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Uncompressed HD(V) Media Transport System

Installation Guide (v.1.1)

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Contents

Chapter 1

Specifications

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-0.3.9.2` 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.
- `uv-0.3.9.2` 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-0.3.9.2` 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, 2x1 Gbps, or 10 Gbps. As for under 1 Gbps solution, we applied image cropping (slicing out a small portion of video frames).
- `uv-0.3.9.2` versioned in 2006 supports XENA_HS, xVideo for video display (`uv-0.3.9.2FC5` supports SDL). In addition, XENA_HS or Linux ALSA (using sound cards) gives an option for audio playout. Enhanced version of `uv-0.3.9.2` is planning to support SDL for video display.

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. If you do not need to consider server's extensity in uses,

you are recommended to purchase a board which has at least 2 PCI-X expansion slots, 1 PCI-express (×8 or ×16) slot, and a dual-port (on-board) 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 X6DHE-XG2 & G, Mainboard MUST have at least two 64-bit PCI-X slots. Opteron servers may work too. As a single CPU option, combination of Intel Due2Quad CPU and SuperMicro PDSM4+ would be possible.

2. **CPU**
   Intel Dual-Xeon 3.0 with FSB 800Mhz, Dual-core single CPU system may work but single-core system is insufficient.

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

4. **Graphics**
   NVIDIA Geforce 6600GT or 7600GT 128MB PCI-Express×16, SHOULD support xVideo extension.

5. **ALSA Sound(Optional)**
   SB Audigy2. At this moment, sound cards other than Audigy2 DO NOT work for 48KHz ALSA audio.

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. **Operating System**
    Redhat 9 (kernel 2.4.25 or 2.4.28), Mandrake 10.1 (kernel 2.6.11.3), or Fedora Core 5 (kernel 2.6.17-1.2139) for 32-bit platform.

1.3 Operating System

Due to the kernel dependency of AJA XENA_HS, you MUST install the exact kernel version that we've thoroughly tested. The kernel sources you installed MUST contain `QT` and `xorg-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 Mandrake 10.1 Community(i586) with kernel 2.6.11.3

There are two types of Mandrake 10.1: 10.1 Official and 10.1 Community (Development ver.). You can get them from
ftp://ftp.nara.wide.ad.jp/pub/Linux/Mandrakelinux/devel /iso/10.1/i586

1. Begin the installation as usual until *Package Group Selection* screen. When you are there, select all in Workstation, Development, Server, and Graphical Environment. After then, choose *Individual Packages Selection*, go next.

2. You are asked to choose the packages you want to install. Manually check and select all packages (double click on $\surd$ image). Follow this instruction as long as you are not sure about whether the kernel source includes `QT` and `xorg-devel` packages.

3. Check if your system has both `qcolor.h` and `Xlib.h`. Don't the kernel source have them? then, you SHOULD manually install `QT` and `xorg-devel` packages.

4. In case that you installed `QT` manually, you SHOULD set `QT` path to `.bashrc`. open `/root/.bashrc` 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 run, #>. .bashrc

5. It's time to make kernel-compile. go download `linux-2.6.11.3.tar.gz` from http://www.kernel.org/

   (a) Extract it to `/usr/src`,
   `tar zxvf linux-2.6.11.3.tar.gz -C /usr/src`

   (b) Let's set the alias to the folder (MUST name it to `linux`)
   `ln -s linux-2.6.11.3 linux`

   (c) `cd /usr/src/linux`

   (d) Need to patch `supermount` and `bigphysarea`

   (e) `cd /usr/src/linux`

   (f) `patch -p1 < [path]/supermount-ng208-2611.diff`

(g) `patch -p1 < [path]/bigphysarea-2.6.11.3.diff`

(h) `make menuconfig`

(i) under "File system", under "Pseudo file system", check "Supermount removable media support"

(j) under "Process type and features", check "Big Physical Area"

(k) Rebuild kernel source
```
make bzImage
make modules
make modules_install
make install
```

6. Now, set `lilo` configuration. open `/etc/lilo.conf`
set default boot image to "26113-bigphys" `default=‘‘26113-bigphys"`
Go to the line tagged "label=26113-bigphys" and put `bigphysarea=10241 vmalloc=384M` on the end of the line starting with `append`.
save it and quit, run `#>lilo`

7. Do you use `grub` instead of `lilo`?. then, open `/etc/grub.conf` and append `bigphysarea=10241 vmalloc=384M` at the end of "kernel /vmlinuz-xxx ro root=/xxx"

1.3.2 Fedora Core 5(Recommendation) 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-devel` and `QT` MUST be in proper place.

