PROPEL – A DICOM ETL and plan quality monitoring system

Carver, A., Webster, G. and Green, S.

Background.

Radiotherapy is a field that should benefit greatly from 'big-data'. In this study we present PROPEL (Platform for Radiotherapy Outcomes, Plan Evaluation and Learning) as a platform for radiotherapy plan quality evaluation between centres. The archetypal data warehousing structure has many varied data sources, each entering data into a 'warehouse' passing though an ETL (Extract-Transform and Load) layer which transforms the data into a format suitable for analysis [1].

Methods.

The version of PROPEL presented here consists of three distinct sections, see Figure 1. The core of PROPEL is a plugin based C++ application that parses and analyses DICOM data. Each plugin performs a specific task, for example DVH calculation. The database described here is a Django [2] application. It extracts metrics from data submitted by the ETL layer. For example, the ETL sends a DVH to the Django application will store the DVH. The Django application also extracts metrics and builds models from the submitted data. If a rectum DVH is found then relevant metrics such as V30Gy are calculated. If a PTV DVH is also found within the same frame of reference then a model that predicts rectum dose from the degree of rectum/PTV overlap is updated. If a plan is sent then plan complexity data are extracted. The dashboard is built using Grafana [3]. Data have been submitted into PROPEL by UHB (University Hospital Birmingham) and Worcester and control charts used to monitor the degree of difference between centres.

Results.

Figure 2 shows one of the dashboard panels, in this case showing Modulation Complexity Score [4], a measure of plan complexity. The control charts colours each centre differently and highlight data that lie within the 2.5% tails of the specified distribution.

Discussion.

Figure 1 shows how PROPEL would fit into a wider ranging oncology outcomes system. The calculation plugins are entirely agnostic with respect to what the data are used for. For example, some future genetic project may wish to use radiotherapy data, in which case they may simply be added as a destination to the ETL layer, it is unlikely to be interested in a radiotherapy plan quality database. Similarly the plan quality database may well wish to use outcome data at some point in the future by connecting the Django system to a new ETL layer.

Conclusion.

PROPEL, provides a powerful and flexible platform for monitoring radiotherapy plan quality. This architecture allows PROPEL to provide radiotherapy data to other projects, or other data sources to be added to the radiotherapy dashboard with no assumptions about what that future data may be.

Key references.

[1] Sahama, T., & Croll, P. (2007). A data warehouse architecture for clinical data warehousing. In *ACSW Frontiers 2007: Proceedings of 5th Australasian Symposium on Grid Computing and e-Research, 5th Australasian Information Security Workshop (Privacy Enhancing Technologies), and Australasian Workshop on Health Knowledge Management and Discovery* (pp. 227-232). Australian Computer Society.

[2] Django Project Team. http://www.djangoproject.com

[3] Grafana. http://grafana.com

[4] McNiven, A. L., Sharpe, M. B., & Purdie, T. G. (2010). A new metric for assessing IMRT modulation complexity and plan deliverability. *Medical physics*, *37*(2), 505-515.

