A Retrospective View of Miriad

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Abstract. Miriad is a radio interferometry data-reduction package aimed at taking raw data through to the image analysis stage. The Miriad project, begun in 1988, is now middle-aged. With the wisdom of hindsight, we review design decisions and some of Miriad's characteristics.

1. A Brief History

Miriad aims at being a "full service" radio interferometry data-reduction package, taking raw telescope data through to image analysis and publication-quality image displays. The Miriad project was initiated by the Berkeley Illinois Maryland Association (BIMA). This followed much internal debate, and a meeting in February 1988 where a number of external experts (from the AIPS, GIPSY and IRAF camps) were invited to express their opinions on BIMA's offline software options. BIMA's decision was to develop two streams. The first stream, the Miriad project, was to build on the experience with the Illinois `Werong` and Berkeley `RALINT` packages, and to develop a package up to, but excluding, the image analysis stage. The second, image-analysis, stream eventually died, and Miriad was extended to cover this area.

Miriad was designed and developed jointly by groups at the three BIMA sites. Most of the infrastructure was written in Illinois by one person, with significant input from Berkeley. The first astronomically useful applications (FITS readers/writers, imaging and deconvolution tasks) appeared in October 1988. A fourth site became involved when two of the Miriad group moved to the Australia Telescope National Facility in 1990, and began extending Miriad to meet the needs of that institute's interferometer.

2. Project Management and Economics

Having the project spread over three or four sites has its difficulties, especially when group members are responsible to individual institutes and not to the project as a whole. In the early stages, there were regular phone conferences, quarterly face-to-face meetings and a barrage of email. There was no real project leader, with the project advancing by the good will of the group members (a true anarchy). The pragmatic solution to the occassional disagreements between group members (and the interests they serve) was nick-named "the free market economy" (a true capitalism). Each piece of code has an "owner" who must approve any change to it. If an owner cannot be persuaded, anyone is free to submit alternative code, and the different codes compete in the open market for users. Generally this occurs only occassionally, but it has led to multiple, functionally similar, tasks of significantly varying quality. This "free market" approach results in some inefficient use of resources which perhaps could be avoided with a "centralised economy".

3. User Interface and Documentation

User interfaces were a controversial issue in the early stages of the project – no interface suits every use. The approach adopted was to make the "front-end" user interface quite separate from number-crunching tasks. Apart from running tasks, the main functions of a front-end program is to provide task documentation and to help assemble task parameters. These parameters are passed to the number-crunching tasks simply as command line arguments. This trivial interface made it easy to develop front-end interfaces to suit different tastes; early front-end programs included a Sunview windowed environment, a VT100 menu system, and a "dumb terminal" interface similar to POPS.

This design means that the front-end task can be completely bypassed, with users initiating tasks at the host command line. More experienced users do this often, particularly with simpler tasks. It is also the best way to develop batch scripts (we prefer to write those in the powerful shell that the host provides, rather than to try to reinvent it).

Using an idea adapted from PGPLOT, task documentation is stored as comments as a preamble in the source code. A tool extracts this 'help file' and stores it in a directory ready for use by the front-end programs (whenever a task is recompiled, its help file is also updated). Help files for subroutines are treated in a similar fashion.

Although help files are good for specific information, additional documentation giving a greater overview is needed. Users and programmers guides appeared early in Miriad's life. Later a guide specifically aimed at Australia Telescope users was also developed. Although this is continually updated, reassignments within BIMA have meant that their guides are now out-of-date.

With the popularity of the WWW, a html version of Miriad's documentation was developed (e.g. see `http://bima.astro.umd.edu/bima/miriad` or `http://www.atnf.csiro.au/ATNF/miriad`). This hypertext version is generated automatically from the source of the users guide and the help files.

4. File Format Issues

Compatibility with FITS is clearly an important goal. Although we considered the possibility of making FITS the 'native' file format of Miriad (as it was in

Werong), we concluded that pure FITS was too inflexible for this purpose. However, we adopted an image data-set structure which shadowed FITS reasonably closely (thus making a translation between the two straightforward). This was not possible with visibility data-sets – the general characteristics of the uv FITS format were seen as too restrictive for our needs. The visibility format adopted is based on the RALINT design of Wilson Hoffman. It has proven to be significantly more flexible than the FITS style of handling visibility data, and has the added advantage of a much cleaner interface for the programmer. We have found it easy to use this format with a number of forms of data not considered in the original design. Unfortunately it has the penalty that the current implementation can be slow to read.

