A VSI-H Compatible Recording System for VLBI and e-VLBI

Jouko Ritakari, Ari Mujunen

Metsähovi Radio Observatory

Contact author: Jouko Ritakari, e-mail: Jouko.Ritakari@hut.fi

Abstract

Metsähovi is developing a scalable disk-based recording system. The system uses standard PC hardware and standard Linux operating system. VLBI data is stored in normal Linux files and can be transported via Internet using normal Linux networking programs. This makes the system especially suitable for short-term storage of data for near-realtime VLBI. We have estimated that it is possible to replace an existing VLBI recorder with only one office PC and that the system is scalable to at least 2048 Mbit/s just by adding a few more PCs.

1. Introduction

The PC-based recording system we are developing at Metsähovi is one of the half a dozen projects that attempt to use off-the-shelf PC technology and Internet in VLBI.

Our project differs from the others in the respect that we do not try to re-design the technology to fit VLBI, we are using it with minimal modifications.

2. Underlying Philosophy

At this moment it is possible to use inexpensive office PCs and achieve 256 Mbit/s recording speed and 480 GB recording density in one machine. For comparison, the recording speed of a Honeywell 96-based recorder is 256 Mbit/s with one headstack and the capacity of a thin tape is 600 GB.

If we want to double the speed or the capacity of an office PC, it is possible but difficult. An order of magnitude improvement is almost impossible.

We think that it is better to stay with the mainstream technology and let the computer industry take care of improving the speeds and capacities.

3. Things We Have Tried to Avoid

The most common mistake in VLBI is to think that the data is somehow special, it must be formatted and transported in real-time data streams that must be synchronized.

Well.

The commercial PCs are very good in storing data in files but they are terrible in synchronizing data streams.

Internet is very good in transferring data, but terrible if real-time transfer is required.

In our opinion it is better to think that the data is normal data. It can be stored on hard disks in normal file formats and the files can be transported with FTP or other commonly used Internet protocols.

4. System Architecture

The system is built using normal PCs with Linux operating system. The data is stored into files in Linux file system according to the well-known FITS format, widely used elsewhere in VLBI.

No formatting of data is required because the 1PPS marker in the VSI data stream is used to divide the data into slices that contain an integer number of seconds.

If expansion beyond the capabilities of a single PC is required, time-multiplexing the data into several PC:s is the preferred method. That means that each PC captures several seconds worth of data synchronized by the 1PPS pulse, then the next one starts the data acquisition.

5. VSI Input/Output Board

The VSI input/output board is a simple standard-size PCI board with the following features:

- Two bidirectional VSI-H ports.
- Data acquisition at VSI clock rate or VSI clock rate divided by an integer.
- Normally one VSI port is used as input, second port as output.
- Facilitates chaining of PCs, which eliminates the need for a separate VSI data distributor. The 1PPS marker in the VSI port is used to synchronize the computers.
- 512 Mbit/s sustained I/O capability to/from main memory.
- Uses PLXtech PCI9054 and Xilinx Spartan II chips.
- 1024 * 32-bit internal FIFO to overcome PCI bus latencies.
- Can either record the data in parallel or separate four 1-bit or 2-bit channels in different files.
- The same board can be used to play the data back to correlator.
- The board supports scatter/gather DMA and can be used to format the data during playback.

The board can be connected directly to the Japanese Giga-Bit VLBI sampler or with a simple adapter to the existing VLBA or Mark IV systems, either directly to samplers or to the formatter outputs.

The programming interface of board is very simple, it really has only two commands. The first command is "reset everything" and the second command is "wait for the next 1PPS pulse and capture X seconds worth of data in computer main memory". These commands facilitate easy time-multiplexing of the data acquisition. The control of the board is not time-critical, the computer has one whole second to start the capturing even in time-multiplexed mode.

A picture of the layout is in Figure 1 at the end of this document.

6. VLBA to VSI converter

The VLBA sampler to VSI converter is a stand-alone module that converts the data from VLBA samplers to the VSI format. It is really only a level converter, but a Xilinx Spartan II chip has been added for expandability reasons.

- Two VLBA sampler 40-pin inputs (differential ECL).
- Two VSI-H compatible LVDS outputs.
- The VSI ports are identical, both output all the sampler signals.

Similar converters can be easily designed for Mark IV sampler to VSI conversion or Mark IV formatter to VSI conversion.

However, we think that the best approach is to connect directly to the sampler outputs. There are two reasons for this: First, the function of the formatter is to change the data into a form that can be recorded on a tape recorder. There is no tape recorder in our system. The second reason is that the formatter fans out the data to lots and lots of tracks, one 32 Mbit/s signal goes to four tracks. If we use formatter outputs, we must have another device to multiplex the data back to one track. Nothing is really accomplished, but a lot of electronics is needed.

7. Performance

At this moment the performance of the system is limited by the speed of the hard disks. One PC can sustain a speed of 256 Mbit/s to disks.

We expect the sustained recording speed to increase to 512 Mbit/s later this year as the speeds of the hard disks and the architectures of PC motherboard chipsets improve.

