



XRAS at 10 Years: Allocations Software as a Service for the NSF HPC ecosystem

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ABSTRACT

The eXtensible Resource Allocation Service (XRAS), a comprehensive allocations environment for managing the submission, review, and awarding of resource allocations has been essential to managing the resource allocation needs of the national cyberinfrastructure for the past decade. As a software-as-a-service platform, XRAS supports not only the needs of its primary stakeholder program, but also the processes of half a dozen other national and regional resource providers. Over the past decade, XRAS has continuously improved on its original feature set and added new features to better meet the needs of its clients. Today, XRAS supports a core workload of 500 allocation requests each quarter, and the development roadmap for the system is focused on expanding the types of resources XRAS supports, enabling resources to be integrated in novel ways, and increasing the number of resource federations that XRAS can support. In this paper, we describe key aspects of resource allocations that have guided XRAS development; discuss the current XRAS clients and our approach to sustainability; and briefly describe the XRAS architecture and how it integrates with client sites and the ORCID ecosystem. We then turn to the XRAS architecture and client integration capabilities and describe major features of XRAS developed over the past decade. Finally, we outline future work planned for XRAS.

CCS CONCEPTS

• **B7; Social and professional topics** → Professional topics; Management of computing and information systems; Implementation management; Pricing and resource allocation.

KEYWORDS

high-performance computing, resource allocations, software as a service

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1 INTRODUCTION

Over the past decade, the research computing landscape has changed dramatically, and the national-scale high-performance computing (HPC) resources available to the U.S. research community through federal agency funding have continually evolved in response to technological advances and changing researcher needs. Despite the changes, these national-scale resources continue to require support for the allocation processes by which resource providers track the demand for these resources and understand the research and instructional objectives of their user communities. The U.S. National Science Foundation (NSF) funds many such computational resources through various programs (e.g., [1]) and the centralized allocation process for a federated ecosystem of these resources is provided through the Advanced Cyberinfrastructure Coordination Ecosystem: Services & Support (ACCESS) program [2], which was launched in September 2022.

To support the central allocations process, the ACCESS Allocations Service is continuing to operate and develop the eXtensible Resource Allocation Service (XRAS). Originally launched in 2014, XRAS has been under continuous development over the last decade. One measure of the success for XRAS was the ability of ACCESS to overhaul allocation policies, implement the necessary changes to put those policies into practice essentially overnight, and continue to accept, review, and process roughly 500 allocation requests per quarter. But as a software-as-a-service offering, XRAS further provides critical infrastructure beyond ACCESS to half a dozen clients who rely on XRAS to be robust and flexible. Looking ahead, the ACCESS Allocations Service has plans to expand and innovate the capabilities of XRAS to support a more diverse and dynamic portfolio of resources.

In this paper, we describe prior and related work including aspects of the original XRAS release and key aspects of resource allocations that have guided XRAS development; discuss the current XRAS clients and our approach to sustainability; and briefly describe the XRAS architecture and how it integrates with client



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sites and the ORCID ecosystem. We then turn to the XRAS architecture and client integration capabilities and describe major features of XRAS developed over the past decade. Finally, we outline future work planned for XRAS.

2 PRIOR AND RELATED WORK

XRAS arose from an effort to update and modernize the Partnership Online Proposal System (POPS), which dated back to 2001 during the NSF Partnerships for Advanced Computational Infrastructure (PACI) program [3]. POPS provided the mechanisms by which allocation proposals were submitted, reviewed, processed, and subsequently communicated to participating resource providers. POPS served in this role through the subsequent TeraGrid program [4] and into the eXtreme Science and Engineering Discovery Environment (XSEDE) program [5]. During the XSEDE program, XRAS was originally developed (as the XSEDE Resource Allocations Service) to modernize the POPS software, and as part of the development effort, XRAS was designed as a multi-tenant software-as-a-service (SaaS) solution [6]. XSEDE pursued a SaaS solution due to the lack of other products or services that included the full scope of allocations process functionality to fulfill XSEDE's broader mission of supporting the NSF-funded resource ecosystem.

