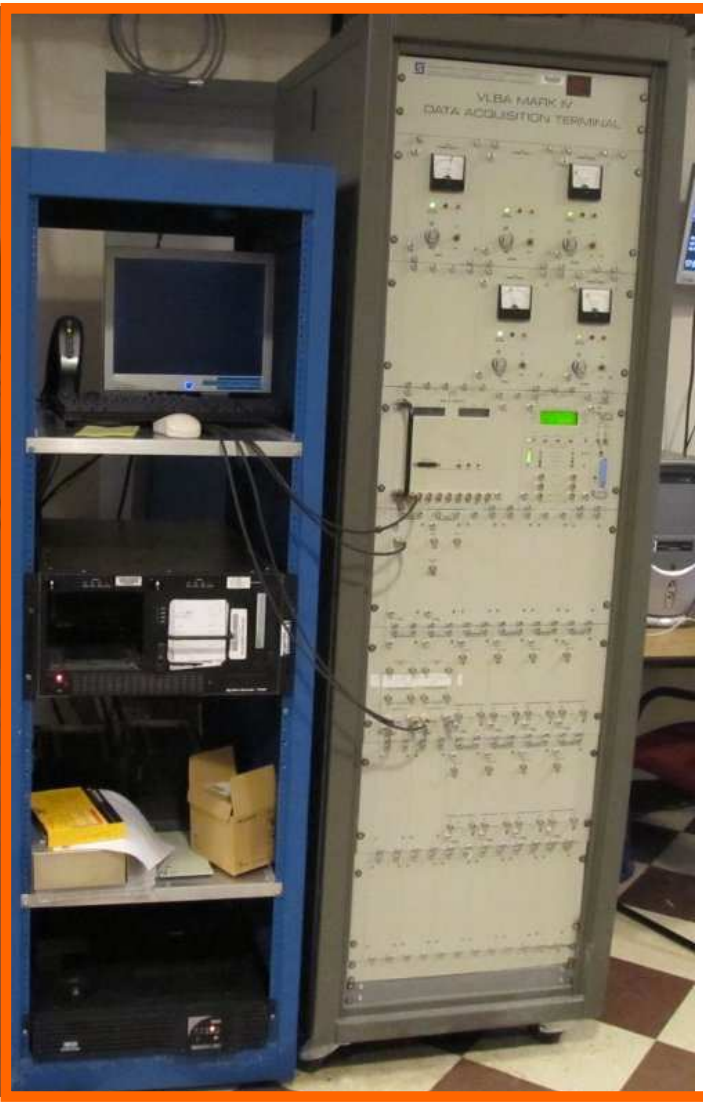
VLBI recording systems at AO

Luis A. Quintero
Digital Section Head
Electronics Department
Arecibo Observatory

VLBI – Very Long Baseline Interferometry

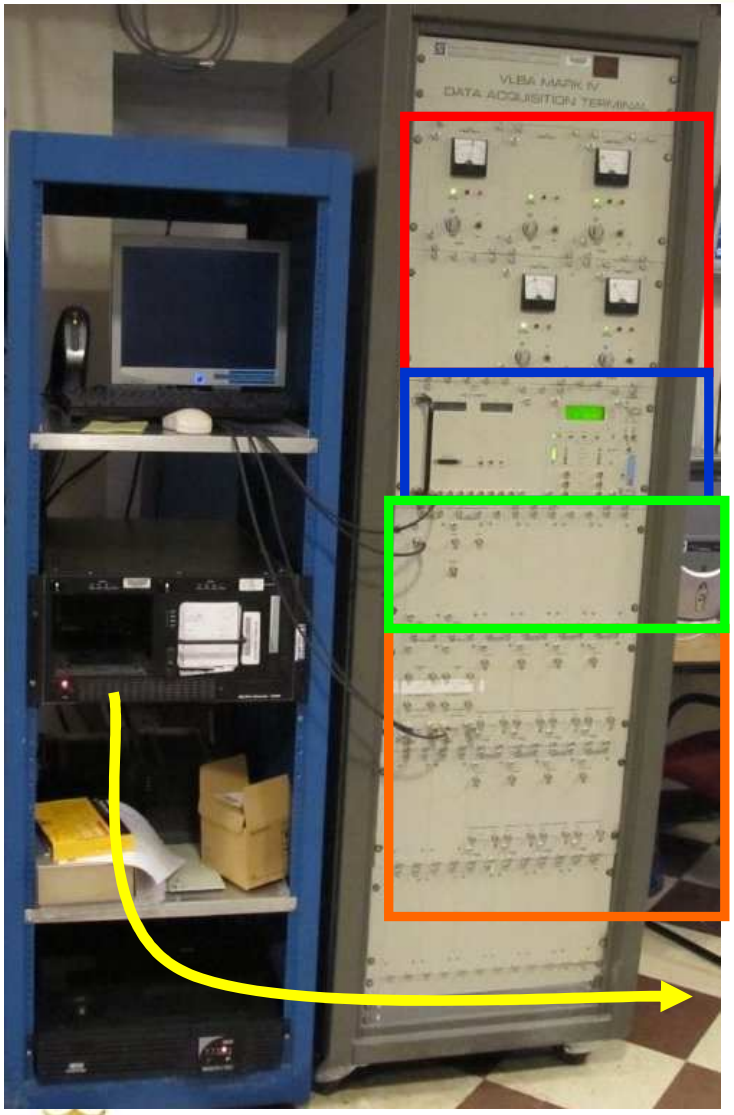
VLBI Systems Available at AO

New



Legacy

VLBI at AO – MarkIV & Mark5A



Power Supplies

Formatter (datataking) and Decoder

Reference Signals, 32MHz and 5MHz

Baseband Converters, eight

Recorder

VLBI at AO – RDBE & Mark5C

RDBE – Roach Digital Back-End
rdbe1, rdbe2, rdbe3, rdbe4

Mark5C – mk5c1, mk5c2

Field System (FS) server – vlbis1, vlbis2

RDBE and Mark5C at AO - timeline

- Apr 2009, Received proposal from NRAO, Steven Durand

- Dec 2010, Received the first RDBE

- 14 Mar 2011. Received Mark5-744, and two disk packs (NAIC+{003,004}/8000/1024).

-11-12 Jun 2011, BB297C[1] observation using Python scripts, single scan observation.

- 29 Aug 2011, EVN TOG 2011, Arecibo PR. Python scripts presented during the meeting.

- Aug-Sep 2011, Arun ordered two new 1U computers for the Field System. Only one installed in the rack, the other computer in the box. Software moved to the new server, but not tested.

RDBE and Mark5C at AO - timeline

- 1-2 Nov 2011, 9th US VLBI Technical Coordination Meeting, NRAO, Socorro NM. Extensive talking with Walter Brisken about porting Executor (VLA and GBT NRAO control program) in AO. Walter is trying to establish the collaboration.

