RDBE Setup and Operations

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Agenda

• System overview
  – Hardware components
  – Firmware components
  – Software components

• Features

• Command set

• Basic operation

• Demonstration
System Overview

• RDBE – ROACH Digital Backend System
  – Joint collaboration between NRAO and Haystack
  – Name is assigned to a specific base system
    • Specific hardware components
    • Can be ordered from Digicom
  – Variations are expected
    • Represented by hyphenating the name RDBE-X
      – X represents the hardware components of the RDBE
    • Presently there are RDBE-H, RDBE-S
    • This overview covers the RDBE-H
RDBE Hardware Components

• ROACH Board
  – Reconfigurable Open Architecture Computing Hardware
  – Developed by the CASPER group at Berkeley / NRAO / KAT

• Virtex 5 FPGA
• 440 PPC processor
• 2G RAM
• 2 ZDOK connectors
  – iADC
• RS232 interface
• 1G / 100M Ethernet
• 4 CX4 10G Ethernet ports
• 1 XPORT interface
RDBE Hardware Components

• iADC
  – Analog to Digital Converter (sampler board)
    • Developed by the CASPER group
  – 2GHz bandwidth
  – 1 Gigs sample / sec
  – 8 bits / sample
• 2 iADC cards supported per ROACH
RDBE Hardware Components

- Synthesizer / timing board
  - Developed NRAO
  - Inputs
    - 5MHz
    - 1pps
  - Outputs
    - 1pps
    - 1024 MHz
  - Provides serial communication interface to ALC board
RDBE Hardware Components

- **ALC**
  - Analog level control
  - Developed by NRAO
  - 2 IFs in / 2IFs out
  - 0-31 dB attenuator
  - Additional 20dB solar attenuator
RDBE Hardware Components

• Miscellaneous
  – Power supply
    • 90 ~ 132 VAC or 180 ~ 264 VAC auto sensing
  – 1pps LED
    • Indicates 1pps to synthesizer board
  – Power LED
  – 10 SMA connectors

RDBE-H Back Panel
RDBE Firmware

• 3 Personality types (FPGA code)
  – Polyphase filter bank-geodesy (PFBG) Version 1.4
    • Input is two 512MHz IFs
    • Output is sixteen of 32 possible 32-MHz channels
    • Output is a 5008 byte Mark5B data format (next slide)
  – Polyphase filter bank-astronomy (PFBA)
    • Input is four 512 MHz IFs
    • Output uses two of the four 10Gbps CX4 interfaces
      – 2-bit quantized
      – 4Gbps / interface
      – 8224 byte packets using the VDIF format.
RDBE Firmware

– Digital down converter (DDC)
  • Input is two 512MHz IFs
  • Output is four tunable channels
  • Bandwidths 128 / 64 / 64 / 64 / 1 MHz (same for all 4 channels)
    – Data rate proportional to bandwidth
  • Tunable in 15.625 kHz quanta (testing incomplete)
  • Output is in 5008 byte Mark5B format 2 bits / sample
  • 250-kHz common quantum with 10-kHz on legacy systems
Mark5B Payload

Original Mark5B packet

- Mark5B Header (4 words)
- 2500 32 bit words

RDBE Mark5B Equivalent

- Mark5B Header (4 words)
- 1252 32 bit words
- Zero Byte fill
- 32 bit PSN

- 1248 32 bit words
- Zero Byte fill
- 32 bit PSN

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RDBE Software
RDBE Software

• rdbe_dev.ko
  – Linux kernel device driver
  – Allows the application to read / write to the FPGA personality

• HAL
  – Hardware abstraction layer
  – Allows the personality to change without changing the application software

• rdbe_server
  – Version 1.15 will be required for operation with FS
  – Accepts VSI-S commands
  – Verifies and takes actions on valid commands
  – Specified in the RDBE command set
# RDBE Command Set