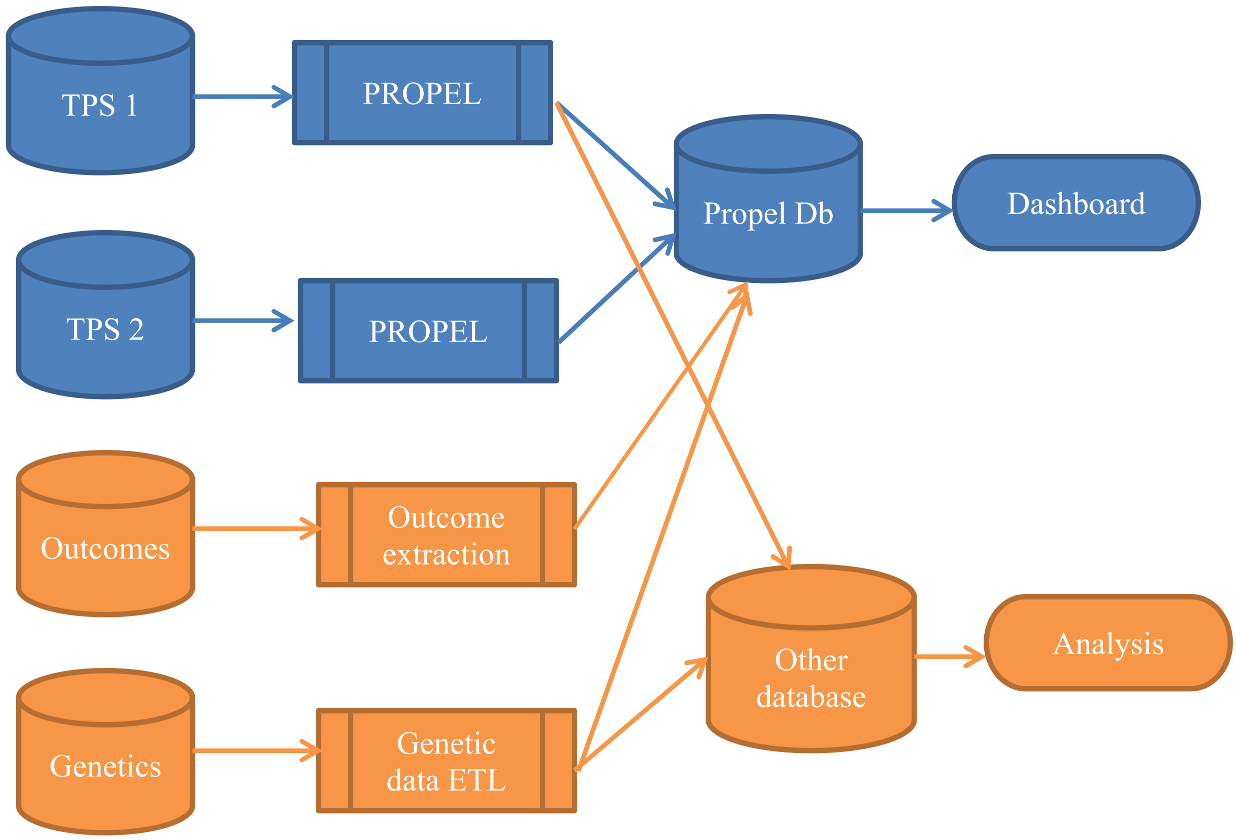

Figure 1. Schematic of PROPEL as a ‘big data’ platform. Blue items are implemented here; orange items demonstrate how it would fit into a greater, hypothetical, architecture.

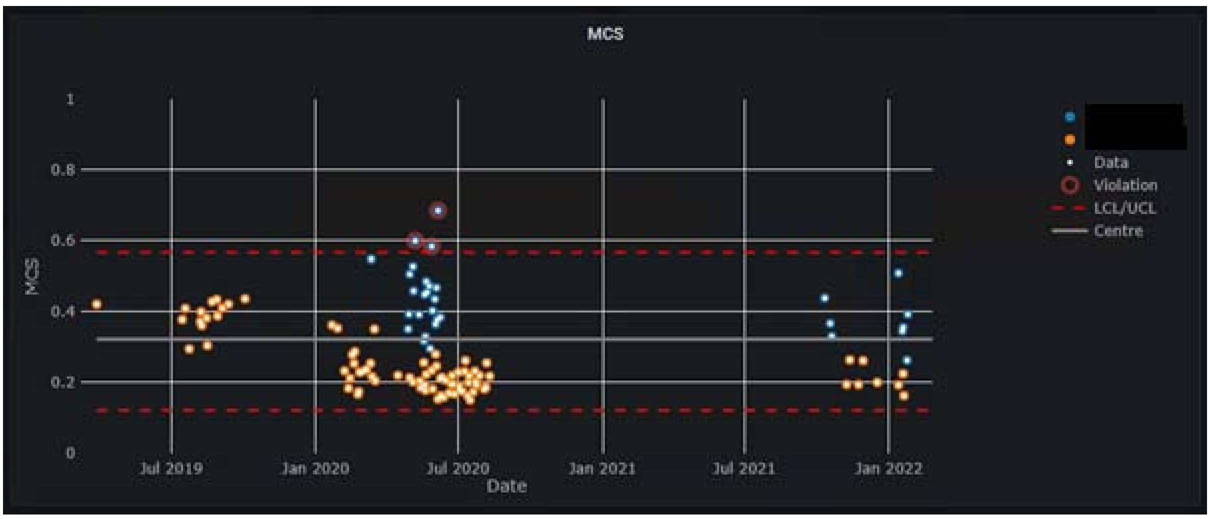

Figure 2. Example dashboard showing plan complexity metrics.

