Haystack Observatory – Status and Developments

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Mark 5 Thumbnail Summary

Mark 5A	- Direct replacement for Mark 4/VLBA tape drive - 1Gbps - Operates with Mark 4 correlator
Mark 5B	- Requires data on VSI-H interface - 1Gbps - Operates with Mark 4 correlator (w/CIM interface)
Mark 5B+	- Requires data on VSI-H interface - 2Gbps - Requires Amazon StreamStor card
Mark 5C	- 10GigE data interface; will support VDIF format data - 4Gbps (requires two Mark 5 modules simultaneously) - Support arbitrary # of channels (i.e. not limited to 2^n) - In development; expect prototype Q4 2008 - Playback through host motherboard/NIC interface

All Mark 5 types compatible with standard Mark 5 disk modules

# Generalized 10GigE Data Distribution Concept
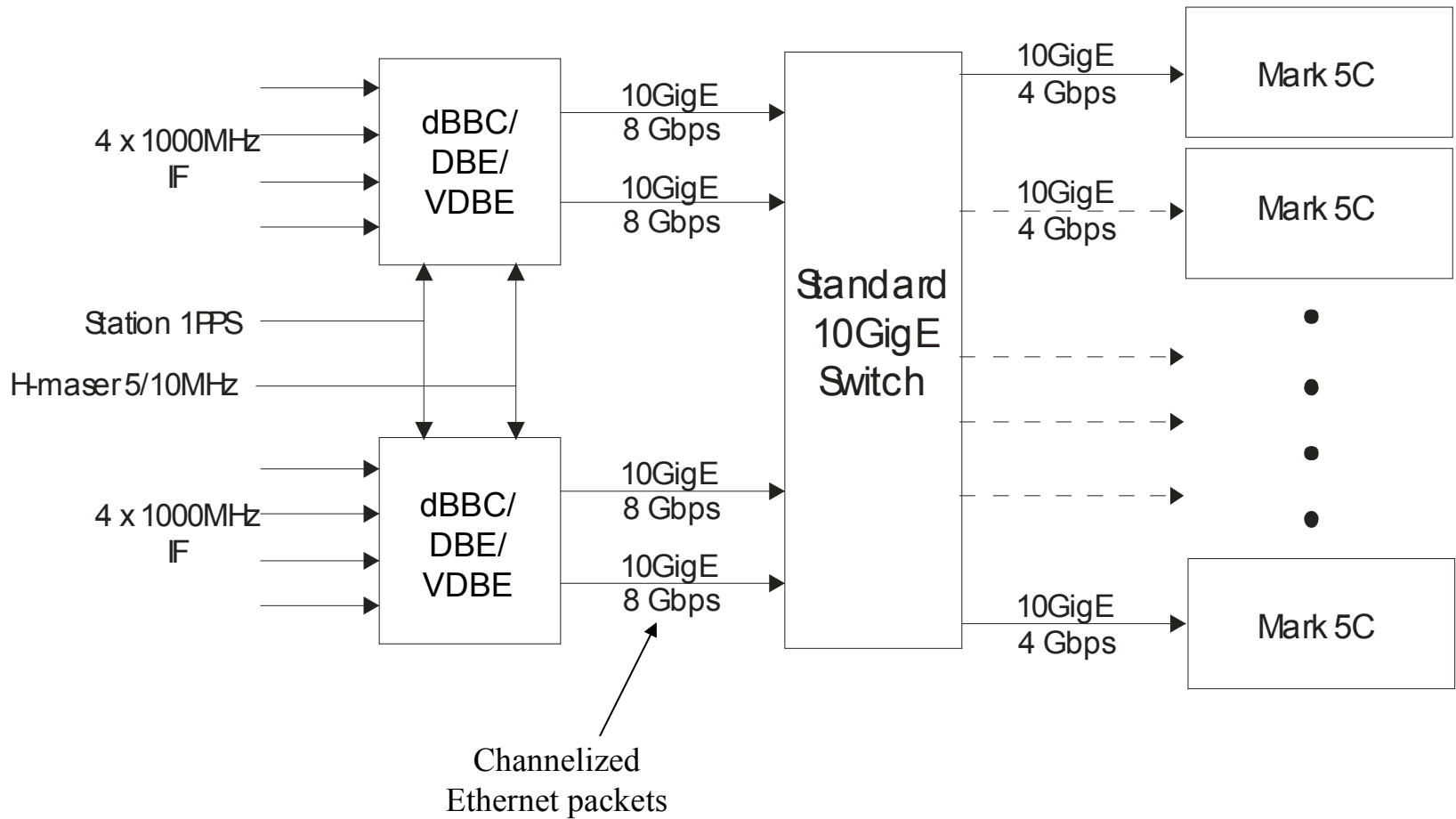
# Mark 5C Version 1 (aka "Mark 5c-")