- 15 Nov, 2011. RDBE Synth/ALC board FPGA firmware update to rev11 or v0x0B. Previous version: RDBE1/NAIC1 v0x09, RDBE2/NAIC2 v0x0A. Updated provided by Chester Ruszczyk.

- 27 Nov 2011, UPRM COOP request for student, see "20111027_lquintero_coop_prj.txt". Student selected (Yolian Amaro, REU2011 student), but no money to hire a student for six months (transition effects...).

- 13 Feb 2012, COOP proposal modified for ten-week REU program, more details on "20120213_lquintero_reu_rdbe.txt". No response from UMET admin.

RDBE and Mark5C at AO - timeline

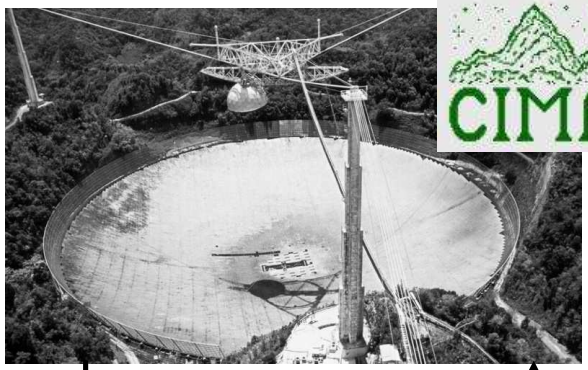
- 14 Mar 2012. Received Mark5-743 and two disk packs (NAIC+{001,002}/8000/1024). Software updated by Chet R. at MIT Haystack. Software update required for Mark5-744, not done yet.

- 26 April 2012, during AOUC 2012 meeting. Electronics dept. meeting with Walter Brisken to talk about RDBE/Mark5C integration to AO. The Executor can not be shared to us, only few codes or specifications. Unknown status of FS. Luis is going to share manuals, software, etc with Prakash and Phil, related to RDBE/Mark5 monitor and control.

- Jan 2013, David Graham and Ed Himwich collaboration installing FS.

- > Feb 2013, BM352 Observations in progress, but a lot to improve (e.g. tsys)