8. Expandability

The system is designed to be scalable.

If we need 256 Mbit/s sustained speed, we need only one PC.

If we need 512 Mbit/s sustained speed, we chain two PC:s together and time-multiplex the recording.

If we need 1024 Mbit/s sustained speed, we use two chains of two PC:s.

When new PC bus architectures (64-bit 66MHz PCI or some totally different architecture) emerge, the design can be easily modified. The bus interface chips have simple interfaces to the local bus on the board and the Xilinx is programmed in VHDL language.

9. Future

The PC technology keeps improving. We expect that later this year we can achieve 512 Mbit/s throughput using only one PC.

When the 64-bit 66MHz PCI chips arrive later this year, the PCI bus speed quadruples and we can achieve up 2048 Mbit/s speed from the VSI port to computer main memory.

When the serial ATA disks arrive, hopefully the disk cabling inconveniencies will be solved.

In this system the data is already organized into normal files in the Linux file system, migration into the use of Internet is easy.

The data in the files is error-free sampler data with no formatting, migration into distributed correlation is easy.

Anyway, the beauty of this design is that it adapts very easily to evolving standards. There are no expensive black boxes anywhere.

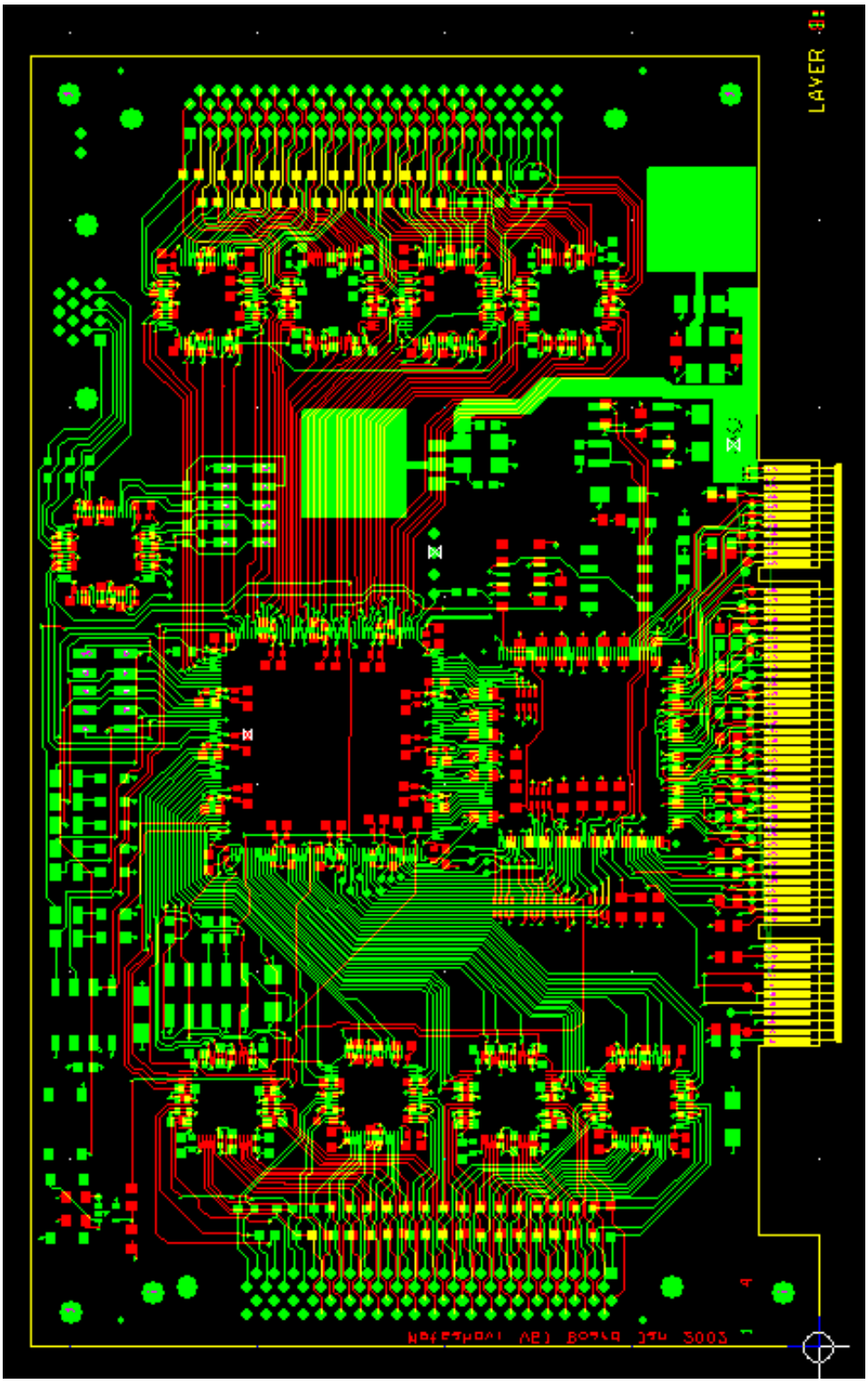

Figure 1. VSI Input/Output board layout.