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Operational Experience with the Mark 5 Recording System at the Bonn and USNO Correlator

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Abstract

We present a short overview of operations with the Mark 5 recoding system at the Bonn Correlator. Most IVS stations and many astronomy stations are equipped with the new Mark 5A units and recordings have been correlated in Bonn since 2002. We describe our experience with those recordings, the problems encountered, and their solutions.

1. Introduction

The Mark 5 VLBI data system is being developed as the first high-data-rate VLBI data system based on magnetic-disc technology. With sustained data rates of 1024 Mbit/s and storage limited only by the ever-increasing capacity of magnetic discs, the Mark 5 represents a radical departure from the traditional VLBI dependence on magnetic tape. The Mark 5A VLBI data system is about to become the most widespread recording system among the IVS community, and it has been defined as the new standard for the EVN. NRAO is actively seeking funding for the implementation of Mark 5 at the VLBA and its correlator.

The Mark 5 is based on a standard PC platform and uses a combination of COTS (commercial-off-the-shelf) and custom-designed interface cards. The heart of the system is a “StreamStor” disk interface card from Conduant Corporation that is specially designed for high-speed-real-time data collection and playback. Developed in cooperation with MIT Haystack, this rack mountable recorder features two hot-swappable 8-drive modules. The Mark 5 can record continuously by alternating between the two 8-pack modules. It can record and play back 8, 16, 32 or 64 tracks from a Mark IV or VLBA formatter with a maximum data rate of 1024 Mbit/s and 512 Mbit/s respectively. As such Mark 5A is a direct replacement for a Mark IV tape unit. Software, firmware, and hardware have been constantly improved by both Conduant Corporation and Haystack Observatory.

A new backplane which will accept both parallel and serial ATA disks is being developed by Conduant Corporation and should be available around summer 2004. NRAO will upgrade their tape tracking software “track” so that it will handle discs as well.

The advantages of the Mark 5 system are:

- robust operations, low maintenance cost,
- easily transportable,
- conformance to the VLBI Standard Interface (VSI) specifications, planned for Mark 5B,
- design based primarily on unmodified off-the-shelf subsystems and components,
- unattended operation limited by available disc sizes,
- cost for recording media (ATA disks) drops continuously,
- rapid random access to any data,
- instant synchronization on playback into the correlators,
- easily upgradable host platform,
- the data are written to all discs simultaneously in a "round-robin" fashion so that a single failing disc will not lead to the complete loss of one or more channels,
- data of a broken disc are replaced by a fill-pattern, which is recognized by the correlator,

Disadvantages:

- The disc modules have to be handled carefully,
- Some kinds of discs are more susceptible to damage in transport as the heads are parked on the disc platters,
- Disc packs must not be inserted into the Mark 5 unit with brute force as the 200-pin connector might get damaged
- The StreamStor card can hang occasionally.

Short history of Mark 5:

September 1999	Haystack Observatory white paper states the goals of a next generation 1 Gbit/s VLBI data system.
May 2000	Haystack Observatory proposed the development of a new high-data-rate VLBI data system based mostly on commercial-off-the-shelf (COTS) technology.
January 2001	COTS-VLBI interim report states discs should be future recording medium for VLBI.
March 2001	First Mark 5 demonstration system at 512 Mbit/s, built in two months. Upgrade plan to 1024 Mbps.
June 2001	Proposal for support of Mark 5 development to BKG, MPIfR and other agencies.
July 2002	First Mark 5P system received at Bonn correlator.
October 2002	Intensives started using Mark 5P.
December 2002	First two Mark 5A systems arrived at the Bonn correlator.
May 2003	First successful observation at 1 Gbit/s in the EVN with four telescopes.
September 2004	Eight Mark 5A systems are installed at the Bonn Correlator.

2. Bonn Correlator Status with Mark 5

Eight Mark 5A units have now been integrated into the correlator. As a default they are connected to the second head input of the station units (SU). In this setup all 32-track modes can be correlated with either tape or disc, changed using just a software switch. Single pass correlation of modes using up to 1 Gbit/s can be done, with simple re-cabling. Correlation with Mark 5 is now more or less standard and already more robust than correlation with tape drives. Various modes (including Mark III Mode C) have been correlated successfully with mixed disks and tape in a production mode. Roughly between 30% to 40% of all data correlated are now on Mark 5.

The Bonn correlator is awaiting its first IVS-R1 experiment which is a Mark 5 only recording. More experience and statistics in detailed form can be found in "Geodetic VLBI at Bonn Correlator" in this proceedings. Current and regularly updated correlator capabilities are listed at http://www.mpifr-bonn.mpg.de/EVN/MK4CORstatus.