In the research computing space, the “standard” resource allocations process can be considered to have several phases, which different providers may address with approaches of varying levels of complexity [7]. The first phase involves taking stakeholder guidance, defining policies, staffing necessary roles, and assembling review panels. The next phase encompasses the solicitation and preparation of proposals, followed by review and processing of those proposals. Next, the applicants and resource providers are notified of outcomes. (Some processes support an asynchronous “appeal” option, which goes through a sub-cycle of submission, review, and processing.) Once outcomes are communicated and projects established, the project execution phase may involve various monitoring, feedback, and progress reporting steps.

XRAS was designed to support all phases of the resource allocations process. However, unlike the earlier POPS software, XRAS provided a wide range of customization options that allows different clients to configure XRAS to support their specific allocations policies and practices.

Since 2014, XRAS has been under continual development as part of the XSEDE program and has transitioned to the current ACCESS program. XRAS continues to support all the original features that enabled its initial 10 use cases, which span functions from establishing an allocations process to awarding or rejecting an allocation request [8]. Within these use cases, XRAS supports a number of features unique to allocations processes in computational ecosystems [6], including

- ongoing and repeating allocations opportunities,
- client-defined types of allocations and panels,
- support for multiple resource types, including computing, storage, datasets, and user support services,
- optional integration with a client organization's accounting service to provide reviewers with up-to-date information related to a submitter's past activity,

- integration with a site's authentication service so users need not obtain another login or password,
- reporting capabilities to support administrator's needs, and
- follow-on requests supporting the management of active allocations, including supplemental requests, time extensions, and final reports.

Some online services, such as EasyChair [9] and ConfSys [10] are available to support the submission and review of conference papers. While these services can be used to support some elements of the allocations workflow, they lack other key components, such as integration and communication with resource providers and their local resource management systems. Since XRAS was originally developed, other systems have been developed that address parts of the allocations workflow. The Puhuri system provides services for managing access to shared resources in a federated manner but lacks the proposal management and review capabilities of XRAS [11]. The ColdFront system, which has been adopted by many campus computing organizations, supports a lightweight allocation request process; however, ColdFront lacks the comprehensive review process features of XRAS, and is more tightly coupled to local resource management while XRAS is capable of supporting allocations processes for a broad federation of resources across multiple sites [12].

3 XRAS CLIENTS AND SUSTAINABILITY

As a product developed with support from NSF awards, the XRAS code base is open source and the code for many front-end components is being made available in open repositories. However, we are primarily approaching sustainability for XRAS by offering it as a for-fee software-as-a-service to other organizations, with the goal of ensuring that XRAS persists beyond the lifetime of initially XSEDE and now ACCESS. Each organization pays an annual rate, and the XRAS team in turn provides hosting, maintenance, database storage, user support and troubleshooting, and training.

The first external client for XRAS was the NSF National Center for Atmospheric Research (NCAR), which began using XRAS in 2015. As an early adopter, NCAR provided essential feedback into XRAS features needed to support alternate allocation policies and practices. Beyond demonstrating the capabilities of XRAS, NSF NCAR also worked with the XSEDE program via the University of Illinois at Urbana-Champaign (UIUC), to develop a formal service and data agreement for use of XRAS. Because XSEDE and now ACCESS are programs arising from NSF funding awards, they are not entities that can enter into agreements with other institutions, thus the service agreements are with UIUC and designated as program income for the associated award.

While NSF NCAR should be considered a “friendly” client, given its involvement in the XSEDE program, conversations with other potential clients had indicated concerns about who had access to and control of client data in the XRAS system. Similarly, the XRAS team needed to set expectations for the levels and types of support available to clients. The standard XRAS service agreement defines the XRAS team's commitments to client organizations: The XRAS team will host the and maintain the XRAS software; support initial setup and configuration of XRAS, including integration with the client's authentication and identity systems; provide database

storage of the client’s allocations request data; troubleshooting and technical support; training for the client’s administrators; and advice and guidance for further customization and integration. Each client organization, in return, contributes financially to XRAS. Because XRAS was and is core infrastructure for XSEDE and now ACCESS, the financial contributions are aimed at offsetting the additional cloud server and storage costs as well as the incremental staff support associated with each client.

