2p unless you have SDK from AJA video systems.)
   open `/usr/src/redhat/BUILD/kernel-2.6.17/linux-2.6.17.i686/mm/Makefile`, and add `obj-$(CONFIG_BIGPHYS_AREA) += bigphysarea.o` to right after the `obj-$(CONFIG_TINY_SHMEM) += tiny-shmem.o`

8. Currently, in `/usr/src/redhat/BUILD/kernel-2.6.17/linux-2.6.17.i686`

9. `make menuconfig`

10. MUST make kernel parameters like
    – `General setup`
    —-[*] `Configure standard kernel features`
    – `Processor type and features`
    —-[*] `Symmetric multi-processing support`
    —-[*] `SMT (Hyperthreading)scheduler support`
    —- `Memory split`
    ——[*] `2G/2G user/kernel split`
    —-[*] `Big Physical Area`
    —- `Processor family`
    ——[*] `Pentium-4/Celeron(P4-based)/Pentium-4M/Xeon`
    – `Preemption Model`
    —-[*] `Preemptible kernel (Low-latency desktop)`
    –[ ] `Enable kernel irq balancing`

11. `make bzImage`
    `make modules`
    `make modules_install`
    `make install`

12. Open `/etc/grub.conf`
    append `bigphysarea=10241 vmalloc=384M` on the line starting with `kernel /vmlinuz-2.6.17`

13. Reboot and log-on with new kernel

1.4 AJA OEM_HS (or XENA_HS) Linux Driver

GLORIAD-KR team only supplies binary driver for XENA HS [1] (MAKE SURE that the binary only works over Intel's processors). Prior to installing the driver, `uv-0.3.9.4` SHOULD be placed in your system. Download it from http://www.gloriad-kr.org/hdtv/.

NOTE that `ntv2linux-4.0.0.zip` DOES NOT work on Fedora Core 5.

1.4.1 Driver Installation on Fedora Core 5

Go after the below steps unless you have AJA SDK. After making validation tests, it will put binary driver and shared library on your system.

1. Get `download uv-0.3.9.4_bin.tgz` from http://www.gloriad-kr.org/hdtv/, and extract it to a folder.

2. `#> cd ./uv-0.3.9.4_bin/ultragrid/bin`

3. `#> sh ./setup.sh`

No errors? then, everything is ready for `uv-0.3.9.4`.

[1] You MUST get an OEM license from AJA Video Systems to fully look into the software development kit (SDK).

From this point, instructions are turned to those who have XENA_HS SDK (ntv2linux-4.1.0). If you don't have it, skip the followings.

1. Extract `ntv2linux-4.1.0.zip` into `./uv-0.3.9.4` folder.
2. Get download `uv-xhs-410.diff` from http://www.gloriad-kr.org/hdtv/, and save it to `./uv-0.3.9.4`
3. `#> cd ./uv-0.3.9.4/ntv2linux-4.1.0`
4. `#> patch -p1 < ./uv-xhs-410.diff`
5. `#> export NTV2TARGET=KHD`
6. `#> make`
   Tips: Got errors?. Refer to Troubleshooting guide.
7. `#> cd ./bin`
8. `#> ./loadKHD`
9. `#> ./programKHD`
10. `#> ./ctwKHD`, You can check whether the driver functions well. If unexpected images show up, `./drawKHD` can precede in `./ctwKHD`.

1.5 uv-0.3.9.4

`uv-0.3.9.4` takes charge of capturing, transporting, displaying uncompressed video and audio. You MUST get into uv-0.3.9.4 with root privileges. Once you get install uv-0.3.9.4, you will see one of the following directory structures. The XENA_HS interface is placed in `ntv2linux-4.x.0/commonapps/ioxena`.

`uv-0.3.9.4` with AJA SDK

```
------- FastDXT
------- tcl-8.0
------- tk-8.0
------- ultragrid
-------------- bin
------- ntv2linux-4.x.0, or
```

`uv-0.3.9.4` with binary driver

```
------- FastDXT
------- tcl-8.0
------- tk-8.0
------- ultragrid
-------------- bin
------------------- scripts
------------------- xhsdrv
```

1.5.1 SDL (Simple DirectMedia Layer)

NOTE! Essential for FastDXT. uv-0.3.9.3FC5 (build17092007) or newer supports SDL display. To make use of this attractive solution, you should download & install SDL library.