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`.
`patch -p1 < [path]/bigphysarea-2.6.11.3.diff`

7. 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. `cd /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 type and features`
    —- `Processor family`
    ——[*] `Pentium-4/Celeron(P4-based)/Pentium-4M/Xeon`
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`

1.4 AJA OEM_HS (or XENA_HS) Linux Driver

You MUST get an OEM license from AJA Video Systems to fully look into the software development kit (SDK). GLORIAD-KR team only supplies binary release for the driver (MAKE SURE that the binary is targeted to Intel's processor type). Prior to installing the driver, `uv-0.3.9.2` 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. Likewise, `ntv2linux-4.1.0.zip` MAY NOT agree with Mandrake 10.1.

1.4.1 Driver Installation on Mandrake 10.1

Don't you have the SDK?. then, let's follow the next steps.

1. Get `download uv-xhs-bindrv.tar.gz` from http://www.gloriad-kr.org/hdtv/, and place it to the `uv-0.3.9.2` folder.
2. `#> cd ./uv-0.3.9.2/ntv2linux-4.0.0/bin`
3. `#> ./install`

Making no errors will drive you to run `uv-0.3.9.2`. From this point, instructions are turned to those who have XENA_HS SDK (`ntv2linux-4.0.0`). If you don't have it, skip the following.

1. Extract `ntv2linux-4.0.0.zip` into `./uv-0.3.9.2` folder.

2. Get download `uv-xhs-400.diff` from http://www.gloriad-kr.org/hdtv/, and save it to `./uv-0.3.9.2`
3. `#> cd ./uv-0.3.9.2/ntv2linux-4.0.0`
4. `#> patch -p1 < ./uv-xhs-400.diff`
5. `#> export NTV2TARGET=KHD`
6. `#> make`
7. `#> cd ./bin`
8. `#> ./loadKHD`
9. `#> ./programKHD`
10. `#> ./ctwKHD`, You can check whether the driver functions well.

There should be no errors on the way of entire driver installation. Drivers older than `ntv2linux-4.0.0` exhibited poor performance. The latest one (`ntv2linux-4.1.0`) requires a little modification in `uv-0.3.9.2`

1.4.2 Driver Installation on Fedora Core 5

You can take similar installation procedures mentioned above. Note again that `ntv2linux-4.0.0` will not work on Fedora Core 5. MUST apply `ntv2linux-4.1.0.zip`.

Refer to the following step unless you have AJA SDK. It will put binary driver and shared library on your system.

1. Get `download uv-0.3.9.2FC5_bin.tgz` from http://www.gloriad-kr.org/hdtv/, and extract it to a folder.
2. `#> cd ./uv-0.3.9.2FC5_bin/ultragrid/bin`
3. `#> sh ./setup.sh`

No errors? then, everything is ready for `uv-0.3.9.2`.

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-0.3.9.2FC5` folder.
2. Get download `uv-xhs-410.diff` from http://www.gloriad-kr.org/hdtv/, and save it to `./uv-0.3.9.2FC5`
3. `#> cd ./uv-0.3.9.2FC5/ntv2linux-4.1.0`
4. `#> patch -p1 < ./uv-xhs-410.diff`
5. `#> export NTV2TARGET=KHD`
6. `#> make`
   Tips: Got errors?. Refer to 1.4.3 Troubleshooting.

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`.

1.4.3 Troubleshooting

Judging from our previous experiences, you may meet errors while compiling and loading the driver.

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-0.3.9.2` 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, go download OpenGL Utility Library from http://sourceforge.net/project/showfiles.php?group_id=3 (RPMs are available at the bottom, under "Miscellaneous").

1.5 uv-0.3.9.2 (or, uv-0.3.9.2FC5)

`uv-0.3.9.2` takes charge of capturing, transporting, displaying uncompressed video and audio. You MUST get into uv-0.3.9.2 (or, uv-0.3.9.2FC5) with root privileges. MAKE no difference between uv-0.3.9.2 and uv-0.3.9.2FC5 unless otherwise mentioned. Once you get install uv-0.3.9.2, you will see one of the

following directory structures.
The XENA_HS interface is placed in `ntv2linux-4.x.0/commonapps/ioxena`.

```
uv-0.3.9.2 with AJA SDK
  ------- tcl-8.0
  ------- tk-8.0
  ------- ultragrid
  -------------- bin
  ------- ntv2linux-4.x.0, or

uv-0.3.9.2 with binary driver
  ------- tcl-8.0
  ------- tk-8.0
  ------- ultragrid
  -------------- bin
  -------------------- xhsdrv
  ------- ntv2linux-4.x.0
```

1.5.1 Build (Mandrake 10.1 or Fedora Core 5 with AJA SDK)

You may already finish the entire installation procedures including driver patch. Now, it's time to make `uv-0.3.9.2` runnable. Let's make install `tcl-8.0`, `tk-8.0`, and `uv-0.3.9.2`.