When a new client organization is ready to begin using XRAS, the XRAS team has several meetings to consult with the client organization to best understand their environment and will recommend initial configuration options for XRAS. The XRAS team then sets up the initial deployment and provides a training session to the local client administrator, which is the person at that organization who is responsible for the day-to-day management of the allocations process. Quarterly meetings are also held with all XRAS client administrators, giving an opportunity for them to express any concerns about operating XRAS, request specific improvements or new features, and hear updates about the planned future direction of XRAS development. The XRAS team then continues to make itself available to these clients, answering support questions, developing new reports or features (within a reasonable scope), and providing debugging and needed.

Because of the fee-based structure of this client agreement, we anticipate that XRAS can continue to be offered beyond the lifetime of major supporting grants such as XSEDE and ACCESS. We plan to continue to support and maintain XRAS as a service so long as client organizations find it useful.

In addition to defining the service agreement structure between organizations, XRAS was architected to allow for new client organizations to be added quickly with relatively low overhead. The team operates a demonstration environment in which potential clients can get an initial feel for the platform, and the low overhead makes it possible to spin up trial environments for deeper exploration of the features prior to executing the service agreements. This capability has been leveraged to respond to new initiatives that require allocation of HPC resources. Recent examples of this include both the COVID-19 HPC Consortium [13] and the National Artificial Intelligence Research Resource (NAIRR) pilot [14]. For the COVID-19 consortium, the existing XSEDE allocations infrastructure and processes were harnessed and adjusted over the course of a weekend to provide new submission opportunities for the consortium. With the time provided by the 90-day window leading up to the NAIRR pilot launch, an entirely new XRAS client instance was set up in about a week, and most requirements for the pilot were met with existing XRAS features and configuration options. Some minor modifications, including stylesheet changes to match the look and feel of the NAIRR pilot website, were made by the development team to configure the submission interface and better meet the needs of the NAIRR pilot.

In addition to these fast-turnaround or pilot opportunities, XRAS has been supporting several client organizations over a longer period. Among these clients are sites managing nationally available resources: the computational resources at NSF NCAR [15]; the NSF’s Lower Atmosphere Observing Facilities managed by the NSF NCAR Earth Observing Laboratory [16]; the NSF’s Frontera system and other resources at the Texas Advanced Computing Center

[17]; and the Anton-2 system, funded by the National Institutes of Health, at the Pittsburgh Supercomputing Center [18]. Other clients use XRAS to manage requests for campus and regional resources: the Illinois Computes program at the National Center for Supercomputing Applications [19] and Carnegie Mellon University [20]. We also host a pilot site in support of the International Science Reserve program sponsored by the New York Academy of Sciences [21].

4 XRAS ARCHITECTURE

The XRAS platform is built as a set of Ruby on Rails web applications that share a PostgreSQL database for storage and data persistence. With the goal of rapid, Agile development of XRAS, its various components were built as individual Rails applications instead of as a single monolith. This allows developers to move quickly in creating and maintaining the individual components, without having to coordinate changes to tightly coupled modules. The following major components communicate with each other via the underlying database and APIs.

XRAS Admin is the application and user interface used by administrators to configure an allocations process, assign reviewers, make final approvals or rejections, post allocations, and so on. XRAS Admin uses a standard Ruby on Rails Model-View-Controller (MVC) design [22], which communicates directly with the database using Rails’ ActiveRecord framework, as well as communicating with the XRAS Rules Engine API.

XRAS Review is the application and user interface reviewers use to read requests, evaluate project usage (if available), and submit their reviews and recommendations. Like XRAS Admin, XRAS Review is built as a Rails MVC application.

The **Rules Engine** application and API interprets configuration rules for an allocations process and determines the functionality available for a given request or action at any time. This API is consumed by the other XRAS components. Centralizing these rules in an API makes it easy to change them without having to change every other application.

