EVN CBD Critical Design Review on DBBCs

Question Areas and Questions (in no particular order)

- Context
    - What are the short term, medium term and long-term ambitions of the EVN? (short < 2 years, medium 2-4 years, long > 4 years)
    - What are the short-term needs of the EVN? e.g. for replacements or provisioning.
    - Are NRAO and NSF committed to VLBA enhancements?
    - What about the geodetic community?
    - Are the designs going to be freely available (bitfiles, PCB artwork, etc. but NOT the tools or, possibly, some of the IP)?

    Answer: the DBBC project provides a flexible platform to assembly a user-defined system in terms of number of bands (1-4) and processing capability . The boards composing the different parts are available mounted. It would be useful to divide in hardware and software the description of the availability design details.

    The conceptual design methodology is covered by a INAF patent pending for protecting the development not in the scientific use, but in the commercial one. Then hardware realization details so as the use of the same methodology, schematics files etc. can be provided at interested scientific institutions under a license that is stating the final use.

    The system itself is seen as an 'open development' environment, due to the very general morphology. So it will be freely distributed all the information necessary for developing own firmware to be run into the system and more in general it will be promoted such activity through seminars or courses having the aim to grow a group of interested 'experts' able to handle and use the flexibility the system can offer.

    The firmware already developed for the main functionality of the system will be available as .bit files, and sources will be available only as examples for some basic configurations, not for the entire set of them, due to the fact that the development costs have been entirely supported by IRA. On the other hand the cost of such configuration files will not be charged on the system.

    In conclusion the use of the intellectual property of the system is exclusively offered to possible interested radio-astronomy institutions for scientific purposes under an agreement with IRA. The firmware will be available as executable files. IRA is willing to spread knowledge of such methods promoting seminars where the program writing of the parts composing the system will be discussed, with the aim to help people interested in developing firmware for additional bands/functionality (autocorrelators, polarimeters, digital receivers, etc.).

    - Are there "hidden" or proprietorial aspects?

Answer: is included in the previous point.

- Performance
  - What can it do? Take Mark 4 capabilities as a reference.

The main bandwidth modes (16, 8, 4, 2, 1 MHz) are possible with potentially similar performance, as seen from the external point of view. Moreover a wide 32 MHz is possible together with a 512 MHz version. Additional configurations have been developed in the time (256 MHz, 128 MHz, etc) with tuned or fixed positions.

Tuning step resolution adopting a 1024 MHz sampling clock is defined as (1024 x10^6)/2^32 Hz. This is achieved without adopting any correction algorithm to have 64 or 32 MHz data rate output. Such solution imposes a frequency offset of fraction of hertz, that can be compensated through a software phase correction as suggested by the previous review. A 2^30 Hz clock can be also adopted producing no need for such correction but producing a different std clk in the output. This last solution has been adopted in some digital receivers, or in realization where the output clock is not restricted to defined values.

Phase-cal detection is not included in the DBBC functionality as this feature is available in the MK5B recorder.

Functionality is different with respect to the MK4, but inter operability between old and new systems is possible giving the chance to add to the existing network immediately new stations.

  - What can it not do?

At present a number of bandwidth have been developed, but it is possible to add more at the need. Moreover the 'open environment' aspect could greatly promote the spontaneous growing of more functionalities to be shared among users.

  - How frequently have missing capabilities been requested?
    See here for some information about EVN scheduling history.
  - What expansion/enhancement potential does it have?

Expansion and enhancement is the key element of the system because it could be realised in the hardware and in the firmware. In particular the hardware upgrade is under way and is going to provide 1) a new AD board (named ADBoard2) with improved performance (max fclk=2.2GHz, max input signal 3.5 GHz, 10 bit representation), 2) a new processing board (named Core2), 3) the new FiLa10G board. The new Core2 allows to adopt a maximum of 4 boards (instead of 16) for a complete set of 16 independent BBCs, having the capability of four units in each device. The FiLa10G is able to interconnect between the three bus: HSI (pure sampled data) – 2xVSI (processed data) – 10G double optical fiber physical layer.

  - How does it integrate with recording and networking?

The output of the DBBC is through 2 VSI connectors, each supporting at present 32 channels with 64 MHz clock, for a total 4 Gbps. The new Core2 can support 128 MHz clock producing an output of 8Gbps of processed data. Recording is then possible with VSI compatible devices. Networking is assured by the new FiLa10G, because data can be forwarded directly after sampling into a 10G network, while keeping the possibility to transfer through 2xVSI connectors. The 10G network can be used to transfer also processed data.

- Operations
    - What does it connect to (at both ends)?

In the input side the DBBC accepts a maximum number of 4x4 RF/IF channels from which 4 are selected to be conditioned and sampled. A 10 MHz reference and 1PPS are necessary to drive the system. The output is composed by 2 VSI connectors, while the upgraded version is going to have also a two fibres operating at 10Gbps each in the two opposite directions, for each AD board and for the processed data output.

- What "knock-on" consequences does it have? e.g. changes to the field system and operational aspects such as dynamic firmware changes.