1. Go download SDL-1.2.9.tar.gz from http://www.libsdl.org/release/

2. Extract it & build the tarball
   ```
   #> cd SDL-1.2.9
   #>./configure; make; make install
   ```

1.5.2 GLEW

NOTE! Essential for FastDXT. The following will place all glew libraries on `/usr/include/GL` and `/usr/lib`.

1. Download `glew-1.5.0-src.tgz` from http://glew.sourceforge.net/

2. Extract it & build the tarball
   ```
   #> make
   #> make install
   ```

1.5.3 Build

You already finish the entire installation procedures including driver patch. Now, it's time to make `uv-0.3.9.4` runnable. Let's build `tcl-8.0`, `tk-8.0`, and `uv-0.3.9.4`.

1. Go to `uv-0.3.9.4/tcl-8.0/unix` (if you have binary, skip it)
   ```
   #> make clean
   #> ./configure; make
   ```

2. Go to `uv-0.3.9.4/tk-8.0/unix` (if you have binary, skip it)
   ```
   #> make clean
   #> ./configure; make
   ```

3. Go to `uv-0.3.9.4/ultragrid`
   ```
   #> ./configure [--enable-xenahs] [--enable-alsa] [--enable-sdl]
   [--enable-fastdxt]
   ```

   - `[--enable-xenahs]` : for XENA HS card
   - `[--enable-alsa]` : for ASLA playout
   - `[--enable-sdl]` : for SDL display
   - `[--enable=fastdxt]` : for DXT1 compression

   ```
   #> make
   ```

1.5.4 Shell Scripts

Scripts will be shown in `uv-0.3.9.4/ultragrid/bin/scripts`. Graphical user interface would automatically invoke all scripts if necessary.

- `chkdrv.sh`, check directory structure and shared library.
- `itune.sh`, tuning script for network and media interfaces.
- `ktune.sh`, tuning script for OS kernel buffer.
- `blt.sh`, you can use the script to remake `uv-0.3.9.4`. Apply it when you already have AJA SDK.
- Others.

1.6 Chelsio N210 10Gbps Network Interface Card

`uv-0.3.9.4` uses either a 10 Gbps or dual-port(2×1Gbps) Gigabit Ethernet interface. Talks in this section will be bound to the 10 Gbps interface carried by Chelsio.

1. get `cxgb-2.1.3.tar.gz`.
2. `#> tar zxvf cxgb-2.1.3.tar.gz`
3. `#>cd cxgb-2.1.3`
4. `#>make;make install`
5. `#>modprobe cxgb`
6. open `/etc/modprobe.conf`, and append `alias eth2 cxgb` on the bottom of the .conf

1.7 Graphic Card

Video frames can be played on either PC monitor or HDTV displayer. To make use of PC monitor, `uv-0.3.9.4` supports xVideo extension (SDL, too). Thus, you must select a proper graphic card which ensures xVideo extension. We adopted NVidia Geforce 6600GT, 7600GT, or 8600GT for the purpose. You may check `#> xvinfo` to know whether your graphic card upholds xVideo.

If you face errors while operating `uv-0.3.9.4` with `-d xv` option, open `/etc/X11/xorg.conf`, and set `DefaultDepth` and `Depth` in `Section "Screen"` to 24.

1.8 Troubleshooting

Judging from our previous experiences, you may face errors while setting up the system or Ultragrid.

