DRAFT

Academic Interfederation into the 2030s

Report of the REFEDS Federation 2.0 Working Group

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Executive Summary

The success of individual national Research & Education federations depends upon the global success of an Academic Interfederation.

R&E federations are key enablers of academic endeavors by facilitating user access to protected online resources, within and across organisations, locally and around the world. They have evolved from seeds planted by select universities to encompass the full range of educational institutions, research institutions, their commercial and governmental partners, and research and scholarly collaborations. The distinctive access needs of the Academy to support trusted collaboration have resulted in a unique combination of technical and policy implementations. We name this singular, global infrastructure, an integration of all of the national R&E federations, **Academic Interfederation**.

The Federation 2.0 Working Group, following a scenario planning methodology, explored the future of 10 or more years hence. We were concerned about what we saw: variations of dystopia across the Academy. We realised that the community of national Research & Education (R&E) federations is not prepared to navigate the critical uncertainties that will determine their future.

What is certain is that one or more of the forces identified in the scenarios will threaten online academic collaboration and the existence of multilateral academic federation in the next ten years. These threats to the Academy and its federations include new demands from governments, Big Tech presenting a different competitive landscape, and communication challenges in signaling trust. Global implementation and resource variations across regions, institutions, and disciplines increase the complexity of managing access controls across application boundaries and challenge our ability to address these threats.

Much needs to be done - the time to act is now. Our recommendations aim to organise the national R&E federations to maximise their ability to execute. They call for leadership and governance of, better messaging about, and broader participation in Academic Interfederation, technical and policy innovation, and sharing its value and expanding its influence beyond the Academy.

Chief among the recommendations is to **establish a global leadership, advocacy and governance function for Academic Interfederation** that will coordinate the implementation of the other recommendations. We see a challenging future that will require our community to create a global leadership structure with the authority and resources to meet its threats and needs. If this is not done, the community risks ceding its traditional network and identity management leadership to newer players, merely reacting to developments across the wider governmental, corporate, and consumer identity landscape.

This report is for leaders of R&E federations, liaisons and stakeholders at participating institutions, funding agencies, and potential participants. Moreover, the key characteristics of

Academic Interfederation are valuable beyond the Academy and so we invite other communities to consider this report.

Introduction

The Academy and Academic Interfederation

The term *the Academy* is used in this report to refer to all of the organisations and people across the international Research & Education sector engaged in research and scholarship, teaching and learning. Use of this singular proper noun underscores the fact that all engaged in the Academy share that common mission, even though they may also compete for students, staff, and resources. This sense of shared purpose creates a trusted community that readily collaborates to address shared problems.

Academic Interfederation, whose future is contemplated in this report, is one product of that trusted community collaborating to address a shared problem. Academic Interfederation is composed of many *individual R&E federations,* each operated by a *Federation Operator*.

The member organisations of R&E federations operate *Service Providers (SPs)* or *Identity Providers (IdPs). Service Providers (SPs)* are online services that restrict access to members of the Academy based on criteria, such as academic standing, academic affiliation, participation in a given project or community, and other attributes. *Identity Providers (IdPs)* provide members of the Academy with login credentials and can attest to the individual's institutional standing and affiliation, identity, and other related attributes. Members of the Academy leverage *Federated access* to enable users to access the resources and services provided by an SP. The SP securely connects to the individual's IdP to sign in (authenticate themself), and the IdP securely provides the SP with facts about the authentication and other information specific to that individual's use of that SP. This information enables the SP to determine whether to permit access (authorization). Individuals use their IdP credentials (typically those issued to them by their home organisation) to login to SPs across Academic Interfederation, and SP operators need not maintain separate credentials for their services' users.

A key feature of Academic Interfederation is its *multilateralism*: each SP and each IdP within Academic Interfederation can mutually authenticate one another and transact without configuration and trust information being shared previously between them bilaterally. Instead, Federation Operators register IdPs and SPs within their jurisdictions -- usually national -- collect and validate technical and organisational information essential to enable secure and trustworthy federated transactions, and make that information available in a standard way to SPs and IdPs generally. This resource provides a technical foundation for mutual trust among participants in Academic Interfedertion for managing access to protected resources. Standard data schemas created for R&E federations expand the semantics of transactions between SPs and IdPs to provide authoritative information about individual users to support enforcement of granular access policies.

The Value of Academic Interfederation

Academic Interfederation provides a secure and privacy preserving access management platform designed to enable collaboration and sharing among researchers, educators, students, academic service providers, and other partners that works at all scales from local to global.

Academic Interfederation supports the Academy by enabling federated access solutions for systems and services used by researchers and scholars, teachers and learners, to do all of the kinds of things they need to do with whomever they need to do them with. It reduces the number of credentials users must deal with in the course of their academic activities and also pays a dividend to service providers, who can rely on home organisation credential management practices and so focus more of their energy on their services.

Academic Interfederation enables the organisations that R&E federations serve to broaden their reach far beyond themselves. It expands the regions, disciplines and communities that are connected. Such scholarly sharing across boundaries provides the backbone for addressing large, global challenges, increasing our understanding of ourselves and the world that we live in, and ensuring that the next generation of humans is equipped with the knowledge and resources needed to thrive.

Examples from the Field

This section provides some examples from the field.

Library resources, including licenced online content

One of the first adopters of multilateral federation was the Hathi Trust, a partnership of academic and research institutions, offering a collection of millions of titles digitised from libraries around the world. Users visit the Hathi Trust page, and can authenticate with their university credentials (assuming the university has joined their national R&E federation). Because users may come from home organisations anywhere, they are given a means to choose an identity provider from which to login. That used by Hathi Trust is a common approach.