Our initial concept of Miriad was of a package working in a shared disk environment of VAXes, Suns and Crays – machine-independence of the data was seen as very important. Miriad data are stored in a canonical format on disk, with the i/o system performs needed conversions during the i/o process (this conversion is invisible to the applications programmer). Although this has been very successful, because of declining interest in VAXes and Crays, machine independence has not been as critical as we had anticipated.

5. Language and Portability Issues

Miriad was designed to be portable, with VMS and several UNIX variants being the initial target systems. Since then, Miriad has been ported, with minimal effort, to many UNIX-based systems. To aid portability, and to reduce our own workload, we have gladly used public-domain software where appropriate. Miriad's plotting tasks are based on PGPLOT, whereas some of the numerical code is based on LINPACK.

Although all the i/o system and ancillary tools are written in C, most of Miriad is written in FORTRAN. We used FORTRAN because we felt that most astronomers would be happiest with it (and we wanted to attract programmers), and because vector machines were important to us (the best vectorising compilers continue to be FORTRAN ones).

As the i/o system is written in C, at some level FORTRAN has to call C routines. This language barrier is invariably system dependent (there are six schemes used in the systems that Miriad has been ported to). We developed a tool which takes a system-independent interface description, and which produces a thin layer of system-dependent code that mates the FORTRAN and C parts of Miriad. Although we have always had some misgivings about a mixed-language system, this approach has worked reasonably well.

6. Visualisation

Visualisation and image display is one of Miriad's failings. In the initial stages, this area was split off to a sub-group to develop. Their plans were comprehensive and their development lagged behind the rest of the project. As a stop-gap, a simple interim set of routines was adopted. Eventually, the comprehensive plan failed and that sub-group disbanded. Somewhat later, a second attempt was made. Although this did progress further, it also effectively failed, and this second sub-group also disbanded.

Meantime, the "interim" routines were slowly upgraded, and made to work under X-Windows, but they are still basic. These shortcomings have been somewhat alleviated by the development of a set of image display tasks using PGPLOT. Though a good plotting package, PGPLOT is not intended to be an image display package, and so its model of a display device is limiting.

7. Miriad's On-Line Component

One novel aspect of Miriad is that it has been integrated into the on-line system of the Hat Creek interferometer. The on-line system generally uses the Miriad user interface and documentation system. Thus, to some extent, the user interface remains the same from driving the telescope to producing publication quality output. The on-line system also writes the raw data directly in the Miriad uv data format (this requirement was one of the reasons uv FITS was unsatisfactory).

8. A Niche Package

Miriad is continuing to be developed. It has proven to be a good and flexible environment for writing specialised applications, as well as for developing new algorithms of greater applicability, particularly to teach students. A natural question to ask is "why reinvent the wheel". Certainly at the original planning meeting there was a strong voice (both from NRAO and some BIMA representatives) for using AIPS to solve BIMA's reduction problems. AIPS, however, did not satisfy a number of the criteria that BIMA felt were essential. We had the choice between a major development in AIPS, or a major development with a fresh system. A fresh start, a system more flexible than AIPS, and a more programmer-friendly environment were probably the deciding factors (politics may have also played a part).

In hindsight, it was the correct decision. We had a useful system comparatively quickly, and have been able to extend it with new algorithms and techniques at a good rate. The overhead of programming in AIPS would have, at best, slowed our software development. At worst, it would have completely dissuaded us from implementing many new applications.

Faced with AIPS++, what is the future of Miriad? Part of the success of Miriad is that it is not a huge package – it has been able to adapt and concentrate on specialised areas, and in a timely fashion. Miriad does not try to address the data-reduction needs of the entire radio-astronomy community, so the overheads are much less than those for AIPS++. We do not believe that mega-packages will, or should, swamp the small and mid-size packages; there will always be a place for these. At the same time Miriad is now showing some grey hairs – perhaps Miriad++ is needed.

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