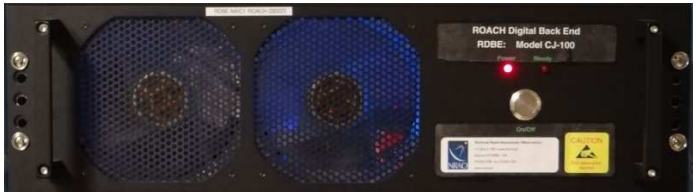
RDBE & Mark5C Data-taking



AO Net

IF/LO

VLBI Net



10GbE

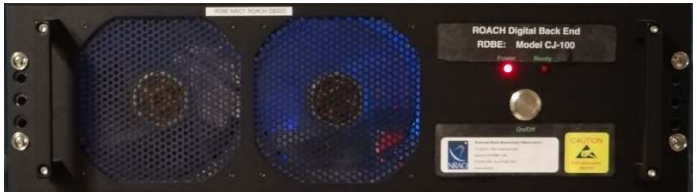
RDBE & Mark5C Data-taking

Modbus

AO Net

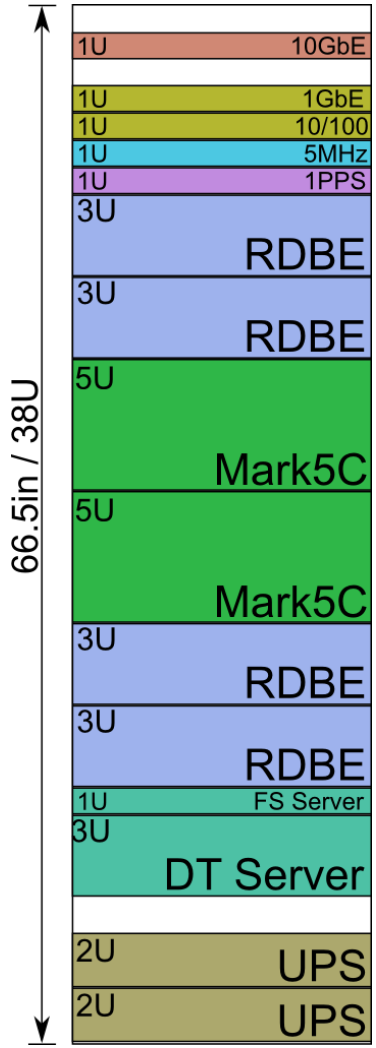
UDC

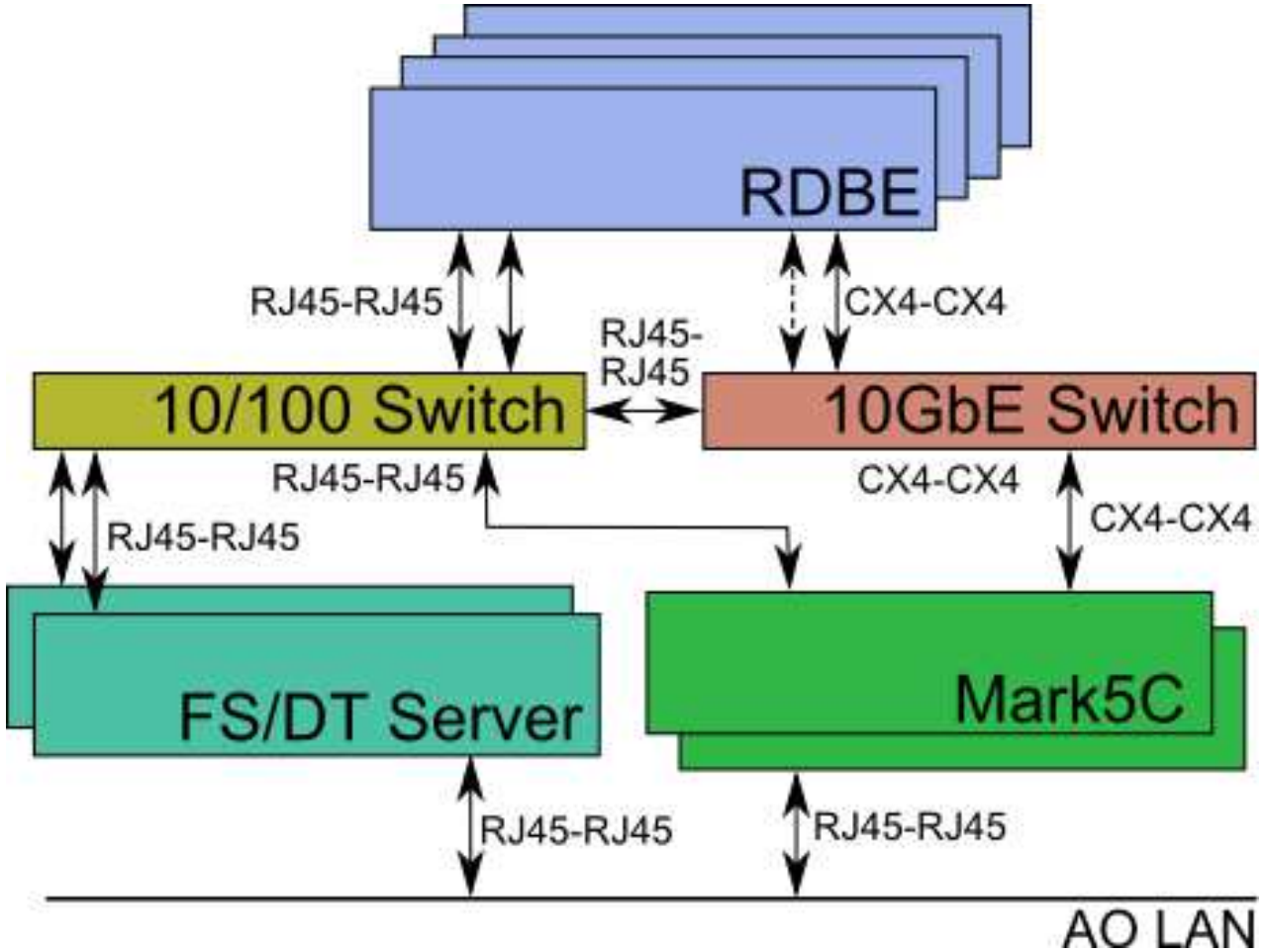
VLBI Net