- Record path
  - Receive data from a standard NIC
  - Store data to COTS storage
- Playback path
  - Read data from COTS storage
  - Outputs data via standard NIC
- Provides the framework of application
- Limited performance capabilities < 1Gbps
- Interface for command / control
  - Command line

Mark 5C Version 2
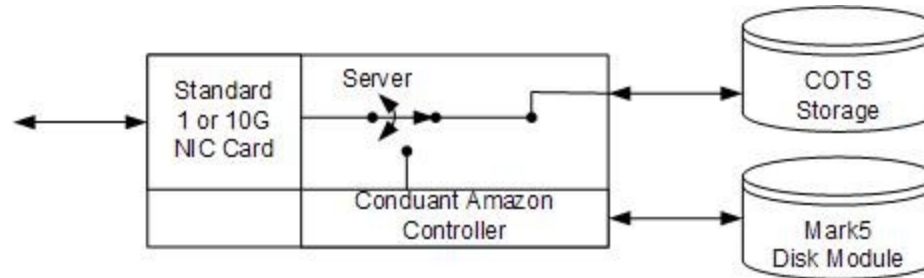
- Added capabilities
  - Record path stores data to Conduant disk module
  - Playback path reads data from Conduant disk module
- Interface for command / control
  - Full command line capabilities
    - for Mark5C-
  - Initial version of Graphical User Interface

Mark 5C Version 3
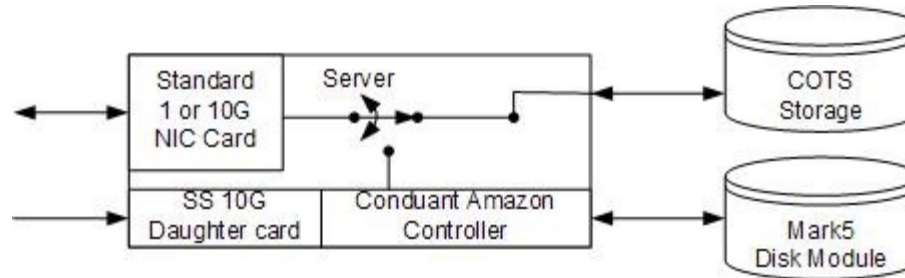
- Added capabilities
  - Support for Conduant's
    - Hardware - 10Gbps daughter card
    - Software Design Kit (SDK)
  - Data received / stored by Conduant controller card
  - Initialization of controller card
  - Packet acceptance criteria
  - Status of hardware / receive process

Mark 5 Upgrade Costs

Existing \ Target	Mk5A	Mk5B (requires VSI-H data source)	Mk5B+	Mk5C (not yet available; rough estimates)
0	Unavailable	$20.8K	~$22.3K	~$23K
Mk5A	-	~$3.5K (Mk5B I/O)	~$13K (Amazon plus Mk5B I/O)	~ $12K (Amazon plus 10GigE DB)
Mk5B	-	-	~$9.6K (Amazon)	~ $12K (Amazon plus 10GigE DB)
Mk5B+	-	-	-	~$3K (10GigE DB)