- Standard VSI-S command format

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbe_1pps_mon</td>
<td>Set the 1pps monitoring broadcast state</td>
</tr>
<tr>
<td>dbe_alc</td>
<td>Set / get the ALC attenuator setting for INPUT 0/1</td>
</tr>
<tr>
<td>dbe_alc_pps?</td>
<td>Station 1pps status (query only)</td>
</tr>
<tr>
<td>dbe_alc_fpgavers</td>
<td>Get the ALC boards FPGA bit code version (query only)</td>
</tr>
<tr>
<td>dbe_arp</td>
<td>Set / get the IP to MAC address resolution</td>
</tr>
<tr>
<td>dbe_data_connect</td>
<td>Set / get the destination IP the data is being sent</td>
</tr>
<tr>
<td>dbe_data_format</td>
<td>Set the packet format mode to either the VDIF native mode or Mark5B compatibility mode</td>
</tr>
<tr>
<td>dbe_data_send</td>
<td>Transmit a data stream out of the DBE 10G interface</td>
</tr>
<tr>
<td>dbe_dc_cfg</td>
<td>Setup down-converters</td>
</tr>
<tr>
<td>dbe_dot?</td>
<td>Get the Data Observable Time (DOT) clock information (query only)</td>
</tr>
<tr>
<td>dbe_dot_inc</td>
<td>Increment the DOT clock</td>
</tr>
<tr>
<td>dbe_dot_set</td>
<td>Set the DOT clock on next 1pps tic</td>
</tr>
<tr>
<td>dbe_execute</td>
<td>Execute specific command on the DBE</td>
</tr>
<tr>
<td>dbe_hw_version?</td>
<td>Get the hardware version information from the DBE</td>
</tr>
<tr>
<td>dbe_ifconfig</td>
<td>Set / get DBE 10G network interface configuration</td>
</tr>
<tr>
<td>dbe_ioch_assign</td>
<td>Set / get the input to output channel assignments</td>
</tr>
<tr>
<td>dbe_packet</td>
<td>Set / get packet transmission criteria</td>
</tr>
<tr>
<td>dbe_personality</td>
<td>Set / get the RDBE FPGA bit code personality</td>
</tr>
<tr>
<td>dbe_quantize</td>
<td>Set / get present channel quantization data</td>
</tr>
<tr>
<td>dbe_status?</td>
<td>Get system status (query only)</td>
</tr>
<tr>
<td>dbe_sw_version?</td>
<td>Get the software version information from the DBE</td>
</tr>
<tr>
<td>dbe_tsys_mon</td>
<td>Set the Tsys monitoring broadcast state</td>
</tr>
<tr>
<td>dbe_xbar</td>
<td>Set / get the DDC crossbar switch positions</td>
</tr>
</tbody>
</table>
Basic Operations

• Topics addressed on the following slides
  – Boot Up
  – rdbe_server daemon communication
    • dbe_data_send operational modes
    • raw capture mode
    • monitoring capabilities
      – 1pps
      – tsys
  – Software utilities
Boot Up

- **U-Boot options**
  - Environment variables defining what the boot loader will execute
    - location of the kernel in flash (address)
    - location of the root file system
      - USB
      - NFS
      - SDRAM
      - bootp
  - Network configuration
    - Static
    - Dynamic
  - Details are beyond the scope of this talk
    - Detail documentation available if needed
rdbe_server

- Loading the FPGA personality
  - Located where the root file system is mounted
  - /home/roach/personalities

- Initialization
  - Setting the FPGA registers
  - Setting the DOT time
    - system time
    - manually
  - Quantization
    - Formats the filter bank channels at 2 bits / sample
  - Monitoring capabilities

- Set for normal operations
  - Transmitting data out CX4 interface
  - Status / etc.
IO Channel Assignment

