The HEP Software Foundation Community

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ABSTRACT: The HEP Software Foundation was founded in 2014 to tackle common problems of software development and sustainability for high-energy physics. In this paper we outline the motivation for the founding of the organisation and give a brief history of its development. We describe how the organisation functions today and what challenges remain to be faced in the future.
1 History

Over the past 50 years, the experimental particle, nuclear and astroparticle physics communities have iteratively evolved a significant amount of community structure. This was a natural result of the growing size, scale and time duration of the experiments and the centralisation of facilities at large laboratories. National, and now international, collaborations are typically required to build, operate and maintain the large detectors used in these experiments. No single university or laboratory can provide all of the necessary expertise and required effort. The largest collaborations have grown from 100s of collaborators in the 1990s to 1000s at (for example) the Large Hadron Collider (LHC) at CERN. This community has also developed a broad ecosystem of methodologies and technologies that are used to build successive experiments and upgrades to existing experiments. While a specific instrument can necessarily only be used for a single experiment at any given time, the large commonalities in methodology should permit the development of research software which can be used widely in the community for different projects. Despite this, much of the software development remained somewhat siloed within individual experiments or, at most, one or another host laboratory, with only a few exceptions.

This is not to say that in the history of HEP there was no common software. CERNLIB [1] was a foundation library written in the Fortran era and used by many experiments. Elements of it have been rewritten in C++ and constitute some of the most widely used software packages in the field. Projects such as ROOT, Geant4, and various generators have effectively acted as common glue for many experiments. However in the software layers above these foundation and toolkit libraries, redundant solutions that are difficult to evolve and sustain over time (years or decades for large experiments!) are common. To a large extent, software speed, performance and efficiency had been ignored previously, because the costs due to inefficient software could be ignored in the past. Software is as much an intellectual product as well as a tool, thus a new approach was needed.

First steps in the direction of collaborating on modernising, in 2011-2012, led to the formation of a cross-experiment “Concurrency Forum” [2] to discuss the specific software challenges brought by changes in microprocessor technology (multi-core, wide vectors, GPUs). Driven initially by CERN and Fermilab, the forum demonstrated community interest in wider software collaborations. By 2014-2015, a number of colleagues involved in HEP software for many years were discussing a more ambitious and broader scope for research software collaborations in HEP. This eventually led to the formation of the High-Energy Physics (HEP) Software Foundation (HSF). The driving motivations for
this initiative were that the physics upgrades anticipated in the coming decades, particularly the High-Luminosity LHC [3], would put enormous pressure on the software used in HEP; that much of our software was already decades old; the changes in microprocessor technology brought new challenges to the table; and that there was an urgent need to train new talent and to attract investment to the field, which could be better supported when common, multi-experiment, efforts were promoted. More generally, additional community structure which promotes research software collaborations, not tied to single experiments or laboratories, has greater potential to enhance the longer term sustainability of the software.

The very first workshop [4] attempted to build on the community experience within the large experiments, however there was too much discussion of “governance” questions. Individual experiments need to operate a large well-integrated detector, manage pooled resources (such as computing and storage) and at the end of the day produce scientific publications signed by the entire collaboration. Thus governance questions within experiments are critical. This top-down approach was less obvious for the envisioned research software collaborations, which can be more “ecosystem-like”. It also made engaging experiments of very different sizes more challenging. By the end of the workshop most participants had concluded that a different structure was needed. Subsequent workshops, one in North America and one in Europe to aid inclusivity [5, 6], brought together many HEP experiments, HEP specific software projects and other non-HEP organisations, such as the Apache Software Foundation and the Software Sustainability Institute. Here, the principle of a “do-o-cracy” was enshrined, to encourage activity from the bottom-up, with developers leading, which was a far more productive approach to community building.