The **XRAS API** application provides an interface for client organizations to read and write XRAS information. Its primary use is to receive request submissions from a submission user interface, and this API allows clients to develop custom submission interfaces as needed. The XRAS API also provides reporting routes that allow clients to pull XRAS data when desired.

The **Submit User Interface (UI)** is the application through which allocation requests are submitted by end users. Because these interfaces are often customized and self-hosted by their client organizations, they are permitted to communicate only through the XRAS API. This ensures that client organizations can only read and write the appropriate data to the XRAS database. A default Submit UI is available from the XRAS team, and XRAS can host the Submit UI on behalf of the client, or the client can host the default or a customized Submit UI in their domain.

The **Cyberinfrastructure Description Repository (CIDEr)**, while not a formal part of XRAS per se, is an essential element of the XRAS infrastructure [23]. CIDEr provides a guaranteed, persistent, and unique reference for each resource as well as essential resource information. Through CIDEr, resource providers

can help maintain how and when their resources appear within XRAS. CIDEr also supports the XRAS integration with ORCID (see below) by maintaining unique identifiers and hosting public pages for resources.

A **PostgreSQL database** is used as a back-end data store to support the suite of XRAS applications. The database schema is designed in a multi-tenancy approach, so that a single database is used to support all client allocations processes.

In addition to these components, XRAS depends on an **Identity Service** and an optional **Accounting Service** defined by each client to support the allocations process and communicate with a client organization's infrastructure. These services and their associated APIs are discussed in more detail in the next section.

5 CLIENT INTEGRATION WITH XRAS

To support a wide range of client infrastructure and workflows, the XRAS platform has several different integration points available. These can be customized as needed to adapt to each client's requirements. As a new client allocations process is configured, the XRAS team reviews each of these integration options with the client administrators to determine how best to support that organization's workflow. These integration options provide opportunities to further enhance and customize the features built into XRAS, some of which are described later in the XRAS Admin Features section.

Identity Service and Authentication. Most organizations require their users' identities in XRAS to match their local institution's user identities, so that their end users can authenticate using familiar mechanisms. To that end, XRAS requires each client organization to specify an Identity Service: an API that lists information about their users. Using this API, XRAS can make these same user identities available across the XRAS software tools. In addition, XRAS has a few authentication modules available, and thus the client can allow users to use their institutional authentication mechanisms. XRAS currently has authentication modules for OAuth-based systems [24], Kerberos [25], RADIUS [26], CILogon [27], Shibboleth [28], as well as anonymous guest logins. Clients can also choose to use ACCESS or ORCID (see below) identities and authentication if they do not have their own identity management systems. With this flexible approach, XRAS can interoperate with a wide variety of identity systems and quickly develop modules for other identity systems.

XRAS Submit UI. As discussed previously, the XRAS Submit UI is another point of customizability for clients. While the XRAS team provides a default Submit UI that clients can use out of the box, many organizations prefer to have an interface that is part of their own infrastructure and includes their own organizational branding. Clients can thus fork and modify the default Submit UI or develop their own interface from scratch. All that is needed is for the application to communicate via the XRAS API. The full range of options has been adopted by current clients. Some use the default interface hosted by XRAS; others host the default interface locally with minor modifications; and yet others have developed entirely new submission interfaces.

As a specific example of custom integration, enhancements were made to the XRAS API to support the ACCESS program, allowing

an even greater range of interactions with the submission interfaces. ACCESS then developed a completely new Submit UI, embedded in the ACCESS Allocations portal [29]. This new interface is made up of front-end-based React components, which provide a more responsive interface than a traditional web application.

Accounting Service. The Accounting Service API specification, which the client can implement as an option, allows XRAS to post new project information to the client's in-house allocation management systems. At this integration point, the organization can then handle incoming allocation data according to their own local system requirements. Additionally, the Accounting Service can provide usage data back to XRAS that can be viewed within the XRAS applications.