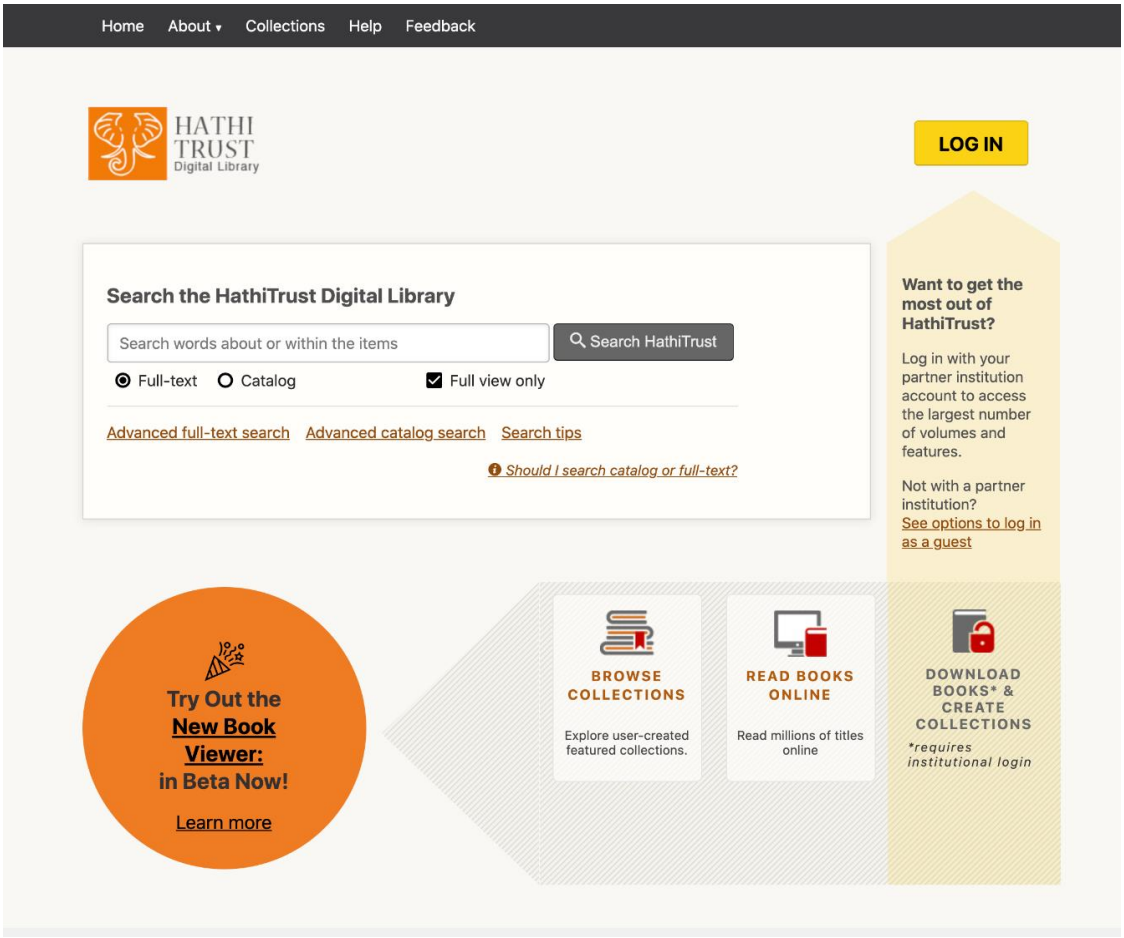


Figure 1. Users visit the Hathi Trust page

A superior approach to discovering where a user will login from has recently (relative to the writing of this report) been developed by several online publishers in partnership with members of the R&E community. Called the Seamless Access service [Seamless], its utility for various federated access use cases is now being explored.

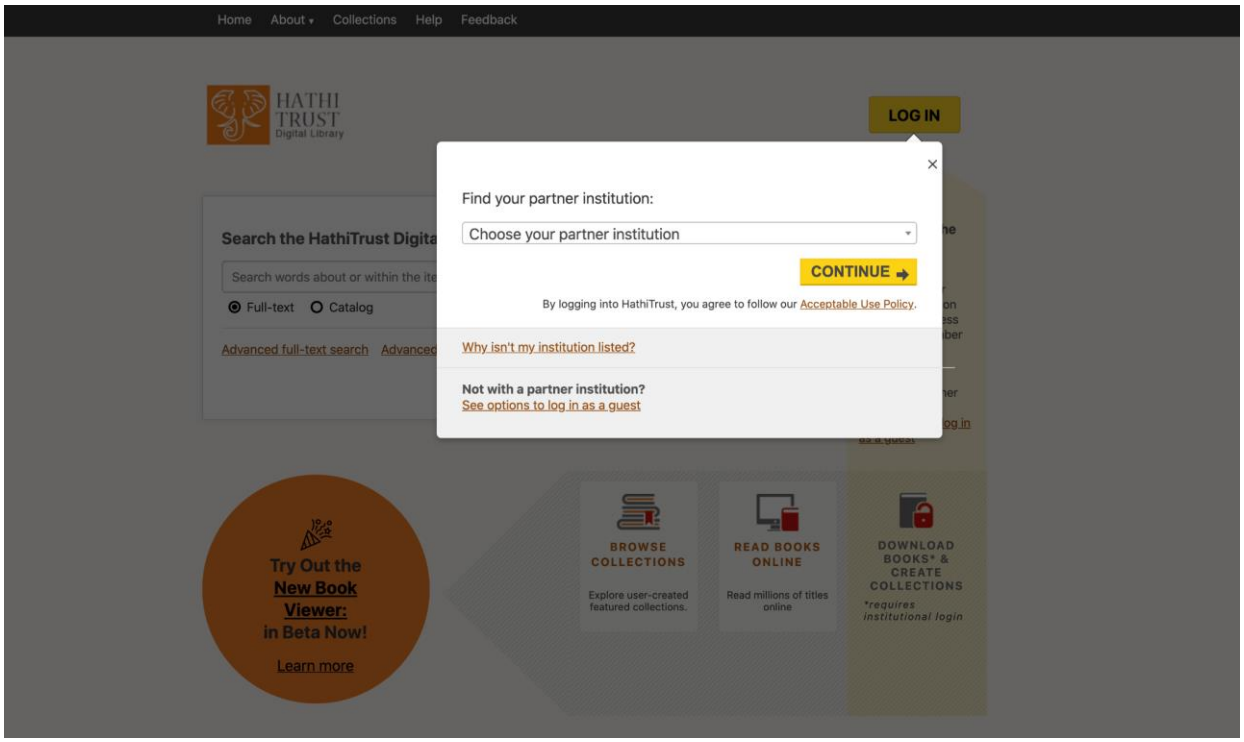


Figure 2. Users select their institution to log in

Research Collaboration

Scientific research projects, especially federally funded efforts, often involve participants from many organisations. Those participants would much rather log in with their home institution Single Sign-On than create a new user account for every application in a research collaboration. Likewise, providers of research systems and services benefit by relying on user credentials managed by trusted partners - the home organisations supporting their users' academic work. Academic Interfederation makes this possible. The following examples illustrate the types of collaborations that leverage federated access:

- The Laser Interferometer Gravitational-Wave Observatory [LIGO] - a national facility for gravitational-wave research. With more than 1200 collaborators from over 80 scientific institutions world-wide, LIGO was an early adopter of multilateral federation.
- The National Institutes of Health [NIH] - the largest public funder of biomedical research in the world. Given the sensitive nature of its data, NIH requires greater security around authentication than many service providers. Their requirements are fully supported by standards and practices developed by the R&E federation community. Users see a "discovery service" upon login, where they can choose their institution and be redirected to their institutional Identity Provider to authenticate.