From these early workshops the idea was born of preparing a Community White Paper (CWP), laying out the roadmap for software and computing in HEP in the 2020s. As a way to fortify these community-led efforts, the Worldwide LHC Computing Grid (WLCG) gave a formal charge to the HSF to prepare this paper [7]. Many individuals volunteered and the US National Science Foundation was an early investor with dedicated funding to help organise and carry out CWP workshops [8, 9]. These workshops were focal points of an intense year of identifying key domain areas and potential solutions for the field and setting up working groups who would prepare topic-specific white papers. This approach was able to greatly broaden the involvement of key individuals and solidified the active communities around the HSF. Once the working groups had produced their domain-specific white papers, an editorial team took charge of synthesising a unified single version of the white paper, which was published with extremely wide community support, 310 signing authors from 124 institutes [10]. The CWP was not the only activity happening in the HSF at this time. Particularly where there was an identified gap between different communities, be these inter-experiment, between projects, or even between theory and experiment, the HSF was ideally placed to bridge gaps and bring different people together. Workshops on analysis ecosystems [11] and on computational aspects of event generators [12] were notable examples. In addition the HSF was a natural forum for considering more radical software developments and their potential, gathering experiment and expert feedback on progress and possibilities [13].

2 HSF Activities

While much of the early HSF activity was focused on software community building through the CWP, working groups were started where common topics were obviously identified within the community, e.g., in the domain of packaging and distributing HEP software stacks. These groups brought together experts and interested parties and focused around technical discussions.
In the wake of the CWP it was clear that this model would work very well for the areas of most concern for the future, so the model was broadened and, over a few years, eight working groups were established with about 3 conveners in each case, appointed annually and with a nomination system that allows both stakeholder (experiment, institution) input and bottom-up volunteers for running these groups. In order to marshall these activities it was necessary to have some critical amount of binding effort, so the decision of CERN management to allow significant (0.5 FTE) time from one person to the HSF was crucial and has had a key multiplication effect.

Where these groups are involved in areas that are ‘traditional’, e.g., detector simulation or reconstruction, there is a strong involvement with ongoing developments in the experiments and in well established software projects. The focus is the exchange of ideas and discussions of common problems. In a number of cases the HSF had identified topics of interest that were simply not covered elsewhere in the field and then the HSF working group has had a further leading and catalysing effect. This is particularly the case for the use of Python in HEP, led by the PyHEP working group; and for computational aspects of physics event generators, led by the Generators working group [14].

In addition to being a focus for the exchange of ideas and techniques, when WGs identify a concrete topic where a paper can usefully be prepared, the HSF is a natural place for organising pan-experiment input and encouraging some standardisation (e.g., in analysis level metadata or in detector conditions data access). This has been recognised by more formal bodies outside the HSF, such as WLCG and the LHCC, who often ask the HSF to marshall community inputs for updates on development activities and reviews of development plans. This is an important point in terms of recognising the contribution of the organisation. In turn, this fosters recognition for the contribution of our individual members and helps their careers to advance. This engagement with strategic bodies in the field, where the HSF advocates for software investment [15], leads the HSF to work in tandem with other funded software R&D projects in HEP, where the HSF will support funding applications and then work with these projects, enhancing their connection to the community and the impact of their work. Practically projects can contribute through the working groups closest to their R&D areas.

The HSF also engages with other like minded bodies and collaborates on regular series of meetings regarding accelerator programming or software and computing for nuclear physics and also organises itself as an umbrella organisation, with CERN, to run Google Summer of Code for HEP software projects and experiments.

In the past the HSF organised face-to-face workshops and the intention is to restart such activities once the pandemic passes, but in the meantime virtual workshops have played a role. In some circumstances these can even have a greater impact, with the PyHEP workshops in 2020 and 2021 registering more than 1000 participants [16, 17]. In large part this reflects a strong didactic element in the Python area. This thread is reflected also in that the HSF, together with IRIS-HEP, SIDIS, The Carpentries and the ROOT project [18–22], has put a strong emphasis on training activities [23] and now runs regular training events in fundamental software skills and in C++ programming. This is seen as a critical activity in the field and attempts are now also being made to have these activities as feeders to encourage trainees to be involved in software development and training.

3 Outcomes and Conclusions

Contrary to initial ideas, the HSF has not, by and large, run software projects themselves - without actually having resources to disburse it is better to allow such projects to be independent and work with the HSF as is useful. That said, HSF events have proved to be fertile ground for people from different
backgrounds to meet (e.g., nuclear and astroparticle physics) and even to start common software projects that then take on a life of their own. Fostering funded projects has led to new investment in software R&D in HEP and a higher recognition of the importance of promoting excellent software developers in their careers; this is a major success that was a direct outcome of the CWP process.