Mapping data flows in a radiotherapy department using in-house developed software

Daniel R. Warren, Adam Chalkley, Martyn Booth, Semrina Asghar, Marie Tiffany, Ian Stronach
University Hospitals Birmingham NHS Foundation Trust, Birmingham, B15 2TH

Background: As the volume of data used to inform, plan, deliver and monitor radiotherapy treatments grows, and the inter-connectivity of clinical computer systems increases, the issue of data transfer quality assurance (QA) has become ever more important.

Recent reports from professional bodies advise designing QA processes that explicitly check the correct transfer of digital data between systems[1,2,3]. AAPM Report 201.A recommends creating a data transfer matrix, which can be used to record connections between systems. This work extends that approach by creating a knowledge management tool for data flows and linking them to test procedures, facilitating the adoption of best practice in data transfer QA.

Methods: A software application was developed to model data flows in a radiotherapy department. The core of the model is a directed graph: computer systems are represented by vertices, and data transfer routes (connections) between systems are represented by edges. Parent-child relationships are supported, such that complex systems (e.g. Oncology Management System) can be broken down into sub-systems.

The application provides a web-based user interface where users can specify and edit all components of the model. Modelled data flows can be viewed in multiple formats: as tables, as a data transfer matrix[1], or as a diagram rendered using PlantUML[4]. Clinical pathways can be constructed from ordered lists of connections, and linked to end-to-end or connection-specific QA procedures stored in another web application e.g. QATrack+. Output can be filtered to display the connections and pathways that are relevant when upgrading, replacing or designing a QA programme for a specific system.

This software was used to map patient data flows in a large, multi-vendor radiotherapy department for a number of common clinical pathways. Systems and connections were identified by reference to ISO 9001 quality management system documentation, system configuration details (e.g. DICOM destinations) and interviews with members of relevant staff groups.

Results: An initial survey of five external beam radiotherapy and brachytherapy pathways identified 26 major systems with 59 separate data transfer routes (54% DICOM; 22% file-based e.g. PDF; 24% others). This increased to 51 sub-systems with 91 routes when complex systems were broken down. Diagrams, as shown in the Figure, were found to be easier to interpret than data transfer matrices. Work is ongoing to map out further pathways and refine the application.

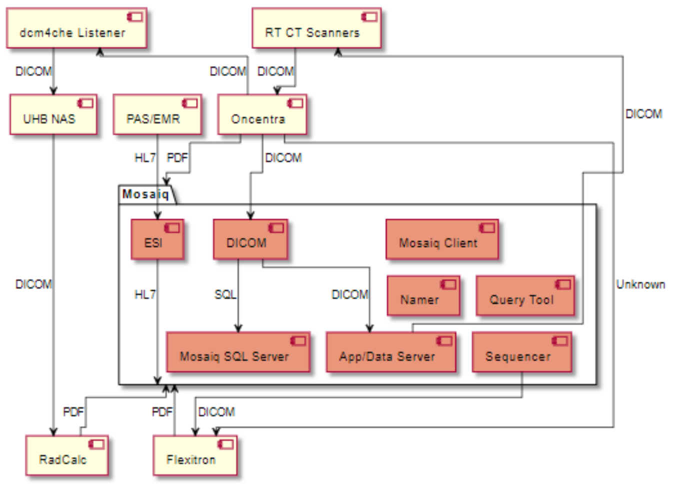

Figure: Example data flow diagram produced by the application (HDR brachytherapy pathway)

Conclusion: Radiotherapy departments have complex data flows. A centralized platform for recording and visualizing flows can disseminate knowledge across staff groups, and assist in designing data transfer QA programmes.

References: [1] AAPM Report 201.A (2021); [2] IAEA Human Health Report 7 (2013); [3] IPEM Report 81 2nd Edition (2018); [4] PlantUML v1.2022.1 https://www.plantuml.com

The first two years of a Scientific Computing Team

J.P.C. Baldwin, B. Wheller, A. Saif
Scientific Computing, Department of Medical Physics and Engineering,
Leeds Teaching Hospitals NHS Trust LS9 7TF

Background. There is an increasing need for a specialised Scientific Computing workforce within the remit of Medical Physics and Clinical Engineering. While Clinical Engineers and Medical Physicists carry out many computing duties [1], the need for specialised roles is becoming increasingly important to carry out specialised aspects of the work. Specialist knowledge is also needed to support and enable others in carrying out high quality scientific computing activity. At Leeds Teaching Hospitals NHS Trust (LTHT), prior to 2019, a Computational Physics and Innovation Team were responsible for all Scientific Computing work. This was a small team of clinical scientists and a clinical technologist with a huge remit where computing was one of many roles within the team. Due to a combination of retirement, promotion and a changing workload, the team was disbanded. The computing responsibility was revised and the resources reformed into a dedicated Medical Physics and Engineering Scientific Computing team.