1. Sometimes, we can hear annoying Click noise. Then, modifying several lines in SDK will gracefully mitigate the phenomenon.
   open `ntv2linux-4.x.0/linuxdriver/ntv2driverdma.c`, and look for the line starting with `if(*bytesBeforeWrapPoint ==0)` (line # 1152?). Fix it like..
   ```
   if(*bytesBeforeWrapPoint ==0) {
   /* STWO ......  */
   *bytesBeforeWrapPoint = 4;
   *bytesAfterWrapPoint = 0;
   iNTimes = 1;
   MSG("....");
   }
   ```

2. Once you got errors in compile time, comment (//) the following lines in `linuxdriver/ntv2driver.c`
   ```
   /* res=pci_request_regions(pdev, ntv2pp->name);
   if(res < 0) {
   MESSAGE("....");
   goto err_disable;
   } */
   ```
   Comment all lines referring to
   `pci_release_regions(pdev);`

3. If you already patched `bigphysarea` (`uv-0.3.9.4` exploits it), uncomment the following line in `linuxdriver/ntv2driverbigphysarea.h`
   `#define USE_BIGPHYSAREA`

4. If you encountered error like "glu.h is not found" while making ntv2linux-4.x.0, then apply either 1 or 2

   1. install `mesa-libGLU-devel` from Package Manager
   2. go download OpenGL Utility Library from http://sourceforge.net/project/showfiles.php?group_id=3 (RPMs are available at the bottom, under "Miscellaneous").

5. building `uv` drives me to "cannot find -lqt-mt" evil.
   `-lqt-mt` is required for QT multi-threading. Open `/root/.bash_profile` and add the following lines.

   `QTDIR=/usr/lib/qt3`
   `PATH=`$QTDIR/bin$`:PATH`
   `LD_LIBRARY_PATH=`$QTDIR/lib$`:LD_LIBRARY_PATH`
   `export QTDIR PATH LD LIBRARY PATH`

   Let's update env., `$root>..bash_profile`

6. While building FastDXT, got an error message "glXgetProcAddressARB was not delared in this scope(dxtplay.cpp)"?

   Open dxtplay.cpp and add `#define GLX_GLXEXT_LEGACY`

7. If your system can not recognize more than two AJA cards (cheeck it with `#>lspci -vt`, disable ACPI PCI bus segmentation in the BIOS (BIOS $->$ Advanced $->$ disable PCI bus segmentation). You could also try

booting the kernel with the pci=noacpi option, or acpi=off. NOTE! do not use the option when system freezes.

8. got "Can't resolve IP address for localhost.localdomain"? open `/etc/hosts` and add the following (if empty).
   `127.0.0.1 localhost.localdomain localhost`

9. `uv-0.3.9.4` vomits "`ALSA lib pcm_direct.c ..... audio open error: (dmix:0,0)`".
   Create the audio group then, `#> groupadd audio`

1.9 Summary - Installation Procedure

1. OS installation (Fedora Core 5)
2. Update Linux kernel
3. Get extract `ultragrid` package (GLORIAD-KR ver.)
4. Place AJA SDK (optional)
5. Invoke graphical user interface

Chapter 2

Tuning & Tips

2.1 Network Interface Card

Any network interface cards supporting Jumbo frames (9K MTU) suffice for our purpose. Make sure that some on-board dual-port NICs DO NOT support this feature.

If you are going to use dual-port Gigabit Ethernet cards instead of 10 Gbps, you are solicited to modify `e1000` module options. Add the following line to `/etc/modprobe.conf`

```
options e1000 FlowControl=0,0 InterruptThrottleRate=0,0
TxIntDelay=0,0 RxIntDelay=0,0 TxAbsIntDelay=0,0 RxAbsIntDelay=0,0
RxDeescriptors=80,80 TxDescriptors=80,80
```

Have just one NIC? slightly modify the above then. For example, `=0` instead of `=0,0`

2.2 Kernel Buffer & NIC Options

Currently, are you using a 10Gbps NIC?. Here i show a sample tuning script for the Chelsio's. Note that `uv-0.3.9.4` already got tuning scripts in `./bin/scripts` directory.

```
mtu_size = 9180
txqueuelen = 500

sysctl -w net.core.wmem_max=128388607
sysctl -w net.core.rmem_max=128388607
sysctl -w net.core.rmem_default=262144
sysctl -w net.core.wmem_default=262144
sysctl -w net.core.optmem_max=524288
sysctl -w net.core.netdev_max_backlog=500
```

