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Database Design for Aperture Array Hardware Management

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Abstract. As the size and complexity of an aperture array grows, so too does the amount of hardware involved. As we approach SKA sized arrays of many thousands of elements, hardware management and characterisation will become an issue. As part of the SKADS programme, we have developed a simple hardware management database "pathfinder", which relates each hardware component to corresponding characterisation measurements and signal information. This database was used to store information about the analogue characterisation campaign conducted on the 2-PAD aperture array in the first half of 2009 (Price et al. 2009). This measurement database is available online at `http://2-pad.physics.ox.ac.uk`.

1. Introduction

2-PAD (the Dual Polarisation All-Digital aperture array), is a fully functional radio telescope demonstator, designed to operate within the 0.3GHz to 1.0GHz radio band (Harris et al., 2009). 2-PAD can be considered a technology pathfinder toward the Square Kilometre Array telescope (Taylor, 2007 and Greenwood, 2007). Due to the large number of components utilised in the 2-PAD analogue chain, there is need of a database to store measurement data. This database needs to be scalable; while we are currently working toward implementing a $4 \times 4 \times 2$ array, the long term goal is to implement the full $8 \times 8 \times 2$ system at Jodrell Bank. This upgrade would see the number of signal paths increase by a factor of 4, from 32 to 128. The number of analogue components will also grow by this factor, from $\sim$ 300 for the $4 \times 4 \times 2$ array, to $\sim$ 1500 for an $8 \times 8 \times 2$ array. To accommodate this expansion, we have created a relational database which links together serial numbers, signal IDs and measurements in a logical fashion. This measurement database is available online at `http://2-pad.physics.ox.ac.uk`.

If we were to extend the current 2-PAD design to the proposed size of a SKA substation (ie. up to $\sim$ 75000 elements, see Faulkner, 2009), then the number of analogue components required could conceivably grow by over three orders of magnitude to over 1×10^6. While 2-PAD is of course not intended to be scaled by such a huge factor, this stills highlights the need to invest time into database design for SKA hardware management. The 2-PAD measurement database can be seen as a pathfinder toward future hardware management systems for the SKA.

The design of the 2-PAD database is discussed below in Section 2. Interface design is discussed in Section 3, and scalability toward SKA sized arrays is treated in Section 4.

2. Database Design

The 2-PAD measurement database is designed and built in MySQL 5, which is relational database software developed and supported by Sun Microsystems. MySQL is widely used in internet applications and is distributed as part of the open-source server software stack, LAMP (Linux, Apache, MySQL, PHP / Perl / Python).

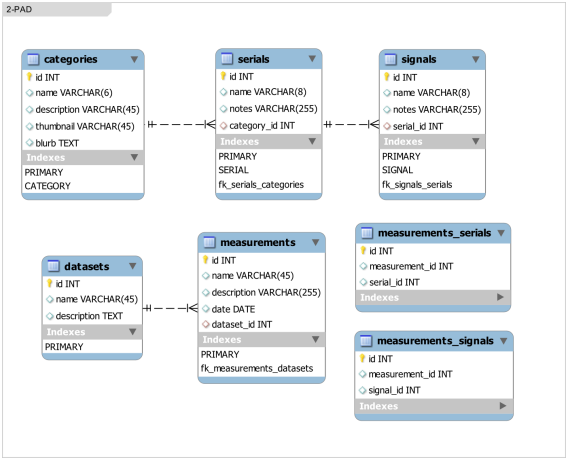

Fig. 1: The entity-relationship diagram for the 2-PAD database. The database design follows CakePHP nomenclature guidelines, which ensures CakePHP's automatic Object-Relational Mappings (ORM) function nominally.

The 2-PAD MySQL database design is shown in the Entity-Relationship (E-R) diagram of Figure 1. The arrows in the figure represent one-to-many relations between database tables. Data is retrieved from the database using Structured Query Language (SQL), which is generated automatically by the CakePHP frontend discussed in Section 3 below.