Methods. The Scientific Computing Team at LTHT was formed in July 2020 with two members, a manager appointed as the Clinical and Scientific Computing Lead and a Clinical Scientist, qualified in Bioinformatics (Physical Science). The Team's remit is:

- Development and implementation of novel clinical computer software devices, applications and models within the relevant quality and legislative frameworks.
- Application of data science methods for the orchestration and analysis of clinical datasets, medical images and the results of computer simulations.
- Evaluation, configuration and commissioning of computerised healthcare technology.
- Working with academics, other scientists and clinicians, participating in multi-disciplinary research activity.
- Training others in the field of bioinformatics.

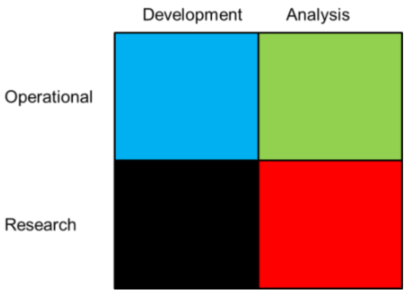

Figure 1

A project based approach is taken where the aim is to balance work over the four sectors [figure 1]. Given the nature of the demand, many of the projects currently relate to Radiotherapy Physics. However, plans are in place to scale up to collaborate with all sections within the LTHT Department of Medical Physics and Engineering. In January 2021 a Bioinformatics Technologist joined the team and in July 2021 a second Bioinformatician was recruited. The team started hosting STP trainees in October 2021.

Results. Over the past two years the team has provided support across the Medical Physics and Engineering department. This includes assisting with data collection, deidentification and storage of clinical data for 27 research projects; developing novel methods for replacing obsolete equipment; carrying out audits; and taking an active role in two deep learning research projects. The team has developed SQL scripts for creating, updating and viewing a new data warehouse; Python programs to extract previously inaccessible patient data from clinical backup systems; and a Raspberry Pi system to read and process parallel printer port signals. The team also manages the research infrastructure including setting up and maintaining the GPU enabled virtual machines.

Discussion. This talk will be given by three members of Scientific Computing. Topics to be covered include: how the team was formed; the projects developed; and experiences from a new member of staff.

Conclusion. With the increased demand for specialised Scientific Computing expertise, more Trusts are creating or formalising Scientific Computing Teams. This talk aims to outline our experiences in setting up, working in, and joining a brand new Scientific Computing team. It should also provide guidance for other Trusts looking to expand their Scientific Computing capabilities.

Reference: IPEM Report on a Clinical & Scientific Computing Workforce Survey 2019: Patterns of Computing within MP&CE. A.Chalkley, E. Claridge, J. Eve and A. Hyett. IPEM. 10/21.

A Reflection on Developing a Clinical Scientific Computing Team from the Perspective of the Clinical Implementation of a Research Dementia Imaging Reporting Tool

James Leighs[1], Neil O'Brien[1], Sofia Michopoulou[2], Matthew Guy[1,2]
[1]Scientific Computing, Imaging Physics, University Hospital Southampton
[2]Nuclear Medicine Physics, Imaging Physics, University Hospital Southampton

Background. Scientific Computing within Imaging Physics has grown from part-time contributions from a clinical and computer scientist over many years to a substantive and growing team. Here, we reflect on the journey from the perspective of a project to implement a research imaging reporting tool into clinical practice as Software as a Medical Device (SaMD). Perfusion 2 diagnosis (p2d) began as the combined output of an NIHR research fellowship and two decades of local clinical and scientific involvement, in addition to interest in improving long-running clinical reporting protocols in a safe and effective way. Combining brain perfusion HMPAO SPECT reconstructions with one-vs-many statistical comparisons to present new reporting metrics related to hyper- and hypo-perfusion, p2d has potential to provide additional clinical insights in the dementia pathway and optimise reporting workflows.