The following command line is subject to Chelsio's 10 Gbps NICs. MAY not work if you apply them to NICs from other vendors. It will set latency timer and MMRBC. You DO NOT need it unless you use 10 Gbps NICs.

```
setpci -d 1425:* 0x0c.l=0x0000FF00 setpci -d 1425:* 0x60.l=0x004a0007
```

The following command MAY be useless if you are not into TCP. It sets SMP affinity to 1. You can find IRQ_NUM (irq number) from `/proc/interrupts`.

```
echo 1 > /proc/irq/IRQ_NUM/smp_affinity
```

Finally, tune MTU size and the length of transmission queue.

```
ifconfig eth[??]  mtu $mtu_size
ifconfig eth[??]  txqueuelen $tx_queue
```

Two things more, dual-port streaming on top of Linux requires ARP filtering (in case of applying dual-port NIC). For instance, `route add 192.168.0.2 dev eth0`.

```
sysctl -w net.ipv4.conf.all.arp_filter=1
route add -host [dest_addr.]  gw [addr] dev [src_interface]
route add -host [dest_addr.]  gw [addr] dev [src_interface]
```

In very rare cases, IPv6 options MAY disrupt networking. To disable it, add `alias net-pf-10 off` to `/etc/modprobe.conf`.

2.3 Tips & Links

2.3.1 System Services

Kill all background services which try to make network connections. These kinds of services include `sendmail`, `ntpd`, `httpd`, `avahi-daemon`, `iptables`, `irqbalance`, and so forth. 10 Gbps network interfaces are likely to collide with these services while traffic is going back and forth through the interfaces.

2.3.2 ethtools

If your system do not make any responses to `ethtool` command, you'd rather install `pciutils` packages. Needs it to tweak 10 Gbps network interfaces. Get download `pciutils-2.1.11-6mdk.i586.rpm` or others, and install it.

```
#> rpm -Uvh pciutils-2.1.11-6mdk.i586.rpm
```

Note that no RPM package other than `pciutils-2.1.11-6mdk.i586.rpm` will not work properly in Mandrake 10.1 (kernel 2.6.11.3).

2.3.3 Network & Performance tests

We may use `iperf` and `ping` trace to evaluate end-to-end performance and network connectivity. `uv-0.3.9.4` will be happy to get at least 860 Mpbs sustained network bandwidth. so, you MUST observe the performance in advance. Although `uv-0.3.9.4` encapsulates media into RTP/UDP/IP packets, we SHOULD check TCP throughput as well because traffic generated by uncompressed hdtv is tend to be more bursty than normal UDP traffic made by `iperf`.

- UDP server, `iperf -s -u -l 9000 -w 2M`
- UDP client, `iperf -u -c [address] -w 2M -l 9000`
- TCP server, `iperf -s -w 10M`

`ping` trace is useful for path MTU discovery and for connectivity validation. It works on Linux platform.

```
ping -M do -s 9000 -i 0 [address]
```

`nuttcp` is another network testing tool simple to use.
See http://www.wcisd.hpc.mil/nuttcp/Nuttcp-HOWTO.html.

2.3.4 Links

- http://www.gloriad-kr.org/hdtv/
  get download `uv-0.3.9.4`
- http://fr.rpmfind.net/linux/rpm2html/search.php?query=kernel
  RPM resource - kernel source