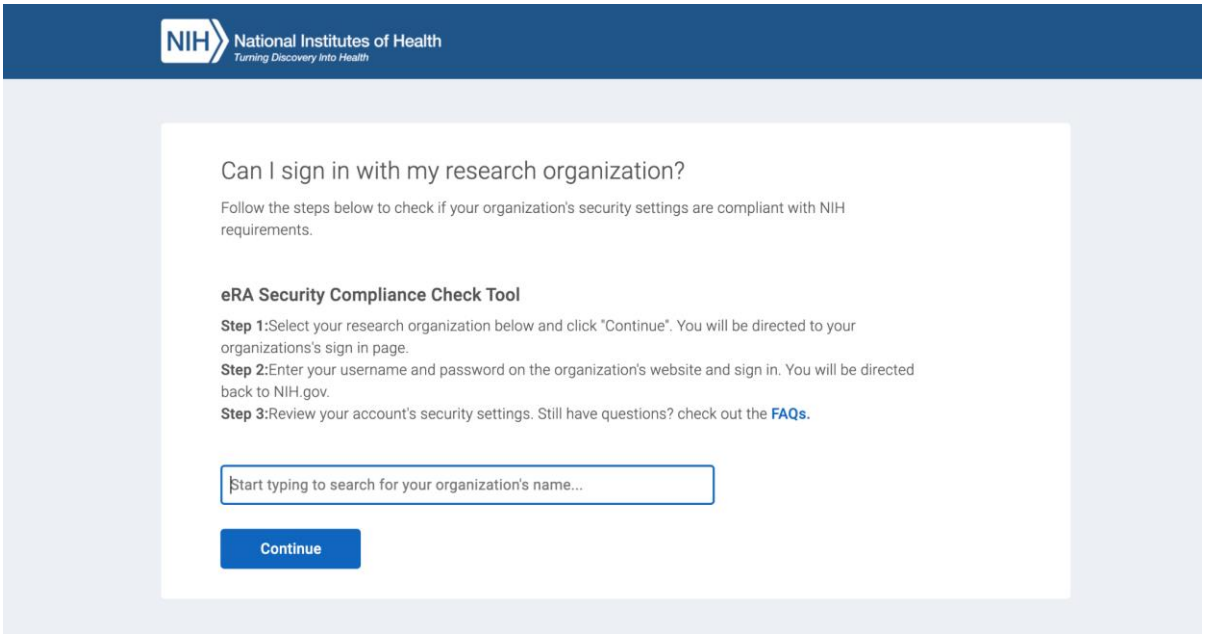


Figure 3. NIH discovery service for its security compliance check tool

- The Environmental Influences on Child Health Outcomes project [ECHO] - a program with the mission to enhance the health of children. ECHO includes a cohort network of 18 states focused on addressing disparities in pediatric research benefiting children in rural and underserved areas in the US. The project leverages multilateral federation for access to shared resources.

Academic Interfederation provides a model for efficiently establishing secure, trusted access to shared online resources. It's not surprising then, that this model has seen broad adoption across the R&E sector.

The Context Beyond R&E Federations

Academic Interfederation exists to serve research and education, however, it depends on tools and standards that are widely used, and are not exclusive to academic environments. Industry standards such as PKI, SAML, and OpenID Connect are common examples. Furthermore, federation and federation-related tools are gaining wider use in areas outside of the Academy. Examples here include security mechanisms for microservice mesh architectures, enabling interactions across multiple container clusters, and enabling interactions across multiple virtual private clouds. Additional examples of both concrete projects and potential federation application areas outside of the Academy are reviewed in Appendix A. The Recommendations below reflect that further development and adoption of interfederation should leverage growing capabilities in industry and government, wherever possible.

Study Process

In preparing this report, the Federation 2.0 workgroup followed the scenario planning process as described in Scearce and Fulton's *What If? The Art of Scenario Thinking for Nonprofits* [Scearce]. For the workgroup, this became three broad areas of work, discussed in turn below:

1. Community observations (information gathering)
2. Future-looking scenarios (projecting implications)
3. "Stone soup" exercise (distilling key takeaways)

Community Observations

The workgroup formed around a series of community blog posts at REFEDS ([Barton], [Hämmerle], [Phillips]) and, once convened, used the scenario planning process. After formulating a central question, "What does the future look like for networked access to collaborative tools and research resources in the next 10-15 years?" the workgroup needed to understand

- what systems affect the organisation (at this point considered the community of R&E federations),
- what are the trends,
- what are the uncertainties in those systems, and
- what are different and diverging possible resolutions.

We developed a questionnaire using the "seven-questions" approach developed by The Institute of the Future [Amara]. By asking our correspondents what questions about the future they wanted answered, we could understand more clearly their concerns and uncertainties. We cast a wide net to mailing lists and professional contacts within and beyond the R&E Federation community inviting people to participate either through the essay answer survey or hour long interviews. We received over 35 survey responses and six participants of structured interviews. More than half the participants had over twenty years of experience in their field.

The responses are synthesised below and presented as a series of key factors, called critical uncertainties, of the environment in which Academic Interfederation operates, or may operate in the future. Some input was provided in the form of suggested actions that should be taken in response to some observed aspect of the environment, and are included in Appendix B. This compilation suggests critical uncertainties whose resolution will shape the future of Academic Interfederation and frame how the Academic Interfederation community can be positioned for, and perhaps help shape, their resolution.

See Appendix B and [Survey] for details of the community observations stage of the study.

Critical Uncertainties

Critical uncertainties are driving forces that play a critical role in shaping the future about which we create scenarios for planning purposes, and whose effects are inherently uncertain or unpredictable.

Mission of the Academy: Internal vs External Priorities

What academic objectives are pursued and how they are pursued is always subject to many forces. Researchers, scholars, and pedagogists discern how best to advance their disciplines. Funders, politicians, regulators, and providers of services to communities have their own agendas and needs and advance them in part through influencing activities of the Academy.

Resources for the Academy: More vs Less

Governments, public and private organisations, and students all contribute to the financial bottom line of each academic organisation to varying degrees. These contributions are subject to an extremely complex mixture of external economic and political forces. Individual academic organisations differentiate and compete for their share of the pie. How does the Academy respond when the pie gets substantially smaller or larger?