As shown in Figure 1, the *categories* and *dataset* tables can be considered the "superordinate" tables of the 2-PAD measurement database. The *categories*[a] table stores general information about the different classes of analogue components (i.e. amplifiers, gain chain modules, coaxial cables, etc). The *categories* table has a one-to-many relation with the *serials* table, which stores information about each analogue component that has been assigned a serial number. This in turn has a one-to-

[a] While the term *components* may be more semantically accurate than *categories,* "components" is a reserved word in CakePHP so could not be used.

many relationship with the *signals* table, which stores signal path information. This structure allows for a single component to have multiple related signal paths, as is the case with many of the components.

The other superordinate table, *datasets*, stores information about the measurement procedure, such as any laboratory working notes. The *datasets* table has a one-to-many relationship with the *measurements* table, which stores information about each measurement conducted. As the VNA outputs data as Comma Seperated Value (CSV) files, the measurements themselves are stored in a flat-file database. Each CSV file has a corresponding entry in the *measurements* table of the MySQL database, of which the *name* field is equivalent to the CSV filename; the naming scheme is discussed in detail in Price et al. (2009). The 2-PAD interface detailed below in Section 3 automatically retrieves and displays these CSV data.

3. Interface Design

We have designed an internet browser based user interface, to allow 2-PAD users to quickly access information and measurement data, as well as allowing technicians to document any changes to the system as they occur (such as upgrades to components, or replacing broken items). The interface is built in the CakePHP framework, which utilises MVC (Model-View-Controller), architectural patterns, allowing for rapid development of internet applications. As the interface is browser based, any standards compliant internet browser can be used to access the database (such as Internet Explorer 7+, Mozilla Firefox 3+, or Google Chrome 2+). As such, the database is accessible from virtually any computer, without the need for software installation.

To display the measurement data, the CSV files are read into an array by PHP scripts, then displayed graphically using the JpGraph library. Users also have the option of downloading these CSV files, if they wish to conduct further data analysis offline.

The 2-PAD measurement database also has a secure administration area, where users can add, edit and delete database entries. In addition to this, as the 2-PAD measurement database is an online application, we have integrated a website with general information about the 2-PAD project to further promote public awareness of the project. The 2-PAD website could easily be extended to provide community building resources, news feeds, forums and collaborative tools. The 2-PAD measurement database can be found online at `http://2-pad.physics.ox.ac.uk`.

4. Scalability

The 2-PAD measurement database has been designed to accommodate expansions and upgrades to the 2-PAD system. While 2-PAD aims to implement an $8 \times 8 \times 2$ array, the measurement database could easily accommodate for a $16 \times 16 \times 2$ array, or even $32 \times 32 \times 2$ array without approaching the table size limitations of mySQL.

The 2-PAD measurement database would not, however, scale to the size required to store the components of an SKA station, for which a more robust database solution would be advisable. It should be noted that an "SKA sized" database could potentially require a dedicated server and commercial database software, which would have both one-off costs in implementation, and ongoing costs in power, maintenance and administration. As such, we would suggest hardware management databases are considered in future SKA costing models and that further groundwork is done toward hardware management in aperture array systems as part of the AAVP.

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References

CakePHP: the rapid development PHP framework. 2009 `http://www.cakephp.org`

Faulkner A., 2009, "Aperture arrays in the SKA," In SKA Cape Town 2009.

Greenwood, C. "Status of Pathfinder Telescopes and Design Studies," SKA Memos. 2007

Harris, G., et al., July 2009, "2-PAD: The New Arrival," SKADS IAU Newsletter. available at `http://www.skads-eu.org/PDF/SKADSnewsletter05_IAU.pdf`

MySQL :: About MySQL. 2009 `http://www.mysql.com/about/`

Price, D., Schediwy, S., Ikin, T., Jones, M., "The 2-PAD Analogue System: Characterisation, Commissioning, and Implications for Calibration and Beamforming," SKA Memo #122, 2010, available from `http://www.skatelescope.org/pages/documents_3.htm`

Taylor, A., 2007, The Square Kilometer Array. Proceedings IAU Symposium No. 248.