3. USNO Correlator Status with Mark 5

Intensives started using Mark 5 with Mark 5P units in October, 2002. Initially, both tapes and discs were used to make sure experiments were successful. From November, 2002, Intensives were Mark 5 only. Today the Mark 5 Intensive processing factor is 1.0, which is better than the tape Intensive processing factor of 1.5. Reprocessing was cut from an average of one scan per experiment to one scan every four experiments. Very few failures occured in more than 200 Intensives. Some failed recordings and a few delayed processing runs were due to vacation of a critical person at a station and a correlator and to a Mark 5P to Mark 5A switchover. In addition two discs were lost in shipment but later found. Experience with our 24 hour experiments show that USNO has reduced the processing factor by 20% to 25% (2.5 to 2.0 and 2.0 to 1.5) and the reprocessing by almost 75%. We attribute this to converting two or three station to Mark 5 operation in the six or seven station experiments, which reduced the need for operator intervention.

4. Mark 5 Correlation Problems

Mark 5 8-packs have to be handled with care. After switching off an 8-pack the disc pack should not be removed from the Mark 5 before all discs have come to a stop, approximately 20 seconds. This is especially true for discs that park the heads on the platters. All disc-packs are uniquely identified with a "volume serial number" (VSN) both on the outside and electronically on the discs. At the correlator occasionally disc-packs are received where the VSN on the discs differs from that on the outside. As a result the modules cannot be identified properly by the operator or software. This can causes problems in tracking modules from station to correlator and creates delays at the correlator. It is not clear where this error happens. However, the stations are requested to check each disc-pack on arrival, and that includes a check of the VSN on the discs before recording.

At the correlators the disc-packs are also identified by the disc serial numbers. Unfortunately the observing logs created at each station during the observation sometimes contain wrong entries. This leads to further delays in correlation if not spotted while the observation is prepared for correlation. All Mark IV correlators have now similar experience with 24 hour experiments. Converting two to four stations to Mark 5A in the six to nine station experiments has reduced the processing factor by 20% to 25%.

5. Gbit/Sec Data Handling with the Mark 5A

5.1. Recording

Mark 5 terminals have been used at several EVN stations at 1 Gbit/s for test observations. Initial problems were encountered due to faulty or outdated firmware, faulty electronics and excessive cable lengths inside the Mark 5 units. After fixing these problems all units could record successfully artificial data generated internally by the Mark 5 unit.

In some cases data from the Mark IV formatters could not be recorded correctly. Apparently this was dependent on cable length between the Mark IV formatter and Mark 5 unit. A length of 0.5 m gave problems, cables of > 2 m similarly. A length of around 1.5 m seems OK. This might be due to bad impedance matching at the formatter output. These cables are also a potential source of RFI. Similary old cables that have been kicking around for many years and have been bent or creased and do not perform well at these high data rates. On the station side it is necessary to check both cables are the same length and routed neatly from the formatter to the Mark 5, and not strapped to any metal objects. These cables must be separated from video monitor cables and other sources of interference, as well as terminator boards plugged into the unused output connectors on the I/O panel on the back of the Mark 5 unit. The built in data checking commands "scan_check" and "track_check" provide an excellent indication of recording quality, unfortunately staff at some stations do not pay sufficient attention to these entries in the log. Dan Smythe has written some field system SNAP files that can be used to configure an acquisition system for 1024 Mbit/s and test its performance (see chk1024/vchk1024 commands).

5.2. Playback

Typically Mark 5 units are connected to the "upper" input connectors of the station unit, originally designed for the second head of tape drives. The single head of a tape unit is then connected to the "lower" input pair of the station unit. This enables easy software switching between tape and disc operation for each station unit. At 1 Gbit/s this is no longer possible, the connection between Mark 5 and station units must be changed to connect 64 tracks of the Mark 5 to the station unit. Correlation seems to be without problems, except for cases in which the online system already reports problems during the recording. Reports from the JIVE correlator indicate problems with data in which a LSB channel has been recorded without accompanying upper sideband channel. Also they reports problems with TRMS, which is visible in auto-correlation. A fix is being worked on. It is not clear if this affects all Mark IV correlations.

6. Mark 5B

The Mark 5B VLBI data system is now being developed by MIT Haystack Observatory in collaboration with other Institutions. It is expected that it will be deployed at the beginning of 2005. The Mark 5B will have a VSI-compliant interface and command set, and will be based on the same physical platform as the Mark 5A. The Mark 5B will bypass the formatter and connect directly to the output of the samplers (through a simple interface). This will allow a maximum data rate of 1024 Mbit/s also for VLBA record terminals. It will be compatible with the planned digital BBCs, which will have only VSI interfaces.

The Mark 5B will include simple Mark IV station unit capability, which will allow us to replace the bug-ridden station units which are the weakest points of the correlator. It will also allow a relatively inexpensive expansion of the number of stations at the existing Mark IV correlators. According to present planning the Mark 5B systems will not be able to play back Mark 5A recordings, while compatibility in the other direction is foreseen.

7. Conclusions

The Mark 5 system has been shown to make VLBI data recording and correlation significantly more robust and at the same time reduces the cost for maintenance and media drastically. Both geodetic and astronomical VLBI observing can soon profit from increased sensitivity provided by recording at data rates up to 1024 Mbit/s. The throughput can be higher than with tapes and should allow IVS to reach its ambituous plans for observing in the next few years.

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