Impact of Social-Technological Change on the Academy: Slower vs Faster

In what ways does the Academy change due to changes in the way its researchers, scholars and students conduct other aspects of their lives, and how quickly does it respond to those pressures? Do academics want their academic life to be like the other aspects, or do they want it to remain apart and with its own character? What happens if the response is too slow? What happens if it is too fast?

Inequity in the Academy: More vs Less

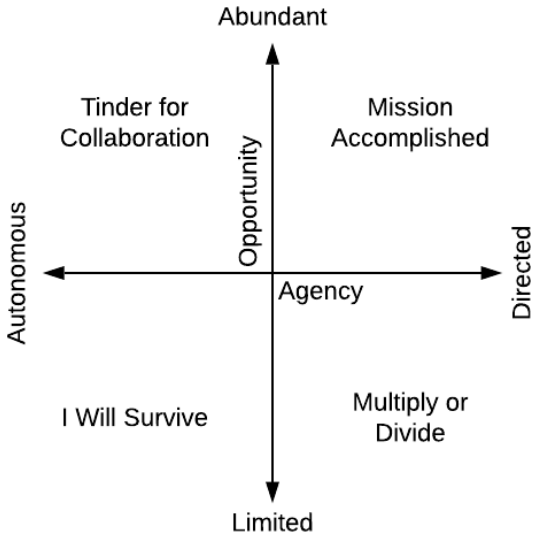
Those with more resources urgently want to solve their problems and move on. But their solutions can be out of reach of those with fewer resources, limiting their participation in forwarding the mission of the Academy. Will they be left behind, or will there be factors that propel equitable participation?

Future-Looking Scenarios

The most distinctive aspect of scenario planning as a form of strategic planning is the formation of the scenarios. Scenarios are stories that reflect the possible futures that will affect what decisions an organisation needs to make, and provide a framework for examining strategic options. This process doesn't attempt to predict the future. Rather it explores the potential outcomes at four extremes while recognizing that the actual future is likely to be a combination of each.

At an all-day in-person session (pre-COVID-19), we participated in future-looking exercises designed to broaden our thoughts outside the typical language and problems common in discussions of federation. The goal was to think about the challenges we attempt to solve through federation with a future focus, and develop a new set of perspectives. The tensions that create uncertainty which were determined through the community observation process (see above) were presented.

We asked ourselves which two of the critical uncertainties were most relevant to the future. For one dimension, we chose “Mission of the Academy: Internal vs External Priorities” where we considered the extremes of research priorities completely driven by the curiosity of researchers to the opposite of government or corporate driven research. (Autonomous vs Directed - the Agency axis). For another dimension, we chose “Resources for the Academy: More vs Less,” where we considered the possibility of unlimited financial resources to very constrained financial resources (Abundant vs Limited, the Opportunity axis). These two axes described a space in which we told stories about four different futures, one for each combination of extremes. The full scenario stories are included in Appendix C, summaries are below. The diagram shows which stories correspond to which quadrant.



Multiply and Divide: A story of directed action under limited resources

Limited in resources by national borders and highly directed by the government, the “Multiply and Divide” scenario leads us to ask how much influence federations can have in governmental policy setting. Federations should be aware of opportunities to influence governmental work in areas of protocols and standards in order to guide powerful funders to use interoperable standards and protocols.

> … students are trained in the system at an early age, and are taught how to be creative and innovative in making things even better for us. They learn how to analyze data and how to use this system to improve things, how to develop processes and policies to make our lives even easier. All research and education is designed to benefit us.

Current federation stakeholders are all shaped and restricted in this scenario. Individuals’ research interests must align with the national interest or receive no support. The spectrum of large to small research organisations and institutions narrows to a smaller band of organisations that meet the national direction. In such a constrained environment, network and system operators are motivated to develop methods that enforce appropriate use of resources and monitor for unauthorised use.

We recognised the opportunity for a federation to coordinate resolution of interoperability issues and data governance requirements. We asked what role federations may have for researchers in fields that lack national funding: those researchers may still have identities that function in the collaboration systems.

Our discussion of this scenario brought forward questions about the trends in national, "universal" identities: how will they function internationally, with respect to immigration? How might identities provided by educational institutions function when education occurs outside the national boundaries? Federations are experienced in asking these questions and can contribute experience in sharing real-world use cases that may seem like edge cases to a governmental policy team.

Restrictions and policy differences at borders are a growing trend that affects international collaboration. Current interfederation efforts assume common governance principles. If a nation's or institution's governance of identities and services diverge in different legal and political jurisdictions, federations may broker interoperation by signaling distinctions -- such as higher surveillance for inappropriate use at one service provider or less discriminating allocation of identities at a particular identity provider -- in order to achieve the most interoperation possible within the limits placed by policies.

Mission Accomplished: A story of directed action under abundant resources

A global technology corporation marshals incredible levels of resources, recognising an alignment between global and corporate need in the Mission Accomplished scenario, which presents us with a blurring between not-for-profit and commercial research.

The scenario preserves the independence of traditional federation stakeholders: the "highly directed" dimension is maintained by intellectual property constraints. Federations *could* continue to serve the Academy in its traditional sense, but must consider the growing population of researchers and students within the global corporation. What barriers to access between the corporation and traditional academic research and education systems should be implemented?

> To bypass the bureaucracy and delays, AppleGoogle establishes massive research centers around the world, directly recruiting research talents in multiple disciplines…. Researchers respond to the call to action, with large-scale defections from traditional higher learning institutes to work in these research centers. Further, AppleGoogle establishes learning institutes

"Mission Accomplished" offers the same opportunity and challenge of crossing borders as the "Multiply and Divide" scenario, but a border that directly challenges the not-for-profit values of the Academy. The global corporation tendency to "bypass the bureaucracy and delays" points to a challenge to consensus building and intentional efforts to invest in outreach and inclusion. Participation in standards setting bodies that have broader industry reach can help include the needs of the Academy early on.

Our discussion of this scenario brought forward observations that external direction from grants can starve academic institutions' human resources by hiring technical contractors for projects who leave when the grant is over. Impact can be built by having people who continue and can contribute broadly.

Directed funding also focuses on the needs of those doing the funded research. Other researchers with less funding still have very similar needs for collaboration and access. We consider that federations need to maintain the scale and support to reduce the cost of the infrastructure support, and then the capabilities are available for both well funded and less funded researchers.