6 ORCID INTEGRATION FOR CLIENTS

The non-profit ORCID organization works to provide connections between researchers, their research activities, and their research associations by providing a unique, persistent identifier for individuals [30]. In the academic world of most XRAS clients, researchers commonly have ORCID iDs and use ORCID to present a public-facing profile of their research. Academic organizations—including many universities, publishers, and federal agencies—are often ORCID members, which allows them to post information to users' ORCID profiles. XRAS has two related ways of integrating with ORCID services—not only as an authentication mechanism and identity service but also as a service that allows ORCID member organizations to post allocated project details to researchers' ORCID profiles.

6.1 ORCID for Identity and Authentication

If an XRAS client does not have an existing identity management and authentication environment, the client can allow users to log into XRAS using ORCID iDs. The NAIRR pilot program has leveraged this capability to provide a “neutral” third-party authentication and identity service for an allocation process that spans many federal agencies and resource providers. To support this capability, the XRAS team has developed an identity service that is based entirely on ORCID identities. This service creates local user identities automatically when a new user authenticates using their ORCID credentials. Allocations processes can then make their allocations process available to anyone with an ORCID iD.

Less directly, ORCID authentication can also be an option clients allow via a federated authentication system. For example, the ACCESS program uses CILogon authentication [27], which allows users to authenticate their ACCESS identities using many identity services, one of which is ORCID. With this mode of integration, users can still have an identity specific to the client organization but can log in using ORCID.

6.2 ORCID for Research Resources

Beyond using ORCID for authentication, XRAS also integrates with ORCID to allow clients to post allocated project data to the Research Resources section of their researcher's ORCID profiles [31]. This feature takes advantage of ORCID's efforts to expand users' profiles and help address the challenges of having users acknowledge the contributions made by research facilities when they publish the

results of their work [32]. Once a client organization has become an ORCID member, XNAS supports all the necessary elements to update researchers' profiles with allocated project information. ORCID integration is best understood as a set of configuration options and not a workflow—all elements must be properly configured before posts to ORCID profiles can occur.

- The client configures XNAS with their ORCID Client ID and Secret Key. These values confirm ORCID membership and access to ORCID APIs.
- The client organization must provide a unique identifier for itself from either the Ringgold [33] or Research Organization Registry (ROR) [34] systems.
- The client declares in XNAS which types of allocated projects are to be posted to ORCID. For example, a client may choose to post merit-reviewed, research-type projects, but not staff-type or local courtesy projects. XNAS will automatically host public pages for any posted projects—a requirement of the ORCID metadata schema.
- The client must declare public pages for its resources and a Ringgold or ROR identifier for the resource provider organization via the CIDER system. As in the case of ACCESS, the organization managing the allocations process and posting project details need not be the same as the organization hosting the resources.
- Finally, researchers must grant permission to the XNAS client (i.e., the ORCID member) to update their ORCID researcher profiles. XNAS can be leveraged to collect the permissions from researchers, or the client organization can collect permissions in external systems and pass the permission tokens to XNAS via the Identity Service.

Once these elements have been configured, XNAS will begin and continue to post awarded project information to ORCID for all projects of the designated types if the researcher has granted the appropriate permissions. XNAS also allows you to later re-post projects within a given allocation opportunity, which will cause projects to be posted for any researchers who have granted permissions to do so since the opportunity was processed. Furthermore, if the same project receives allocation awards in the future, XNAS will post updates to the project record in ORCID.

7 XNAS REVIEW FEATURES

The review capabilities of XNAS represent one of the most well-developed areas of XNAS and set it apart from most related products. From the outset, XNAS Review has supported a full range of panel management and review features, including multiple panels, conflict of interest management and tracking, review assignment support, a proposal rating tool, and more. Since 2014, several key features have been added to XNAS Review to handle the evolving needs of XSEDE, ACCESS, and other XNAS clients.

- XNAS allows clients to define and administer multiple review panels for a single review workflow. This multi-phase review feature is highly configurable and can have many applications. To illustrate one use case: A first-phase review panel of researchers can evaluate proposals based on scientific or computational merit. In a second phase, a panel

representing resource providers panel can review the proposal for suitability on the requested resources. This feature has been leveraged in XSEDE, ACCESS and the NAIRR pilot instances.