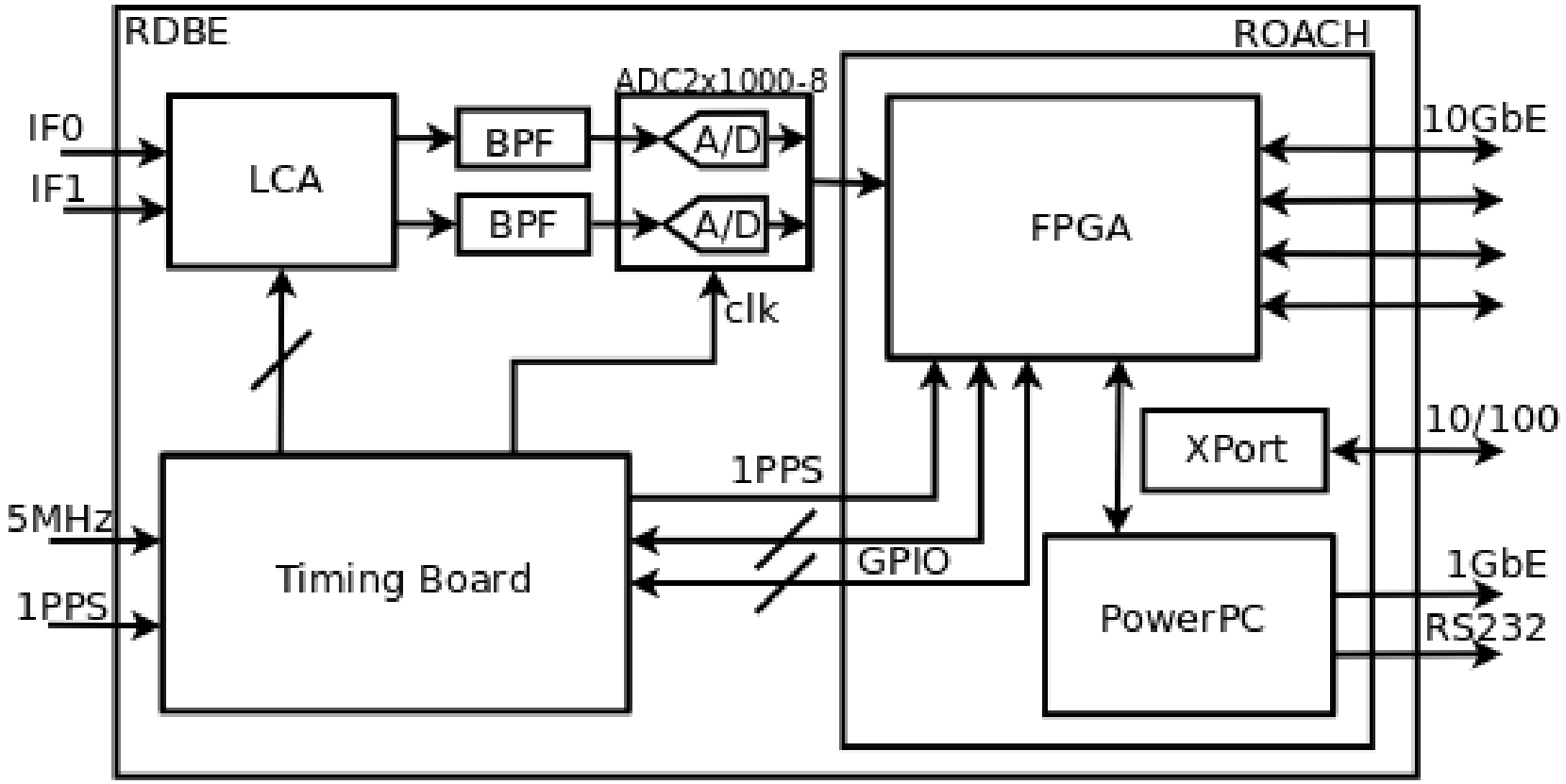
10GbE

RDBE & Mark5C Network





RDBE Architecture - Hardware



RDBE Architecture - Firmware

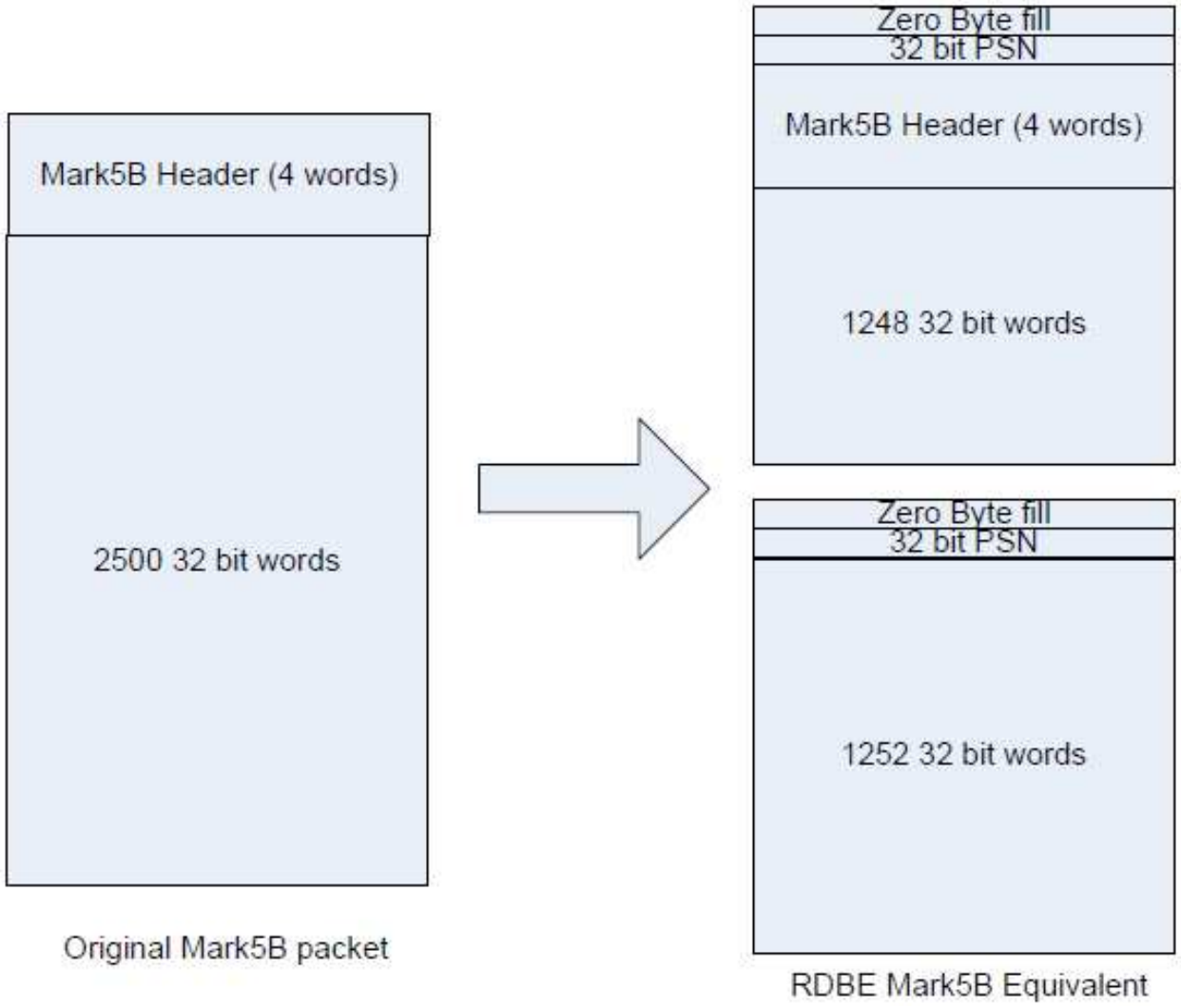
FPGA Personalities:

1. Polyphase filter bank-geodetic (**PFBG**): channelization into sixteen 32-MHz channels from