Other discussion touched on the need for coordination in addressing interoperability issues and data governance requirements so that resolution in one locale can be shared across all R&E federations. We asked how the governance of data is impacted if identity providers shift from educational institutions to government or corporate ones.

Tinder for Collaboration: A story of autonomous action under abundant resources

Given unconstrained resources, where needs are met and research is driven by personal passion, the story quickly identifies that individual researchers may be delighted. However, motivation for effective collaboration is much lower than when resources must be pooled for success, and "Mars-shot" scale projects suffer.

> Once upon a time (in the not too distant future), in a Holodeck far far away, there was a stream of young collaborators searching for their perfect collaboration match. These collaborators are young, energetic, and confident. Around them are so many opportunities, so many choices. Will they find that perfect match… only time will tell…

Many current stakeholders fade into the background in the premise of this model. One can consider it a success story for federated access: the tools and infrastructure just work and aren't a concern the researchers must negotiate.

To be a success story, the working group expects that the collaboration spans national borders and supports trust, academic freedom, and openness across those borders. As we discussed the scenario, we recognised the importance of trust in research. Openness and freedom are strong academic values facilitated by trust. Is a researcher able to trust the source of a dataset they are accessing? Is a researcher able to trust that use of a dataset will comply with any restrictions placed on it? How does attribution of a dataset's creator get reflected in the research that depends on that dataset?

Even with abundant resources, establishing shared standards and ensuring that there are skilled people to support a successful framework requires coordination. There is a gap in present offerings and supporting a seamless, global, and effective ad hoc collaboration framework that expresses the details of attribution, human subject privacy rights, usage rights and restrictions that would allow the trust between researchers to be expressed in a global,

digital realm in the way that is now done in direct communication or in the limited boundaries of an institution.

I Will Survive: A story of directed action under abundant resources

The scenario in the highly autonomous - low resource quadrant is one where financial pressures on institutions lead to infrastructure investments in off the shelf “enterprise” solutions that don’t enable inter-institution collaboration, much less global collaboration.

Luckily, Alfred's institution is also G Suite. However, when Jenny went to share her Google Drive folders out, she found out that to "protect the institution", she wasn't able to share her material with an account external to her own institution. In order to collaborate with Alfred, she had to copy all of her work over to a personal Google account so that she could add Alfred.

Current stakeholders in research federations include the “virtual organisations” of large research labs. These organisations provide much support to academic interfederation, through staff supported by pooled grants at large national and international research laboratories. In this scenario we would expect the funds for such organisations to be far less available.

A proliferation of smaller “virtual organisations” may occur: we wondered if those organisations would be able to find the shared infrastructure and standards that would allow them to build on each other's successes or if each small collaboration would devise solutions that would isolate them from other research organisations.

We considered that collaboration would be with trusted associates, and that again researchers would need an infrastructure that allowed access controls to enable collaboration with trusted researchers. The sense of competition in the same field for scarce resources presents a landscape where privacy controls may be important. However, the use of “freemium” services that exposes the work and research to commercial exploitation.

We wondered about how researchers might currently discover service providers in the federation that offer tools to support their work: we noted the absence of a taxonomy of service providers available through federated access, providers who may have solutions for researchers aligned to the values of the Academy.

Limitations in resources results in limitations in IT staff and training for the staff that does exist. Solutions supported directly by the Academy need to be easy to deploy and support. This support may need to come from regional and national organizations.

We concluded that this scenario offered a creation story for federations, illustrating the value of building a shared infrastructure for research.

Post-workshop process and strategic conclusion

At the conclusion of the workshop and for some time thereafter, the scenarios and the quadrants were analysed from numerous angles. For more details, refer to the documents in the Reflections section [Reflections] of the Federation 2.0 wiki.

The **most important strategic conclusion** came about as we examined how all of the future scenarios, including the story of abundant resources and autonomy, have a dystopian direction. To improve the outcome of every scenario, a global organisation with the standing to collaborate and negotiate with researchers, large corporations, governments, and enterprise solution developers could intercede to allow the goals of the Academy to continue to be met. No existing single organization has this visibility. The absence of the broader community of R&E national federations from all of the scenarios indicates that **this community currently is not prepared to successfully navigate the critical uncertainties that will determine that future**.

It became clear that **an Academic Interfederation community must be organised so as to maximise its effectiveness and influence**. This requires establishing global leadership, advocacy, and governance over Academic Interfederation.

Finally, a “stone soup” exercise was used to identify some of the biggest issues or “stones” facing Academic Interfederation and put them all in a “cauldron” for further contemplation. The tale of “Stone Soup” ([Story]) is itself one of collaboration, where a leader is able to motivate a community into sharing all the ingredients necessary to create nourishment for all.

In this exercise, working group members contributed the insights they had based on the community survey, the future scenarios and subsequent discussions, and their own experience. We compared reactions to the stones, looking for common themes, connections among them, and the issues that emerged from previous exercises. For more details of the stone soup segment of the working group’s process, refer to the documents at the Stone Soup section [Stone Soup] of the Federation 2.0 wiki.

Key Takeaways

The key takeaways produced by the stone soup exercise are five themes that motivate and contextualise the Recommendations and First Steps detailed further below:

1. Effective global leadership, advocacy, and governance is critical.
2. Better messaging around the relevance and value of Academic Interfederation is critical to drive adoption.
3. Participation and inclusion are the cornerstone of Academic Interfederation.
4. Innovative and forward-thinking technical standards will continue to be a critical foundation.
5. We must focus efforts on growth and expansion to promote future sustainability.

Effective global leadership, advocacy, and governance is critical

The tech “giants” are driving the agenda and don't understand the distinctive needs of the Academy for the variety of trusted interactions in providing access to collaboration and online resources. No current voice can speak for Academic Interfederation as a whole, leaving Big Tech to court the R&E market with consumer solutions that do not suit R&E use cases. To provide a counterpoint to their influence on leaders of research and scholarly organisations, as well as technology solution providers, Academic Interfederation needs a clear, consistent, and consolidated voice. Academic leadership knows the value of the Academy’s own global research network. They should also be continually presented with an understanding of why the Academy is best served by also having its own global infrastructure for managing access to the resources interconnected by its global research network.

Better messaging around the relevance and value of Academic Interfederation is critical to drive adoption

The Academic Interfederation community lacks common, easy to understand language that describes what it does. Common terms like “federation” and “trust” do not have a universally understood definition. Big brand technology solution providers have well-funded marketing teams who promote quick implementation and interoperability of their solutions. Given the lack of support for multilateralism and standards that address the Academy's needs in many commercial solutions, extra effort is often required to implement truly multilateral federated services. The Academic Interfederation community has a wealth of technical experts that have developed common technology standards to support collaboration. Now the community needs a set of marketing experts to develop standard messaging and a consistent voice to raise awareness and promote adoption of Academic Interfederation.