Chapter 3

Run uv-0.3.9.4

3.1 User Interface

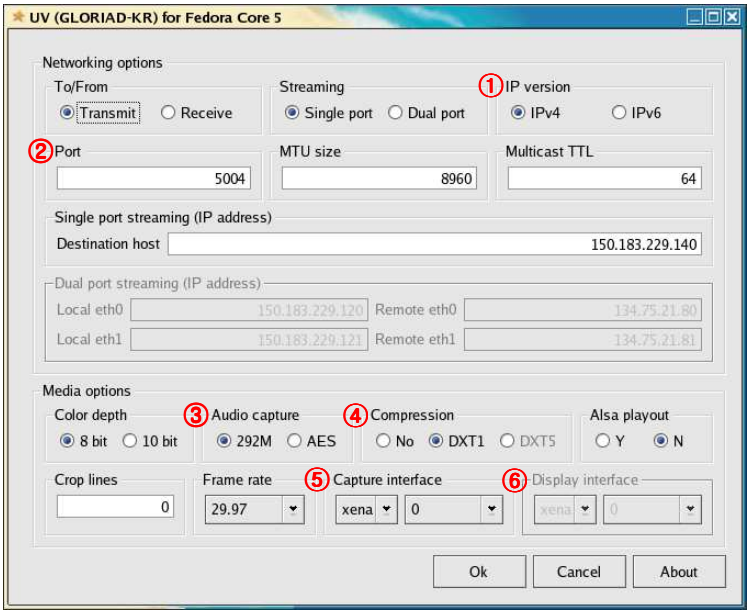

Figure 3.1: User interface for uv-0.3.9.4.

`uv-0.3.9.3` or newer got graphic user interface (We took advantages of Qt library (ver. 3.3.7)). To make it shown up, call `ultragrid/bin/guv`. No longer need to tune kernel and network interfaces. On invoking the GUI, it automatically sets all system options. No descriptions for `networking options` (in Fig. 3.1) would be provided since they are straightforward and quite intuitive.

Regarding to `media options`, you can figure them for the next instructions. First, video would be either 8-bit or 10-bit YUV. XENA cards can grab audio frames from SDI-embedded signal or from external AES(XLR) (see ③). 8-bit YUV video plus audio slightly exceeds 1 Gbps. Bottom lines of each video frame

can be cropped to support under-1 Gbps transmission. The `crop lines` option only plays with 8-bit video.

DXT1 in `Compression` (④) works with 8-bit video depth. Select `dxt` from the `Display interface` to see DXT1-compressed video. A DXT1 stream yields 250 Mbps.

Identification numbers (Right-side ComboBox in ⑤ and ⑥) for `Capture` or `Display interface` would be listed automatically as long as your system has more than one XENA HS cards.

Table 3.1: `media options.`

options	remarks
depth	color depth (8- or 10-bit)
embedded audio	select 292M if SDI audio available. XLR for AES I/O
sound card	activate only when displaying with `xv`
C/D interfaces	select XENA HS and an identification number

3.2 Command Options

The main software, `uv`, exists in `uv-0.3.9.4/ultragrid/bin`. The `uv` can take one or more of the following options.

`uv [-d <display_intf.>] [-t <capture_intf.>] [-i <xena_intf_num] [-m <mtu>] [-b <bit_pixel>] [-c <crop_lines>] [-F <frm_format>] [-D <drop_frm>] [-e <embedded_audio>] [-a <software_audio>] [-f <framerate>] [-l <local_interface_1>] [-r <remote_interface_1] [-L <local_interface_2] [-R <remote_interface_2] [-x <0 or 1>] [address]`

- `-d <display_intf.>`: name of display interface. ex) `-d xena`, or `-d xv`
- `-t <capture_intf.>`: name of capture interface. ex) `-t xena`, or `-t disk`
- `-i <xena_intf_num>`: Identification number of capture or display interfaces. ex) `-i 0`
- `-m <mtu>`: MTU size should be less than NICs allow. ex) `-m 9000`
- `-f <framerate>`: obsolete, see `-F` option
- `-b <bit_pixel>`: color-space sampling of video. ex) `-b 8`, or `-b 10`
- `-c <crop>`: number of lines to be cropped out. Bottom lines will be out. ex) `-c 40`
- `-F <frm_format>`: 1080i standard frame rate. Can take one of followings: 25.0, 29.97, 30.0, 50.0, 59.94, 60.0. The number should be up to Camera's output format. ex) `-F 59.94`

- `-D <drop_frm>`: the number of frames forced to be dropped. It MUST not exceed 15. ex) `-D 10`
- `-e <embedded_audio>`: system will take audio signal embedded in SMPTE292M(1) or came from external devices(0). ex) `-e 1`
- `-a <software_audio>`: set to 1 if you want to play audio with sound cards. It only works with `-d xv` option. ex) `-d xv -a 1`
- `[address]`: in case of single port transmission, set destination address
- dual-port transmission needs 2 sender-side addresses and 2 receiver-side addresses. use the following options.
  - `-l <local_interface_1>`: sender-side first IP address
  - `-r <remote_interface_1>`: receiver-side first IP address
  - `-L <local_interface_2>`: sender-side second IP address
  - `-R <remote_interface_2>`: receiver-side second IP address
  - `-x <0 or 1>`: Disable or Enable DXT1 compression

Now, let's see some sample usages. Make sure that audio is always enabled by default.