Very few modifications are necessary to the Field System because the set of commands available in the DBBC console are FS-like. So the FS needs only to transfer the commands without having to translate them. The status of the total gain of each channel is known by the FS through a dedicated background process. This needs to be included similarly to a station-like additional software feature.

Dynamic configurations change is transparent to the FS because is due to the PCSet internal to the DBBC system. Change in the general configuration of the digital bbcs could or not impose a change in the configurations, but it’s not affecting in any way the FS knowledge.

- Have these knock-ons been factored into the planning?

Yes, a dialogue is open with Ed Himwich for an easy integration of the DBBC needs within the Field System.

- Are delay changes with bandwidth compensated?

Yes, the delay is adjusted by an additional buffering necessary to compensate possible differences between configurations.

- If the configuration is cycled, does phase recover?

Possibly yes, more extensively check needs to be done to confirm phase recover.

- Do the FPGAs need "setting up" after configuration?

After configuration the FPGAs needs to be tuned, and then the gains are adjusted in order to properly meet the statistics of the states. This process is kept alive all the time, together with the automatic gain control at the input of the AD samplers. The general gain status is available at the FS and or at the general managing software system.

- Are there built in calibration procedures?

No at present.

- Will parameter/temperature drifts require recalibrations?

There is no evidence for such a need at present.

- How long does reconfiguration take?

Reconfiguration is performed at 12 Mbps and a CoreBoard configuration takes, considering also the dead time due to files reading from disk, about 2-3 sec. A typical 8 BBCs takes then less than 30 seconds. Increasing of downloading speed is possible up to about 33 Mbps, but the time spent can be shortened of about a time factor 2.

- How long would recalibration take?

No recalibration is necessary, with exception of the dynamic states statistics control, set starting from the reset status in about 1-2 sec.

- Is the field system enough or is another processor/driver required?

The DBBC includes a PCSet (1 single board PC+2 PCI interface boards+ 1 HD) able to handle the entire functionality of the system. The DBBC can be a stand-alone instrument.

A software interface is provided to dialogue with the FS through a network socket for the main functionalities or, using an appropriate terminology, for sending any kind of command the DBBC is able to recognize. A simple command console is available where high level FS-like commands are interpreted for setting the complete functionalities.

- Are mixed operations, i.e. old and new, possible/convenient?

Yes, mostly. A useful option is at present to have new stations able to join standard network observations. Differences in the band shape are kept into account and dedicated configurations have been developed. This might give the chance a new station to observe.

- Are there other impediments to either, DBBC/DBE2 solution?

Not in principle. It looks as a convenient way to go would be to look for compatibility, more than the opposite, leaving a general freedom for particular modes.

- Is phased deployment, e.g. DBBC early, DBE2 late, feasible?

Both systems should offer a complete inter-change-ability. Any un-compatibility should be avoided.

- Is phase cal practical, necessary, convenient?

Phase cal is useful and in particular would be necessary whether a very wide band correlation process is required, possible natural evolution for a very wide band acquisition system.

- Are there obsolescence-prone or risky parts?

  Yes in principle. This is mitigated in the DBBC because a std typology of boards is adopted. Maintaining the same geometry of the boards and the same signal distribution as it is defined could allow to replace in a future boards with faster and cheaper devices. This method also today is adopted in the DBBC upgraded version.

- Manufacture
  - Are extensive manual calibration procedures required?

  No, a functionality test is required after construction before placing into operations.

  - Is there a suite of tests?

  Not still an organic set of tests and tools is present. A collection of what is adopted today would be required to be offered with an organic organization.

  - How far advanced is it? Can production begin?

  Yes, at present a pretty slow internal to IRA production is in course.

  - What plans are there for production?

  There is an option from INAF to generate a Spin-off small company to manage the production operations. All the phases requiring production tools as PCB, BGA soldering, etc. are to be realised by external companies. The main activity of the spin-off company is to manage the operations, to assembly, to perform a dedicated set of tests, to assure maintenance and promote the diffusion of the DBBC environment as an 'open system' to develop dedicated applications. Dedicated seminars or course to spread the particular FPGA knowledge necessary would be provided.

  - What are the timescales?

  IRA is building for BKG three systems that would be realised one in the first version and the other two units in the upgraded version. The first unit should be delivered shortly and possibly will be used for demonstration purposes at the CDR meeting. The other two units will be delivered at the beginning of summer.

- Costs
  - What are the costs?

  Costs vary greatly with the configuration that is required. The DBBC version 1 with a number of 8 CoreBoards costs about 45 K€, including everything is necessary for 4 RF/IF. The minimum cost for a fixed configuration system is below 10K€. Single board of the CoreBoard1 are about 3K€ and ADB1 about 2K€. Cost are fully due to materials and manpower. No additional charge for the configuration firmware is added.

  - How do costs vary with quantity and phasing?

  The upgraded version could potentially cost less and perform faster in a more compact fashion. At present reduction of cost has been explored and even in the case of full flexibility of a system a reduction could be expected of about 25%. Different aspects could be considered whether a less general system would be required with fixed or semi-fixed observing modes. In such case several tools are possible to greatly reduce the costs, but it looks an efficient solution for multiple simple back-ends, more than a single powerful and flexible system to be present in a scientific radio-telescope.