Participation and inclusion are the cornerstone of Academic Interfederation

Truly world-wide research initiatives require action by all national R&E federations and require all nations to have R&E federation access. Currently, success depends on implementing common requirements across each R&E federation independently: a slow and unreliable process. To expand participation and make global collaboration more inclusive, new efforts could be undertaken to enable more countries to create national federations. A global perspective over Academic Interfederation could also be used to foster shared solutions among multiple nations, reducing effort, expense, and speeding progress. That same vantage can also illuminate inconsistencies across national R&E federations that undermine inclusivity of federated access depending on where users and the resources they wish to access are located.

Streamlining access to Academic Interfederation, especially by service providers, is another tool for increasing participation. Many individual R&E federations, open source projects, and commercial partners have undertaken measures to shorten implementation time for their adopters and to extend the federation model to newer technologies. Extending those benefits across all R&E federations broadens the effectiveness of Academic Interfederation

Finally, a more expansive vision includes industries outside of research and education which stand to benefit from multilateral federation, and some of the marketing effort mentioned above could be directed to reaching out to those industries proactively.

Innovative and forward-thinking technical standards will continue to be a critical foundation

The R&E community has made great strides relative to many other sectors in developing common standards to support collaboration. From common data schema, to open source software that enables trust frameworks, to participative standards development, this community has set an example for other industry verticals. As technology changes, as the globalisation of service delivery expands, and as organisations (including universities and research organisations) shift to “the cloud”, our community must continue to evolve technology standards and tools to support its specific needs in these contexts.

It must be made easier for organisations that deliver digital services, and those that consume them, to understand and implement Academic Interfederation. As new authentication protocols are widely adopted, we must determine how to incorporate them in federation models. For example, as global efforts increase to support passwordless authentication, the R&E community must keep pace with deploying these new tools, or better, lead the way. We must continue our work to maintain a standard data schema for our community, and develop new approaches to authorisation that make it easy for authorities anywhere to manage access to resources everywhere.

Considering the influence of large commercial technology providers, it is also important that the benefits of new schema and technologies developed by the R&E federation community be accessible to institutions that choose to adopt commercial solutions. Although efforts to convince the big technology providers to enhance their products accordingly are worthwhile, a key strength of our community has been our willingness to resist the pressure to compromise when it comes to support for collaboration across organisations. Until such time as our influence is strong enough to ensure that happens, innovative developments should not be considered complete until they address means of integrating them with commonly adopted commercial solutions.

We must focus efforts on growth, expansion, and modernisation to promote future sustainability

Academic Interfederation has seen widespread adoption in research and education because collaboration is critical. Some other industry verticals have similar needs for cross-institutional collaboration (see Appendix A), but not all have developed their own solutions to support that collaboration. Likewise, commercial identity solutions focus on bilateral integration between enterprises and their service providers, and not on solutions for sharing services across multiple enterprises. One path to sustaining the Academic Interfederation ecosystem is to expand that ecosystem into other industry sectors that stand to benefit. Even within the education sector,

adoption by some post-secondary schools has been limited, and there has been little uptake by K-12. The community should look for new ways to support the growth of Academic Interfederation, and federations more broadly, across a variety of sectors.

All of the efforts envisioned in these Key Takeaways need skilled people to make them happen. Many of the early designers and developers of core federation standards, practices, schema, and technologies are getting older and these burdens must shift to younger shoulders. We need to expand investment in recruiting and training the next generation of technologists, analysts and evangelists for Academic Interfederation. And we must expand our set of partners, for its own sake as explained above, and also to reduce the number of new people within the Academic Interfederation community needed to get the job done.

Recommendations

To act on the Key Takeaways requires establishment of the ability to speak for and act on behalf of all of Academic Interfederation, to present a single face to the world and to coordinate among each of its parts. **Our overall key recommendation is the establishment of a body that represents the Academic Interfederation construct, both externally and internally**. This requires the establishment of effective global leadership, advocacy and governance for Academic Interfederation. It would execute a coordinated plan to Sustain, Innovate, and Grow Academic Interfederation.

When considering the following recommendations, bear in mind the 10+ year horizon within which the working group framed its considerations. These recommendations describe where Academic Interfederation should be towards the end of that period, and hence many of them will need to have been initiated sooner than that.

1 SUSTAIN

Academic Interfederation exists, but is not coordinated nor resourced as a viable and evolving infrastructure. While there are notable global programs, they are implemented by individual R&E federations deciding to do compatible work (or deciding not to) rather than as a unified effort in its own right. This approach underdelivers on the value that can be had. The Academic Interfederation community can increase its ability to execute if it is willing to organise in a new fashion. We advocate for rethinking its current organisation and to signal a change through action. Specifically, we suggest the following.

1.1. Establish effective leadership and governance

Charter a group that incorporates representation of individual R&E federations and is given the endorsement and authority to make meaningful progress in implementing the recommendations in this report. This group would

- Drive a broadly understood, refreshed understanding of how federated systems generally and Academic Interfederation in particular provide value into the future.
- Establish a strong culture of mutual support, continuous innovation, and laser focus on mission, both as a necessity for the work to be done and as a means to attract and retain world class talent to the Academic Interfederation community.
- Develop, maintain, and track progress on an aggressive long term work plan of collaborative effort to extend the value and influence of Academic Interfederation.
- Establish agreements on how the work in the plan will be resourced.

How this group's charter is created and gains endorsement is described further in the First Steps section below.

1.2. Establish sustainable resourcing

Although not a focus of the working group, some ideas for funding and other means of resourcing were encountered during its work.

- Pursue partnerships with commercial organisations that have added public benefit to their mission, in addition to their bottom line.
- Continue to seek funding from funding agencies.
- A Transition To Practice program to identify software and services developed with term funding that are especially good at amplifying the value of Academic Interfederation, and match at least some of them with individual R&E federations (or other constituents of Academic Interfederation) into whose operations they can be incorporated.
- Leverage resources to greatest effect by packaging key solutions as services that are operated centrally and available globally. Coordinate seconding of resources who operate these services, with the overall effect of reducing funding needed to provide the solution across all of Academic Interfederation.
- Continue to encourage and support community volunteerism and seconding, yet aim to fully fund key strategic needs and operations.