1. Go to `uv-0.3.9.2/tcl-8.0/unix` (if you have binary, skip it)
   ```
   #> make clean
   #> ./configure; make
   ```
2. Go to `uv-0.3.9.2/tk-8.0/unix` (if you have binary, skip it)
   ```
   #> make clean
   #> ./configure; make
   ```
3. Go to `uv-0.3.9.2/ultragrid`
   `#> ./configure --enable-xenahs`, or
   `#> ./configure --enable-xenahs --enable-ALSA` (In case that you've already installed Linux ALSA driver).
   `#> make`

1.5.2 Build (Mandrake 10.1 or Fedora Core 5 without AJA SDK)

You don't need to re-build `tcl`, `tk`, and `ultragrid`. Use the package as it is.

1.5.3 Shell Scripts (Mandrake 10.1 or Fedora Core 5)

Mandrake 10.1

There are 4 scripts (pertaining to system tuning) in `uv-0.3.9.2/ultragrid/bin`. You MUST change given parameters (IP address, alias, and so forth) in the scripts to make your system reflect networking environment. NOTE that one of the *tuning* scripts (`init.sh`, `10init.sh`, or `dual_init.sh`) MUST be ran prior to the use of `ultragrid`. The role of each script is as follows.

- `init.sh`, initialize XENA_HS driver, tweak kernel parameters and network interface. Apply it if you're using a single Gbps NIC.

- `10init.sh`, same as `init.sh` other than it is for 10 Gbps interfaces. Apply it if you're using Chelsio's 10Gbps NIC.

- `dual_init.sh`, same as the previous except it is the script for tuning dual-port Gbps interfaces. Apply it if you're using a dual-port NIC.

- `blt.sh`, You can use the script to remake `uv-0.3.9.2`. Apply it as long as you already have XENA_HS SDK.

Fedora Core 5
Three scripts will be shown in `uv-0.3.9.2/ultragrid/bin`. The roles and uses of the scripts are like these. NOTE again that `tune.sh` has to be invoked before driving `ultragrid`

- `setup.sh`, device driver and shared library will be placed onto your box. It only works for our binary release.

- `tune.sh`, tuning scripts for kernel buffer and interface options.
  - direction for use -
  `sh ./tune.sh single eth0`: tweaking 1 Gbps interface named eth0
  `sh ./tune.sh chelsio eth0`: tweaking 10 Gbps interface named eth0. script subject to Chelsio's 10 Gbps NIC.
  `sh ./tune.sh dual eth0 eth1 192.168.0.2 192.168.0.3`: tweaking two 1 Gbps interfaces for dual-port transmission. 192.168.0.2, destination will be bound to eth0 and 192.168.0.3 to eth1.

- `blt.sh`, you can use the script to remake `uv-0.3.9.2`. Apply it when you already have AJA SDK.

1.6 Chelsio N210 10Gbps Network Interface Card

`uv-0.3.9.2` 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-0.3.9.2` supports xVideo extension (SDL, too). Thus, you must select a proper graphic card which ensures xVideo extension. We adopted NVidia Geforce 6600GT and 7600GT for the purpose. You may check `#> xvinfo` to know whether your graphic card upholds xVideo.

If you face errors while operating `uv-0.3.9.2` with `-d xv` option, open `/etc/X11/xorg.conf`, and set `DefaultDepth` and `Depth` in `Section "Screen"` to 24.

1.8 Summary - Installation Procedure

1. OS installation (Mandrake 10.1 or Fedora Core 5)
2. Update Linux kernel
3. Get extract `ultragrid` package (GLORIAD-KR ver.)
4. Place AJA SDK (optional)
5. Load device driver and put shared library in place
6. Run tuning script

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 InterruptThrottleRate=0,0 TxIntDelay=0,0 RxIntDelay=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-0.3.9.2` already got tuning scripts in `./bin` directory.

```
mtu_size = 9180
tx_queue = 90000

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=6000
```

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 [destination_addr.]  dev [source_interface]
route add [destination_addr.]  dev [source_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`, 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-0.3.9.2` will be happy to get at least 860 Mpbs sustained network bandwidth. so, you MUST observe the performance in advance. Although `uv-0.3.9.2` 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]
```

2.3.4 Links

- http://www.gloriad-kr.org/hdtv/
  get download `uv-0.3.9.2`
- http://fr.rpmfind.net/linux/rpm2html/search.php?query=kernel
  RPM resource - kernel source

Chapter 3

Run uv-0.3.9.2

3.1 Command Options

The main software, uv, exists in uv-0.3.9.2/ultragrid/bin. The uv can take one or more of the following options.

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

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`