- A Review Meeting App helps better support the discussion of requests at review panel meetings. Designed initially to help reduce the need for printed materials and tracking of handwritten notes at XSEDE panel meetings, the Meeting App allows for easy navigation of proposals, quick data entry of the panel recommendations, and capturing of notes from meeting discussions. An allocations administrator can also define a set of tags that can be used to flag proposals during the meeting discussion for use during or after the meeting.
- Along with the Meeting App, XNAS provides the option for client administrators to download meeting results to a spreadsheet, finalize amounts to be awarded in that spreadsheet, and upload the completed spreadsheet to populate the final award amounts in XNAS. While this task can be handled one proposal at a time in XNAS, the spreadsheet approach has been useful in XSEDE and ACCESS due to the need to engage resource providers in the final award decisions. The spreadsheet format also enables a holistic view of the proposals and the ability to use the full range of spreadsheet calculations and features.
- XNAS has added an interface that allows client administrators to customize review forms for different allocation types. By default, XNAS provides a review form with a single long-text field, and some clients may require reviewers to answer specific questions. For example, this feature is used by the Pittsburgh Supercomputing Center to tailor the review form as defined by the National Academies of Science for Anton-2 reviews.
- XNAS clients can assign default reviewers for different submissions, automatically assigning an individual to all incoming proposals that request a specific resource or to all proposals for a particular allocation type. Default reviewers can be defined for any combination of allocation type, submission type, and resource. In high-volume processes such as ACCESS, this feature saves time and speeds up the review process, because reviewers can be immediately notified (using the notifications feature of XNAS) of incoming assignments.

Other smaller-scale features have enhanced the XNAS Review over the past decade, such as adding an optional Reviewer Agreement form that panel members must confirm on a configurable cadence. More recently, as part of our NAIRR pilot efforts, we have modernized the underlying code libraries to improve the look and feel of the Submit UI, and this work will be carried over to enhance the Review (and Admin) sites for all XNAS clients.

8 XNAS ADMIN FEATURES

The XNAS Admin component houses all the configuration options and allocation processing interfaces used by client administrators. From the outset, these capabilities have included defining allocation types and setting up proposal opportunities; managing review panels and reviewer assignments; controlling the allocations workflow

and making allocation awards; and generating meeting materials. In addition to the new XRAS Review features described above—which are configured in XRAS Admin—several major new features have also been added to XRAS Admin since 2014.

- An administrator dashboard has been added as the front page to XRAS Admin. The dashboard provides a convenient view of requests that are in process and that need attention. For high-volume processes such as ACCESS, the dashboard has significantly streamlined the workflow for administrators who previously had to keep track of these tasks using help tickets or email-based tracking.
- The client can define templates for email messages and to configure to whom and when these notifications are sent. Some example scenarios include emailing an administrator when a submission arrives, notifying a reviewer when they are assigned to a proposal, notifying the project lead after a project is approved.
- A reporting section has been added with prebuilt reports that can be generated by administrators. Report options can allow administrators to limit reports by date range, opportunity, and so on. New reports need to be added by XRAS developers at the request of clients, and a framework was created that makes defining new reports simple in most cases. ACCESS currently has more than 20 reports defined, so this feature has seen high use.
- Administrators can define proposal opportunities to be invitation-only—that is, limited to submissions from only a defined set of people. Individuals without invitations will not see the opportunity in the Submit UI. This feature is useful for previewing an opportunity before it is made widely available or for supporting very controlled opportunities. In ACCESS for example, a resource provider may leverage the allocations system to manage discretionary projects by inviting selected individuals to submit proposals to an invitation-only opportunity.
- Custom opportunity questions allow administrators to define non-standard questions to be asked as part of all submissions to a proposal opportunity. This feature provides a simple, flexible way to add to the submission forms without extra development work. Several types of responses can be captured including text, checkbox, selection list, date, and so on.
- Custom resource questions provide resource providers with the same flexibility to link tailored questions to individual resources. These questions only pertain to a given resource and need only be presented when that resource is selected. An example might be “How many virtual machines are needed?” for a resource that specializes in virtual machines.