1.3. Establish effective advocacy and messaging

- Establish a professional marketing and communications program to promote coordinated, global messaging advocating the value of Academic Interfederation.

What specifically this program would aim to accomplish and how it might proceed is determined by reference to many of the various bullets under the Innovate and Grow sections of the Recommendations, below.

2 INNOVATE

The work plan and its implementing agreements in Recommendation 1.1 above are the scaffolding on which Academic Interfederation will continue to evolve to meet the unique requirements of research and higher education. We suggest the following to guide the work plan. Recommendation 2.1 lists its guiding principles, and Recommendation 2.2 identifies its key deliverables.

2.1. Drive innovative technical architecture, standards, and policies

- Evolve Academic Interfederation architecture so as to outsource capabilities that become commoditised (for example, authentication) and insource capabilities that can expose, manage, and leverage information especially valuable to academic collaboration, such as attributes, assurances, provenances, and authorisations that are specific to students, scholars, researchers, supporting staff, and the collaborative organisations in which they engage.
- Evolve Academic Interfederation standards, technologies, services, and policies to address the changing risk environment of those relying on it.
- Evaluate prospective development of technologies, standards, services, and policies through the following lenses:
    - Long-term value
    - Specificity to and utility for the Academy's mission
    - Leverage of technologies, standards, and solutions provided by others beyond Academic Interfederation
    - Amount of outreach, engagement, and technical overhead entailed

2.2. Embark on major initiatives to foster global deployment

- Develop a singular, global access management component of Academic Interfederation to manage constrained delegation of authority over resources that builds on its foundation of globally unique identification and authentication of people.
- Develop multilateral federation connectors and place them in commercial and private cloud ecosystems to enable qualified identities and services embedded in those ecosystems to participate in Academic Interfederation.
- Develop policies and processes to ensure that the most important aspects of trust in and value of Academic Interfederation are ubiquitously implemented.

3 GROW

The Academic Interfederation community on its own cannot accomplish all that is required to keep it vibrant and valuable over the long term. Moreover, increasing its influence, itself a key

enabler of sustainability, depends on involving others and establishing its value to them. We must build bridges to other communities that endorse the Academy's central values: individual privacy, academic freedom, independence from external interests, diversity of perspectives, openness, collaboration, and education. Specifically, we suggest the following.

3.1. Engage related industries, organisations, and individuals

- Establish communication with and participate in related communities. These include software or standards communities concerned with other identity and access management approaches, application platform stacks, etc, as well as those engaged in science and other aspects of public good outside of the Academy. Appendix A also describes some opportunities for engaging with related communities. The goal is to understand their purposes and issues, determine if and how multilateral federation fits into their environments, and collaborate with them to address those issues.
- Engage with vendors, governments, academic societies, and funding bodies to advocate for support of the unique requirements of research and higher education.
- Identify and develop advocates among institutional leadership of research, instruction, administration, and student services at leading higher educational organisations. Get them talking with their peers at other institutions.
- Apply the expertise of the Academic Interfederation community to improve academic workflows having an essential trust component, such as peer review or scientific workflow automation.
- Act on what is learned in partnership with these communities, both to deliver value and to enlist more members into the Academic Interfederation community.

First Steps

Immediate action is required. The Recommendations above embody an extremely ambitious agenda, even considering that it is to be achieved over a period of 10 or more years. It is challenging because the current community of national R&E federations creates solutions by a community consensus process that is unconnected with implementation by individual national R&E federations. This approach is insufficient to undertake the Recommendations above, all of which we believe are essential in order for the community's work to remain relevant and valuable into the future. We lack an organisational structure by which the community of R&E federations can both come to consensus on solutions **and implement them**.

Achievement of the two first steps identified below relies on resources and methods currently available to the Academic Interfederation community. The first, creating a charter for leadership, advocacy, and governance of Academic Interfederation, opens the way to greatly enhance the capacity of the Academic Interfederation community to execute, maximising its effectiveness and influence. The second, implementing Baseline Expectations across Academic

Interfederation, demonstrates its willingness to take responsibility, as a unified global community, for keeping Academic Interfederation valuable into the future.

Deliverable 1: Charter for leadership, advocacy, and governance of Academic Interfederation

A Charter Working Group will accomplish the first step key to realising Recommendation 1.1 above. Its deliverables should include the following:

- A proposed charter that enumerates key principles, authorities, limitations, and methods of operation.
- A proposed means of embodying the activities of individuals and groups engaged in operating under that charter. Some legal consultation may be required, depending on the approach(es) to be considered by the working group.
- A proposed process by which individual R&E federations and other organisations involved in Academic Interfederation can agree to support the charter and the actions of individuals and groups operating under it.
- Regular and prominently communicated updates of the working group's progress, key ideas, issues, next steps, and opportunities for community engagement in those steps.

Given the current strengths in the community, we believe the following organisations can provide the capabilities to bring this first step to completion, and whose endorsement ensures its success.

- REFEDS to convene a summit to kick off the process
- Large or regional federation support organisations (such as AFREN, APAN, ASREN, CANARIE, GÉANT, Internet2, and RedCLARA) to commit leadership and resources
- Individual R&E federation operators to track and provide input
- Stakeholder communities like FIM4R [FIM4R] & FIM4L [FIM4L] to provide critical feedback

Deliverable 2: Implement Baseline Expectations across Academic Interfederation

Federation succeeds when its most essential characteristics hold true ubiquitously, "a common set of expectations of all participant organisations to establish a baseline of trust in identity federations" [Baseline]. The REFEDS Baseline Expectations working group [BE] has published *REFEDS Identity Federation Baseline Expectations* after guiding it through the community consensus process, but its path to implementation by all R&E federations is not yet clear. The Baseline Expectations program will be transformative and capable of producing great value, aligning with one of the major initiatives enumerated in Recommendation 2.2 above. We urge REFEDS to continue or reconstitute its Baseline Expectations working group to devise the processes by which a baseline of trust can be made to hold ubiquitously.

These two Deliverables share a **critical challenge: the lack of a repeatable process by which all R&E federations agree to implement something together**. We believe that proceeding with both Deliverables simultaneously will produce the best solution to this problem in the shortest time. Each Deliverable has its own specific need for what such a process must accomplish. It may be easier to design a process that serves in the more constrained context of one Deliverable, then leverage its existence to address the process needs of the other Deliverable.

To take on the demands of the next decade with the visibility and authority needed to address the uncertainties and complex challenges it will face, the Academic Interfederation community must establish such a process in order to succeed.