SATA Disk Support

- SATA now fully supported
- Must have proper firmware and software
- Significant difference noted between disks from different vendors (Seagate best, WD OK, Maxtor poor)
- Conduant will replace old boards in SATA modules already purchased

Debian 'Etch' Mark 5 distribution available

- Replaces Red Hat with freely distributed Debian
- Available as 2 ISO-CD disk images; including Mark 5 software
- Use latest SDK 8.1 release from Conduant
- Has proven quite stable
- Only known issue is somewhat corner-case of switching between 2 SATA modules and 2 PATA modules
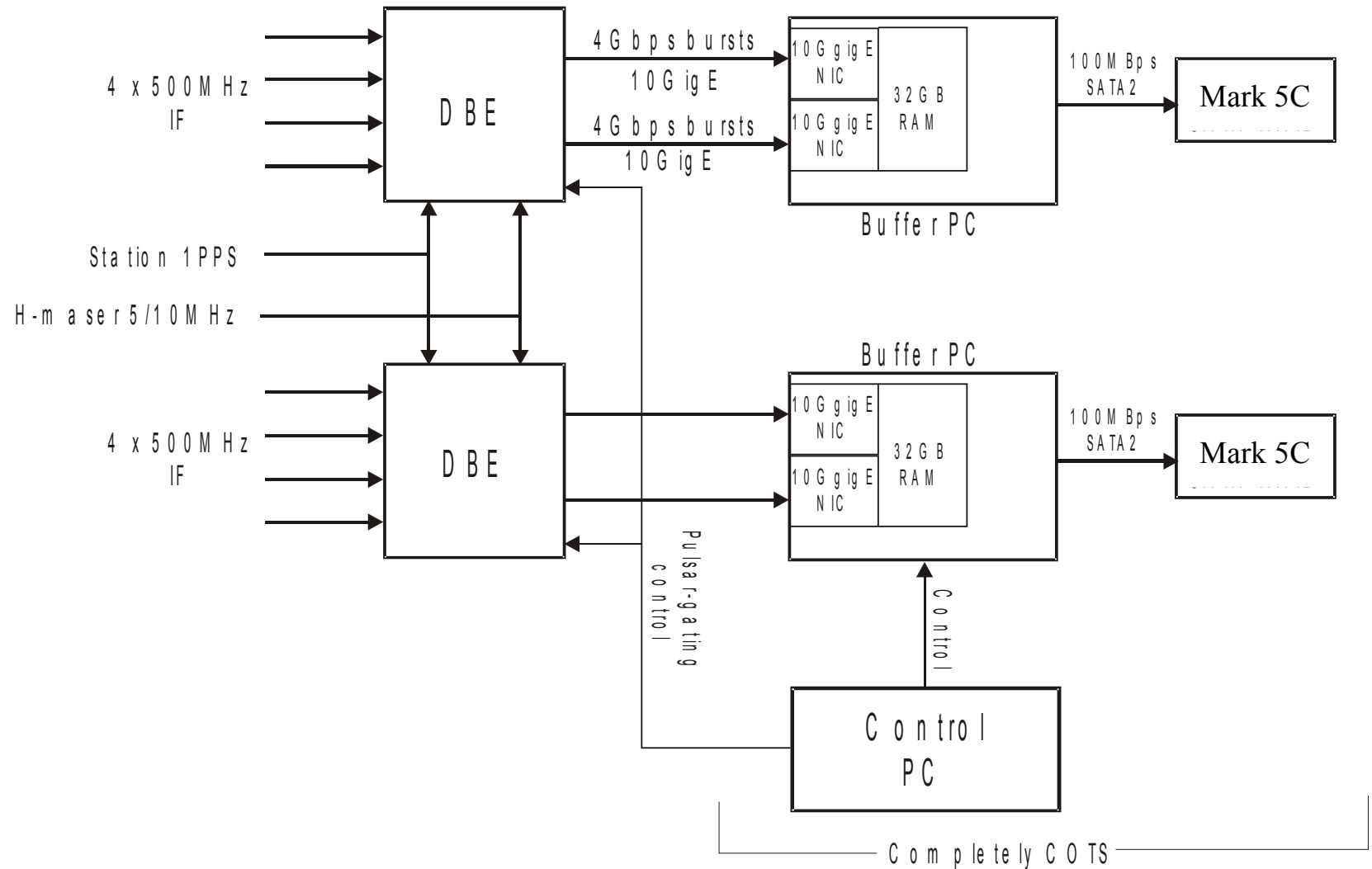- Check Haystack website; contact Chet Ruszczyk with questions