Many other XRAS Admin features have been added or updated over the years to simplify the allocations workflow for administrators, implement process features for clients, or provide interfaces allowing administrators to configure existing features. For example, an XRAS Admin interface was added to allow full configuration of the rules in the XRAS rules engine, replacing the initial implementation that required uploading a spreadsheet. For more details on the many customization options within XRAS, the XRAS team has

developed and maintains an XRAS Client Administrator’s Guide in support of our XRAS Clients [35].

9 FUTURE WORK

As part of the ACCESS Allocations project, which also supports the team’s participation in the NAIRR pilot program and the National Discovery Cloud for Climate (NDC-C) initiative [36], XRAS is undergoing continued development and enhancement. Most future work is pursuing three objectives: expanding the types of resources XRAS supports, enabling resources to be integrated in novel ways, and increasing the number of resource federations that XRAS can support.

In terms of new resource types, the ACCESS Allocations team is pursuing three related activities. We are focusing first on better integration of commercial and other cloud type resources. This work is proceeding in partnership with the CloudBank [37] team and others as part of ACCESS, the NAIRR pilot, and the NDC-C initiatives. We are also working to understand better how the needs of researchers and their end-to-end scientific workflows, as well as the needs of science gateway operators, can be supported within XRAS and allocation processes more broadly. We are pursuing these efforts to allocate resource “packages” for cross-resource use cases in partnership with SGX3 [38] and FuncX [39]. Finally, we are looking to expand the features of XRAS to better support sensor networks, instrumentation, and other resource types that have calendar-constrained scheduling needs. In this space, we are working with the SAGE Continuum [40], the NSF NCAR Earth Observing Laboratory, and others.

Regarding novel integration capabilities, we are focused on three activities. Initially, we are working with partners to develop and experiment with a variable resource marketplace. Here, we are hoping to help resource providers to diverge from the “one-size-fits-all” approach and support more flexible options for offering allocations and defining allocation units. We are also looking to change how researchers find resources and request allocations from the ACCESS program, by developing resource discovery and allocation request interfaces that can be integrated with campus-side websites. In this activity, which we have dubbed “On-Ramps,” we want to help ACCESS meet their researchers closer to where they first seek support for their computational resource needs. Finally, we will be enhancing the XRAS-provided Identity Service to provide better support for sites using ORCID and other OAuth providers for authentication and identity.

The most aggressive future work is related to improving XRAS support for “resource federations.” The ACCESS ecosystem, the COVID-19 HPC Consortium, and the NAIRR pilot are all examples of resource federations—collections of resources joined under a common banner and, in the XRAS context, a single allocations process. In its current state, XRAS can support a single resource federation and any number of clients that each represent a single resource provider site. A “multi-federation” XRAS would allow resource providers to participate in and exchange allocations information with more than one XRAS-supported federation. To replicate the underlying XRAS capabilities used within the ACCESS program will require a full-platform review of the component interactions

such that federation identifiers are used to direct resource provider data to and from the appropriate federation data sources.

10 CONCLUSION

The XRAS platform serves a vital role in supporting allocations for many national-scale HPC resources, including most national systems funded by NSF, and in supporting national initiatives such as the NAIRR Pilot. Under continual development over the past decade as part of the XSEDE and ACCESS programs, XRAS has not only improved on its original features but also added new capabilities such as integration with the ORCID ecosystem to continue to serve a range of clients. XRAS has also pursued a somewhat novel approach to sustainability that involves establishing formal, for-fee service agreements with client organizations and laying the groundwork for a possible future in which a central funding award is unable to maintain the service. The next few years promise significant new features for XRAS as it continues to expand the types of resources in the cyberinfrastructure ecosystem and the evolution of processes to meet the needs of this changing allocations landscape.

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