two 512MHz Ifs, output in Mark5B data format.

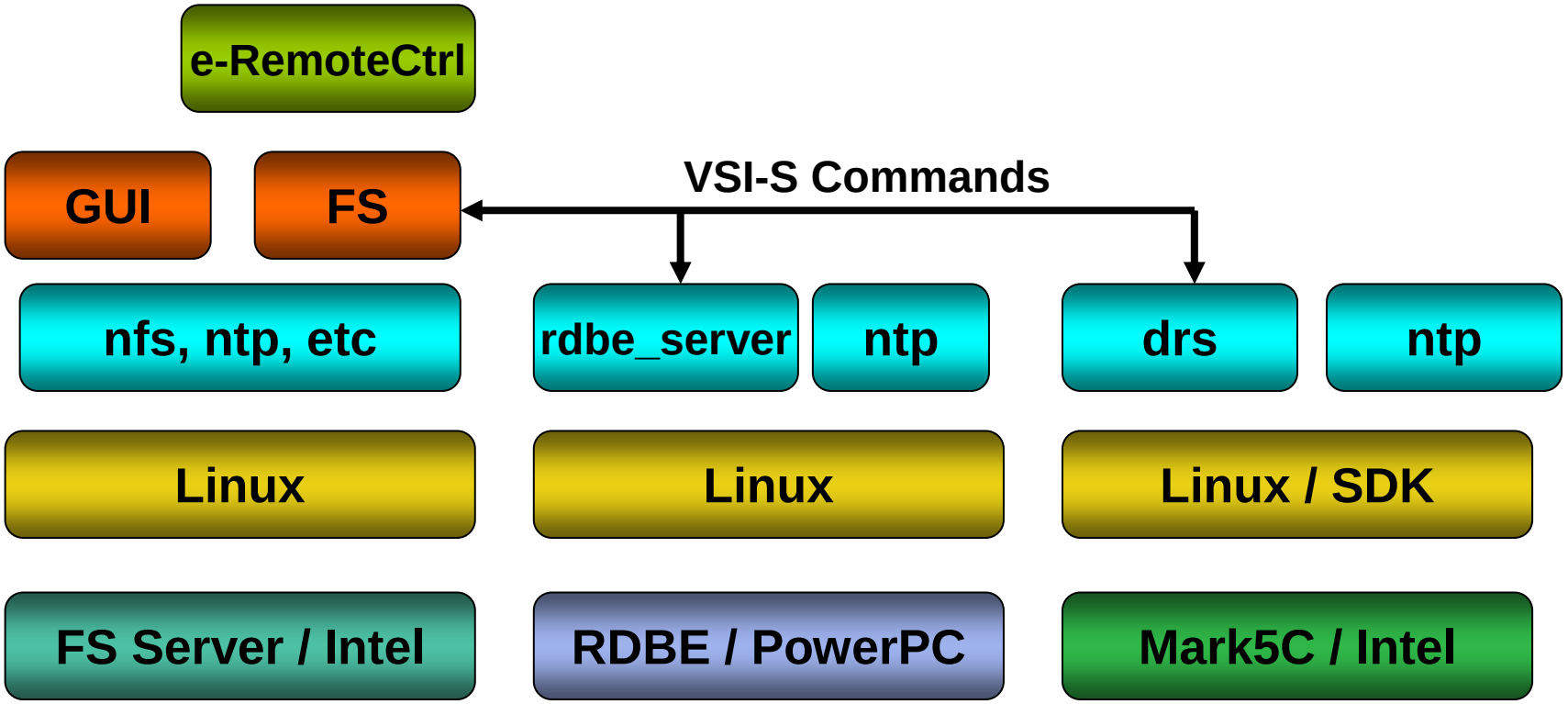
2. Polyphase filter bank-astronomy (**PFBA**): four 512-Mhz IFs are 2-bit quantized and output using two of the 10Gbps CX4 interfaces at 4Gbps / interface with 5000 byte packets using a VDIF format.