• Capability to set the input output channel assignment for the VLBI Payload
  – Feature for PFBG personality only
    • Input is two 512MHz IFs
    • Output is sixteen of 32 possible 32-MHz channels
  – The command
    • dbe_ioch_assign = <input>:<channel(s)>: [<threadID>] : ...
      [<input>]:[<channel(s)>]: [<threadID>] ;
    • input
      – 0 or 1 for IF0 or IF1
    • channel(s)
      – Either individual channels or a range of channels
    • threadID
      – vdif specific and presently ignored
IO Channel Assignment

• The channel ordering
  – Directly related to the assignment combination
    • input and channel specified in this command
  – The present geodetic personality
    • dbe_ioch_assign? returns
      – with the first input / channel combination 0:1
      – assigned to the least significant position in the data array format (bit 0,1)
      – the most significant bits being assigned to input 1 channel 15
IO Channel Assignment

- A common setting used for testing with DBBC
  - `dbe_ioch_assign = 0: 0-15 ;`
  - Assigns all of IF0s 32 MHz channels to the VLBI Payload
  - `dbe_ioch_assign?` returns
    - `dbe_ioch_assign ? 0: 0:1: : 0:2: :0:3::0:4::...0:14: :0:15: ;`
      - with the first input / channel combination 0:1
      - assigned to the least significant position in the data array format (bit 0,1)
      - the most significant bits being assigned to input 0 channel 15
Data Transmission

• In the past data were always available and the gating function was performed on the recording device
  – Record = on / off commands

• A new approach has been taken for when to transmit data out of the interface
  – Since the start and end time are known apriori
    • use the dbe_data_send to gate the output on the 10G
    • past option is still available
Design Philosophy

• start time <= present DOT time < end time
  – Personality will transmit valid packets
  – Times are specified as integer seconds

• Start and end times are programmed into the FPGA using the command:
  – dbe_data_send
  – command format
    • dbe_data_send = < state > : [< ts >] : [<te>] : [<delta>];
      – state - either “on” or “off”
      – start and end times (ts, te) are of the format YYYYDDDHMMSS
      – delta - specified in integer seconds.
dbe_data_send options

- Specify start / end time
  - YYYYDDDDHHMMSS
- Or specify start and delta time
  - t2 is generated as t1 + delta
  - delta is integer seconds

- Ability to abort an active transmission
  - send the off state with
    - a specified time
    - no time - meaning next integer second
Raw Capture Mode

• Provides ability to see the incoming signal from the iADC before it is processed by the FPGA personality

• It is a separate thread within the rdbe_server
  – Listening on port 5000
  – Responds to a client requesting a specific IF to capture
    • 32000 samples are captured
    • the raw data are returned to the calling client to be processed
      – by software utility “bpplotter”
        » developed by NRAO
bpplotter
bpplotter
Monitoring Capabilities

• 1pps monitoring
  – dbe_1pps_mon = <enable> : <multicast IP address> : <port>;
  – Use gDot.py on a system attached to same network to receive multicast data

• Tsys monitoring (version 1.4 of fpga code)
  – System temperature measurement
  – On power / off power of the receive chain
  – dbe_tsys_mon = <enable> : <multicast IP address> : [<port>] : [<interval>];
    • default interval is 6 secs
    • tsys data is summed every second
  – dbe_tsys_diode_ctl must be set to use above function
  – Use tsys.py for gathering data
Software Utilities

• **rbde_client -h <machine>**
  – Command line interface to RDBE
  – `-h <machine>` is the target RDBE systems IP address (defaults to localhost).
  – **rdbe_server** must be running on `<machine>`

• **rdbe_gui**
  – Graphical client interface to the RDBE
Software Utilities

- **gDot -h <multicast address>**
  - A graphical multicast 1pps time receiver
    - that displays the broadcast DOT time
  - The RDBE server must be configured
    - with the dbe_1pps_mon command.

- **power_est_client -h <machine>**
  - A command line client
    - calculates the mean, standard deviation and maximum power of a specified input IF into the RDBE.
    - the input IF is selected by sending a 0 or 1 at the command prompt.
DEMONSTRATION
TIME PERMITTING