- Want to send 10-bit video captured by XENA_HS to a remote host, 192.168.0.2.
  `./uv -t xena 192.168.0.2`
  and display streamed 10-bit video coming from 192.168.0.1 with XENA_HS
  `./uv -d xena 192.168.0.1`
- Try to make dual-port transmission of 10-bit video and 24-bit audio. assume that sender's network interfaces have set to 192.168.0.1 and 192.168.0.2, and that 192.168.0.3 and 192.168.0.4 are assigned to a receiver.
  `./uv -t xena -l 192.168.0.1 -r 192.168.0.3`
  `-L 192.168.0.2 -R 192.168.0.4`
  and display the streams with
  `./uv -d xena -l 192.168.0.3 -r 192.168.0.1`
  `-L 192.168.0.4 -R 192.168.0.2`.
- Let's transmit 8-bit video and 24-bit audio to a remote host, 192.168.0.2. Note that 8-bit 1080i video consumes roughly 995 Mbps network bandwidth.
  `./uv -t xena -b 8 192.168.0.2`
  and get display it coming from 192.168.0.1
  `./uv -d xena -b 8 192.168.0.1` with XENA_HS
  `./uv -d xv -b 8 192.168.0.1` with xVideo
- Not enough network bandwidth?. just send 8-bit video with cropping (cut 20 bottom lines off) to 192.168.0.2. `-b 10` option can not take or accompany `-c 1`
  `./uv -t xena -b 8 -c 20 192.168.0.2`
  and play it with XENA_HS,
  `./uv -d xena -b 8 -c 20 192.168.0.1`

or play it with xVideo and Linux ALSA.
`./uv -d xv -a 1 -b 8 -c 20 192.168.0.1`

- Control multiple XENA HS cards from one system? `./uv -t xena -i 0 -b 8 -p 5004 -c 20 192.168.0.2`
  applying the first XENA HS interface for capturing,
  `./uv -d xena -i 1 -b 8 -p 5014 -c 20 192.168.0.1`
  and the second one for displaying.

3.3 Process multiple A/V streams with XENA HS

With a single machine, `uv-0.3.9.4` can put, get, or put/get multiple A/V streams if you have multiple XENA HS cards. Note that a single `uv` process can handle just one stream so multiple `uv` processes are required to make it.

- To simultaneously process `N` streams, you have to invoke `uv N` times.
- User interface do not recognize I/O operation of XENA cards (Can not figure which XENA gets or puts SMPTE292M signal). You have to manually pick up a board-identification number from the user interface (count up from the bottom PCI-X).
- Not made any tests for 10-bit video yet.

NOTE If you face unexpected events like data drops, do not share the same port number for service providing and requesting. For example, use <5014> for receiving requests if your system already set <5004> for sending requests.

3.4 Troubleshooting

1. Not able to run the "`uv -d xv`" on the computer with the GeForce 6600, I am getting seg., faults here.

   xorg.conf should support 24-bit color depth to use "`-d xv`". open /etc/X11/xorg.conf, make sure lines should be···

   ```
   DefaultDepth 24
   Depth 24
   ```

2. `uv` says 'unknown color name "Black"'. What is the problem?

   Probably, that would be a bug in default Xorg setup on certain ver., of Linux. Let's assume rgb.txt is being under /etc/X11/rgb.txt. Following will sweep out the evil.

   ```
   $ ln -s /etc/X11/rgb.txt /usr/lib/X11/rgb.txt
   $ ln -s /etc/X11/rgb.txt /usr/X11R6/lib/rgb.txt
   $ ln -s /etc/X11/rgb.txt /usr/share/X11/rgb.txt
   ```