3. Digital Down Converter (**DDC**): channelization into sixteen channels with tunable bandwidths ranging down in binary steps from 128 MHz from two 512Mhz IF and output in Mark5B formats 2 bits / sample

Data Packets



Software – Abstraction Layers



VSI-S Commands - RDBE

DBE Memo#12.1
Mark 5 Memo #090.1

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886

5 June, 2012

Telephone: *781-981-5951*
Fax: *781-981-0590*

TO: Distribution

FROM: Chester Ruszczyk, Mikael Taveniku

SUBJECT: Digital Backend Software Command Set – Ver. 1.2

1. Introduction

This document describes the command set that the program to be used as the primary software interface on the second generation VLBI digital backends must support. This program will be the command and control interface for the embedded device. The name of the application is rdbe_server, for DBE command and control server daemon, where RDBE refers to the ROACH Digital Backend.

http://www.haystack.mit.edu/tech/vlbi/mark5/mark5_memos/090.1.pdf

VSI-S Commands – Mark5C

Mark 5 Memo #091.1

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886
25 May 2012

Telephone: *978-692-4764*
Fax: *781-981-0590*

TO: Distribution
FROM: Alan R. Whitney, Dan L. Smythe, and Chester A. Ruszczyk
SUBJECT: Mark 5C Command Set Version 2.0

Note: The current version of the Mark 5C program is called '*drs*', for the VLBI Data Recording Service and will adhere to the command set in this document.

1. *drs* program

The commands detailed in this memo are implemented by a program named *drs* and control the DIM functionality of the Mark 5C VLBI data recording system. The details concerning the operation of *drs* are available in documents at http://web.haystack.mit.edu/mark5/Mark5.html. The DOM functionality is not be handled by this application and will depend on the particular end use of the Mark 5C, e.g., a software correlator with fuseMk5 providing read access to the Conduant disk modules or using mark5 utilities of the software correlator, e.g. m5cp.

The startup command-line for *drs* is as follows:

drs –m [0|1|2|3|4] –e 'command'

http://www.haystack.mit.edu/tech/vlbi/mark5/mark5_memos/091.1.pdf

VSI-S Commands – RDBE data send

dbe_data_send – Set the time interval for transmitting data

Command: → dbe_data_send = < state > : [< t_s >] : [<t_e>] : [<delta>] :[<threadID>];

← !dbe_data_send = <return code>;

Query: → dbe_data_send?;

← !dbe_data_send ? <return code>: <state> : <t_s> :<t_e> : <present DOT time> ;

Purpose: To start or stop the transfer of data from the RDBE out of the 10G Ethernet interface.