The HSF has now established itself as a recognised part of the HEP software landscape where it links strategic bodies to the community of software developers. It remains a challenge to continue to build the next generation of HEP software developers and make them feel involved and part of an organisation like the HSF, but work to improve training and engage younger colleagues through the working group process is hoped to improve this. Looking forward to post-pandemic activities, where face-to-face interactions can happen again, will also help to continue to build HEP software communities.
References

[1] CERN Program Library. URL: https://en.wikipedia.org/wiki/CERN_Program.Library.

[2] Forum on Concurrent Programming Models and Frameworks. URL: https://concurrency.web.cern.ch/concurrency/index.html.

[3] The High-Luminosity LHC project. URL: https://home.cern/science/accelerators/high-luminosity-lhc.

[4] HEP Software Collaboration meeting. Apr. 2014. URL: https://indico.cern.ch/event/297652/.

[5] HEP Software Foundation Workshop (SLAC). Jan. 2015. URL: https://indico.cern.ch/event/357737/.

[6] HEP Software Foundation Workshop (LAL). May 2016. URL: https://indico.cern.ch/event/496146/.

[7] Charge for Producing a HSF Community White Paper. July 2016. URL: https://hepsoftwarefoundation.org/assets/CWP-Charge-HSF.pdf.

[8] HEP Software Foundation Workshop (SDSC). Jan. 2017. URL: https://indico.cern.ch/event/570249/.

[9] HEP Software Foundation Workshop (LAPP). June 2017. URL: https://indico.cern.ch/event/613093/.

[10] Johannes Albrecht et al. “A Roadmap for HEP Software and Computing R&D for the 2020s”. In: Computing and Software for Big Science 3.1 (Mar. 2019), p. 7. ISSN: 2510-2044. DOI: 10.1007/s41781-018-0018-8. URL: https://doi.org/10.1007/s41781-018-0018-8.

[11] HEP Analysis Ecosystem Workshop. URL: https://indico.cern.ch/event/570249/.

[12] Physics Event Generator Computing Workshop. URL: https://indico.cern.ch/event/751693/.

[13] HEP Software Community Meeting on GeantV R&D. URL: https://indico.cern.ch/event/570876/.

[14] Andrea Valassi et al. “Challenges in Monte Carlo Event Generator Software for High-Luminosity LHC”. In: Computing and Software for Big Science 5.1 (May 2021), p. 12. ISSN: 2510-2044. DOI: 10.1007/s41781-021-00055-1. URL: https://doi.org/10.1007/s41781-021-00055-1.

[15] Graeme A Stewart. The Importance of Software and Computing to Particle Physics. Dec. 2018. DOI: 10.5281/zenodo.2413005. URL: https://doi.org/10.5281/zenodo.2413005.

[16] PyHEP 2020 (virtual) Workshop. July 2020. URL: https://indico.cern.ch/e/pyhep2020.

[17] PyHEP 2021 (virtual) Workshop. July 2021. URL: https://indico.cern.ch/e/pyhep2021.

[18] Institute for Research and Innovation in Software for High Energy Physics (IRIS-HEP). URL: https://iris-hep.org/.

[19] Software Institute for Data-Intensive Sciences. URL: https://sidis.web.cern.ch/.

[20] The Carpentries. URL: https://carpentries.org/.
[21] R. Brun and F. Rademakers. “ROOT: An object oriented data analysis framework”. In: Nucl. Instrum. Meth. A389 (1997), pp. 81–86. DOI: 10.1016/S0168-9002(97)00048-X.

[22] ROOT Data Analysis Framework. URL: https://root.cern/.

[23] Sudhir Malik et al. “Software Training in HEP”. In: Computing and Software for Big Science 5.1 (Oct. 2021), p. 22. ISSN: 2510-2044. DOI: 10.1007/s41781-021-00069-9. URL: https://doi.org/10.1007/s41781-021-00069-9.