Methods. Using this project as a case study, we have reviewed key elements of our Team's growth that made this project successful, including the following: (1) The creation of a Quality Management System (QMS) and associated cross-department working group for SaMD development; (2) expansion of the team and its expertise, widening our ability to take on a variety of work to better support others within Medical Physics and outside; (3) challenges faced along this journey and how we attempted to tackle them; and (4) the way we changed our working practices and project management, particularly considering the pandemic and increase in remote working.

Results. By forming a multi-disciplinary project team, p2d was successfully developed and deployed as an in-house medical device, engaging with a variety of stakeholders including reporting clinicians, Nuclear Medicine physicists, and academics. Against a background of limited resources and changing demands, the many identified factors key to success included early stakeholder engagement to identify clinical and technical requirements, removing unnecessary user-interaction to optimise processing, and consequently reducing development and testing burden. In addition, this work helped define an invaluable SaMD clinical validation process, which, whilst requiring additional resource, engaged clinical representatives in an exercise successful in proving p2d's positive impact on the clinical pathway, and provided stakeholders with confidence in its outputs. Conversely, whilst engaging with a variety of stakeholders was vital, these other groups had conflicting and challenging priorities, which added to the overall time to release the tool.

Discussion. For small teams, projects like p2d present challenges and opportunities. Forming and working in a multi-developer team was a positive experience, but required careful organisation compared with solitary development; the use of collaboration tools such as Confluence, Jira and Bitbucket proved invaluable. The translation elements of this project also presented challenges, such as incorporating open-source research-driven libraries, requiring in-depth study to validate for clinical use; and complete tool redesign to better facilitate end-user needs, an area where SciCom involvement earlier in the research may have saved resource.

Conclusion. Reflection on this work highlighted successes, along with areas for improvement, for our expanding SciCom team in Imaging Physics. p2d was our first multi-developer project, and its success led to us repeating this model more recently when developing an iPhone app for paediatric drug calculations. The p2d project was pivotal in helping to create and improve our SaMD QMS, which is scheduled to attain external ISO13485 accreditation later this year. The story of this work highlights the path through which we have successfully created and continue to grow our SciCom team; one which could well inspire others wishing to do so in future.

Title of Study Benefits of Redmine in Radiotherapy Physics
Submitters details Robert Ross, Radiotherapy Physics, GHNHSFT

Abstract no more than 1 page in Arial 11 point, presenting speaker underlined

Background. Redmine was introduced to log faults on radiotherapy equipment, but it's wider applicability was clear.

Tying in with the article "Open Source Project Management Significant Benefits" in the Summer 2022 issue of SCOPE, I will demonstrate and discuss the use of Redmine as a platform to enhance radiotherapy physics services.

The use of Wikis will be demonstrated, showing how they can be created, searched and peer-reviewed. Other uses, such as clinical status monitors, run up logs, QA scheduling, patient specific QA tracking and archive tracking will be demonstrated, along with examples of scripting to interface Redmine to our Treatment Planning System and in-house interfaces, via Python. The benefits of a single open source solution for all these applications will be discussed, along with how the system is maintained.

"ImportError: No Module named pydicom" – Finding Suitable Platforms for Scientific Computing Projects

Drew Davie, Clinical Scientist, Scientific Computing, Bristol Haematology and Oncology Centre.
drew.davie@uhbw.nhs.uk

A discussion around the challenge of finding sustainable and safe platforms for scientific computing projects within the constraints of the NHS.

Three principle types of software development platforms will be discussed with specific examples:

1. **Leveraging the development capabilities of commonly available products i.e. developing software within Microsoft Office through tools such as VBA, and whether Office 365 can be safely harnessed within the cloud.**
2. **Using technologies that have external dependencies but greater scientific potential i.e. Python, and how we can package them to be used widely within a department.**
3. **Developing web applications that allow much greater control of access and ease of use along with dedicated database servers, but require significant computing resources and skills to maintain.**

For each approach a few key strengths and weaknesses will be discussed with an invitation for the audience to contribute their own ideas and experiences.

A review into the challenges facing small scientific computing teams in this area will form the second half of the talk, covering areas including:

1. **Pathways for staffing into scientific computing (with respect to the STP and the syllabi of the different courses) and whether the other areas of software development other than coding are fully appreciated.**
2. **Whether IT departments are able to support niche in-house developments and platforms, plus the use of Unix/Linux.**
3. **The Medical Device Regulations and whether in-house software can really be safe given the platforms we use.**

To conclude, the delegates will be asked to suggest some of the platforms they use for deploying their projects and how they deal with some of the challenges presented.