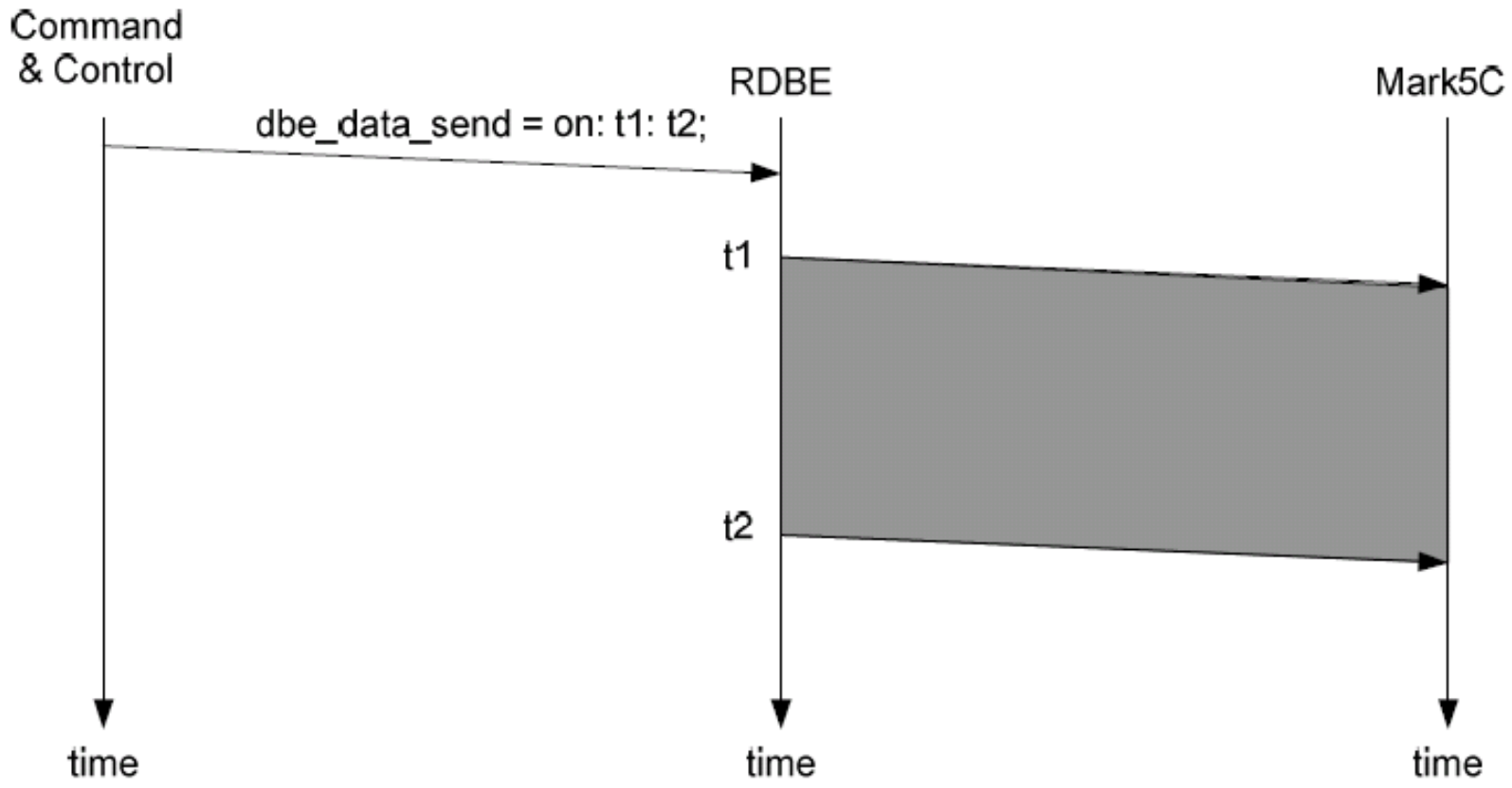
Settable Parameters:

Parameter	Type	Allowed Values	Defaults	Comments
state	ASCII	on | off	off	on - transmission of data should begin at t_s off - cease or abort transmission of data on a 1pps boundary, t_e
t_s	time	YYYYDOYHHMMSS		Optional start time of valid data on 1pps boundary
t_e	time	YYYYDOYHHMMSS		Optional end time of valid data on 1pps boundary
delta	time	≥1		Optional duration of valid data (integer seconds) (see note 1)
threadID	int	0-n	0	Thread id associated with the send command (VDIF payload ONLY)

Monitor Only Parameters:

Parameter	Type	Values	Comments
status	char	on | off | waiting	on – transmission active off – transmission inactive waiting – dbe_data_send command received and waiting for start time.
ts	time	YYYYDOYHHMMSS	start time of valid data on 1pps boundary
te	timr	YYYYDOYHHMMSS	end time of valid data on 1pps boundary
time	time	YYYYDOYHHMMSS	The present time

VSI-S Commands – RDBE data send



VSI-S Commands – Example: RDBE

```
VSI command:   dbe_dot?;
VSI response:  !dbe_dot?0:2013158131038:syncerr_eq_0:2013158131038:0:45047438;.

VSI command:   dbe_sw_version?;
VSI response:  !dbe_sw_version=0:rdbe_server 1.1.4o:HAL version 1.0 PFB:Linux
                2.6.18-128.1.1.el5;

VSI command:   dbe_personality?;
VSI response:  !dbe_personality?0:pfbg:pfbg_1_4.bin:loaded;
```

VSI-S Commands – Example: Mark5C

```
VSI command:   bank_set=A;
VSI response:  !bank_set = 0 ;

VSI command:   bank_set?;
VSI response:  !bank_set? 0 : A : NAIC+004/8000/2048 : - : - ;

VSI command:   bank_info?;
VSI response:  !bank_info? 0 : A : 8001546551296 : - : 0 ;
```

Python Utilities – rdbe_proc.py

Run a procedure file:

```
# RDBE procedure file
dbe_sw_version?;
dbe_personality?;
dbe_dot?;
#dbe_fs=on:on;
dbe_fs?;
```