'VDIF' (VLBI Data Interchange Format)

- Panel discussion at Shanghai e-VLBI meeting led to formation of VLBI data standards committee (Mark Kettenis, JIVE; Chris Phillips (ATNF), Mamoru Sekido (NICT), Alan Whitney (MIT, chair)
- Intent is to allow easy transfer of data among heterogeneous systems (Mark 5C, PC-EVN, K5, Australian disk system, etc) using real-time e-VLBI, e-transfer and/or disk files
- Address <u>data format only</u>; e-VLBI transfer protocol will be addressed in a separate specification, yet to be written; combination will replace VSI-E, which was judged too complex
- Based on a Data Frame philosophy with header and data-array, similar to Mark 5B, Mark 5C; Data Frame length is user-selectable according to best compatibility with need
- Draft specification is available, but some discussions still on-going, particularly wrt time format

Digital Backend (ROACH) Development

- Follow-on to highly successful 'iBob' DBE development
- Joint development with NRAO, Haystack, UC Berkeley, South Africa
  - UC Berkeley – concept development, hi-level FPGA design tools
  - S. Africa – schematic design, initial checkout, PPC support
  - NRAO – board layout, "VDBE" design
    - 500 MHz BW IF input
    - 4 (maybe 2) digital BBC; channel BW 64kHz to 256MHz
  - Haystack – PFB "DBE2" design
    - 2 x 1 GHz BW IF; 8 Gbps aggregate output rate
- VDIF data-format standard will be supported
- Packaging: standard 1U PC server "pizza" box
- Cost <$5K
- First ROACH boards – May 2008; initial checkout in S. Africa
- First working VDBE, DBE2 prototypes expected early 2009

16 Gbps Burst-mode System

4 x 500MHz IF

Station 1PPS

H-maser 5/10MHz

4 x 500MHz IF

DBE

4Gbps bursts 10GigE

4Gbps bursts 10GigE

Buffer PC

10G gigE NIC

10G gigE NIC

32GB RAM

100MBps SATA2

Mark 5C

Buffer PC

10G gigE NIC

10G gigE NIC

32GB RAM

100MBps SATA2

Mark 5C

Pulsar-gating control

Control

Control PC

Completely COTS

Frequency source for mm/sub-mm VLBI

- Haystack working with Univ. of Western Australia to develop Cooled Sapphire Oscillator (CSO) technology for VLBI frequency reference

- CSO is as better than most H-masers to 100 seconds; ideal for mm/sub-mm observations

- Requires batched-cooled with liquid H2

- Cost is of order $10,000 per unit (<u>much</u> cheaper than H-maser)

- Expect one CSO with GPS-conditioned, phase-locked 10MHz ref output available for VLBI in 2009

e-VLBI at Haystack/U.S.

- Increasing use of e-transfer for geo-VLBI
    - All daily UT1 'Intensive' observations
    - All geo-VLBI data from Japan and Antarctica
    - Fortaleza connected at ~600Mbps; under test
    - Kokee Park (Hawaii) to be connected soon
    - USNO correlator to be connected soon at ~600 Mbps
- e-transfer critical for verification of mm-VLBI setup
- 10Gps connection active between Haystack and GGAO (Maryland); primary use is for testing of VLBI broadband system
- Investigating 10Gbps connection to Australia for VLBI/MWA, under Internet2 sponsorship; costs unknown
- No support for e-VLBI from NSF; some possibility of NASA support for e-transfer from some VLBA stations for precision spacecraft tracking, but far from certain; very expensive to connect VLBA stations