Python Utilities – mk5c_proc.py

```
oper@vlbis2:~/proc$ mk5c_proc.py -i mk5c1 test_proc.mk5c

VSI command:   packet=36:0:5008:0:0;
VSI response:  !packet = 0 ;

VSI command:   personality=mark5c:bank;
VSI response:  !personality = 0 ;

VSI command:   bank_set=A;
VSI response:  !bank_set = 0 ;

VSI command:   bank_set?;
VSI response:  !bank_set? 0 : A : NAIC+004/8000/2048 : - : - ;

VSI command:   bank_info?;
VSI response:  !bank_info? 0 : A : 8001546551296 : - : 0 ;

VSI command:   dir_info?;
VSI response:  !dir_info? 0 : 0 : 0 : 8001546551296 ;
```

Python Utilities – disk pack related

DEMO

dptest.py

dpscan.py

perase.py

Python Utilities – rdbe_alc_adj.py

```
oper@vlbis1:/home/oper/proc$ rdbe_alc_adj.py 0
alc_set(): ALC setup, VSI-S command:   dbe_alc=0:31:off;
alc_set(): ALC setup, VSI-S response:  !dbe_alc=0;
alc_set(): ALC setup, VSI-S command:   dbe_alc=0:31:off;
alc_set(): ALC setup, VSI-S response:  !dbe_alc=0;
Variance (max. attn):  2.82696419844 @ 31 dB

alc_set(): ALC setup, VSI-S command:   dbe_alc=0:30:off;
alc_set(): ALC setup, VSI-S response:  !dbe_alc=0;
Variance:  3.43681268328 @ 30 dB

alc_set(): ALC setup, VSI-S command:   dbe_alc=0:29:off;
alc_set(): ALC setup, VSI-S response:  !dbe_alc=0;
Variance:  3.67090893817 @ 29 dB
…
alc_set(): ALC setup, VSI-S command:   dbe_alc=0:24:off;
alc_set(): ALC setup, VSI-S response:  !dbe_alc=0;
Variance:  10.6509614797 @ 24 dB

Final variance:  10.6509614797
```

Field System for RDBE & Mark5C

oper@vlbis2:/usr2/sched$ ls

…

b352dc.vex ar_drudgc_feb13b.pl b352dcar.snp b352dcar.prc

b352dc.vex

```
VEX_rev = 1.5;
*    SCHED vers: Version 11.1 Beta of about April 26, 201
*    VEX/SCHED:  1.5.87
*    Other versions: Sched:  11.1  Plot: 1.06  JPL-ephem: 1.01
*----------------------------------------------------------------------------
$GLOBAL;
    ref $EXPER = BM352DC;
…
$EXPER;
*
def BM352DC;
    exper_name = BM352DC;
…
```

Field System for RDBE & Mark5C

b352dc.vex

```
scan No0143;
* intent = "REFERENCE_POINTING_APPLY"
     start=2013y158d14h11m48s; mode=v4cm-phaseref; source=HII174;
     station=Br:   11 sec:   85 sec: 2117.688 GB:   :       : 1;
     station=Ov:   11 sec:   85 sec: 2085.637 GB:   :       : 1;
     station=Kp:   11 sec:   85 sec: 2120.509 GB:   :       : 1;
     station=Fd:   11 sec:   85 sec: 2122.304 GB:   :       : 1;
     station=Pt:   11 sec:   85 sec: 2120.253 GB:   :       : 1;
     station=La:   11 sec:   85 sec: 2120.509 GB:   :       : 1;
     station=Nl:   11 sec:   85 sec: 2120.252 GB:   :       : 1;
     station=Hn:   11 sec:   85 sec: 2121.022 GB:   :       : 1;
     station=Sc:   13 sec:   85 sec: 2150.252 GB:   :       : 1;
     station=Gb:   31 sec:   85 sec: 1293.329 GB:   :       : 1;
     station=Eb:   30 sec:   85 sec: 1286.920 GB:   :       : 1;
     station=Ar:   27 sec:   85 sec:  280.769 GB:   :       : 1;
endscan;
…
```

Field System for RDBE & Mark5C

b352dcar.snp

```
" BM352DC   2013 ARECIBO  L Ar
...
"scan_name=No0127,b352dc,Ar,155,155
source=0204+151,020450.41,151411.0,2000.0,
setup01
!2013.158.13:45:29
setup01
!2013.158.13:46:29
preob
!2013.158.13:46:39
mk5=pointers?;
mk5=record=on:no0127;
!2013.158.13:46:44
mk5=pointers?;
data_valid=on
midob
!2013.158.13:49:14
data_valid=off
mk5=record=off;
mk5=pointers?;
...
```

Field System for RDBE & Mark5C

b352dcar.prc

```
define  exper_initi   13158134129x
proc_library
sched_initi
enddef
define  sched_initi   13158134131x
rdbe_cmd=0,3,dbe_execute=init;
!+5s
rdbe_cmd=0,3,dbe_dot_set=;
!+1s
rdbe_cmd=0,3,dbe_data_send=on:201315813462:201315816294:0;
!+1s
rdbe_cmd=0,3,dbe_1pps_mon=enable:239.0.2.25:20020;
!+1s
rdbe_cmd=0,3,dbe_tsys_mon=enable:239.0.2.25:20021:10;
!+1s
"rdbe_cmd=0,3,dbe_tsys_diode_ctl=80:100;
rdbe_cmd=0,3,dbe_quantize=reset;
!+1s
rdbe_cmd=0,3,dbe_quantize=hold_set;
enddef
```