Appendix A: Industry and Government Efforts Beyond Academic Interfederation

Concrete Efforts and Tooling

There are many federation-like or federation-related efforts across industry and government. The landscape of these efforts should be recognised, and where possible, leveraged to enhance federation capabilities for all. The following are concrete efforts and tooling:

- **Proprietary Products**
  Several proprietary products exist that provide federation-like capabilities in specific market niches. One product enables a provider of corporate services to sell those services to customer corporations. These are services such as email and travel management. To access a service, such as email, a corporate user must authenticate to the service provider. To enable this, the customer corporation makes their corporate identity store available to the service provider. This is an example of a static, bilateral trust relationship for a single, fixed service, e.g., email.

  Another example is when corporations merge. When they do, they are often faced with merging their IT infrastructures, including their identity stores. Proprietary tools exist for linking the identities, and then publishing them according to a user-defined model. While products such as these serve specific market requirements, they nonetheless illustrate the need for wider development and adoption of general federation techniques.

- **Secure Production Identity Framework for Everyone (SPIFFE)**
  As the on-line world became more connected and on-demand, with a growing number of devices that are increasingly mobile, it has become clear that traditional, perimeter-based security methods are inadequate. To address this issue, the Cloud Native Computing Foundation (CNCF) has developed a model and reference implementation for automatically managing cryptographic identities at the service level within trust domains. This is the Secure Production Identity Framework for Everyone (SPIFFE) and the reference implementation is called SPIRE. However, the SPIFFE model also addresses *federation across trust domains*. Federated identities are managed in the SPIFFE model by exchanging *trust bundles* among the trust domains. Of course, to completely manage federations will require that SPIFFE is augmented with tools to manage resource discovery, access, policies, etc.

- **Confidential Computing Consortium and Trusted Execution Environments**
  The goal of the Confidential Computing Consortium (CCC) is to facilitate the adoption and use of Trusted Execution Environments (TEEs) -- special memory regions whose access is protected in specialised hardware. CCC has identified several target TEE use cases, including *Multi-Party Computing* to support *federated analytics* (their

terminology). In this use case, a user places their data into a TEE offered by a remote site. The data is encrypted until the specialised memory management hardware puts the data into the TEE, where it can be computed on, but in the protected TEE. How the discovery and access to such remote TEEs can be managed the discovery and access to such remote TEEs could be managed by static, manual methods, but would be more effectively managed in a federated environment where discovery and access are controlled by well-defined policies.

- **ETSI's Multi-Access Edge Computing (MEC) Specification**
  ETSI's MEC Specification defines an architecture of interacting *MEC Platforms*. External users can instruct MEC Platforms through a Multi-Access Edge Orchestrator to instantiate different edge services out of an edge service registry. MEC Platforms can also directly interact among themselves. The MEC WG has clearly recognised the need to manage this model as part of a federated environment. How users can discover available edge services and have authorisation to instantiate those services needs to be addressed. How MEC Platforms peer to one another must also be addressed. To complicate matters, different application domains will have different governance models for managing sets of MEC Platforms. These design goals require a general federation environment wherein policy and governance can be managed on a per-federation basis.

- **OGC's Data-Centric Security**
  The Open Geospatial Consortium (OGC) has prototyped a data-centric security service where Data Centric Servers (DCS) serve encrypted data to anybody. Another set of independent Key Management Servers (KMS) manage the distribution of keys to whereby authorised users can decrypt the data. The prototype use case was a mobile device (phone) that could adopt one of several, pre-defined, roles. A role enables the device to access specific data. The demo scenario was a Fire Chief that goes to a 5-alarm fire and can access relevant data on their phone, as long as they are in the physical vicinity of the 5-alarm fire. What this previous demo did not address was how the user (and phone) were granted roles. It is recognised that federations can be used to manage the granting of roles. That is to say, DCS and KMS servers and their users can be managed within different federation instances.

- **The NIST and IEEE Joint Cloud Federation WG**
  Federation was identified as a high-priority requirement in the NIST US Government Cloud Computing Technology Roadmap, Volume I. As a result, NIST and IEEE started a joint working group to address this requirement. NIST extended the established NIST Cloud Computing Reference Architecture into the Cloud Federation Reference Architecture, NIST SP 500-332. As a reference architecture, this document is inherently conceptual as it organises the entire federation design space. However, two examples are given in Appendix B that illustrate how the CFRA federation model could be mapped to concrete implementation approaches. The IEEE P2302 WG is now defining a RESTful API for the *core federation functions* based on the NIST model. Additional *Federation Capability Levels* have been defined where API calls will be eventually added

to support capabilities such as legal agreements, billing, compliance, trust frameworks, and automation.

Potential Federation Application Domains

These examples above are all quite concrete, yet there is no shortage of potential application domains throughout industry and government. For example:

- **International Disaster Response**
  International disaster response efforts need to be effectively coordinated. Such coordination among stakeholders could be done by an *International Disaster Trust Federation* that can instantiate a federation in response to an international event. Stakeholders, such as government agencies and NGOs, could be added to a federation depending on where the disaster occurs and who is responding. Stakeholders could be granted different roles, such as first responders, medical personnel, logistics managers, etc., that enable them to share the appropriate information. Such governance would be defined as part of the Trust Federation prior to specific disaster responses. When a disaster has been adequately addressed, the federation could be decommissioned.

- **National Strategic Computing Reserve**
  Computing in a globally connected environment is central to and supports all human endeavors. Hence, at the national level, ensuring the availability of such resources at all times is a critical national requirement. This has motivated the conceptual development of a *National Strategic Computing Reserve (NSCR)* to be available during times of national emergency. The COVID-19 HPC Consortium is a prime example of what a National Strategic Computing Reserve could support. The planned NSCR Implementation and Operations clearly identify the need for *dynamic federation* of resources across the NSCR stakeholders to meet national objectives.

- **CISA's Sixteen Critical Infrastructure Sectors**
  International disaster response is actually one area in the sixteen Critical Infrastructure Sectors of the DHS Cybersecurity & Infrastructure Security Agency (CISA). Each one of these sectors have a wide and diverse set of stakeholders that need to securely share information for specific purposes.

- **The United Nations Seventeen Sustainable Development Goals**
  Similar to CISA's Critical Infrastructure Sectors, the United Nations identifies seventeen Sustainable Development Goals. These goals are very high-level and very broad covering all sectors of human existence. While all of these areas need concrete investment in terms of physical resources, achieving many of them would also benefit from the secure sharing of information. This includes clean energy, economic growth, industry innovation, and sustainable cities.

- **Smart Grids, Houses, and E-vehicles**

A driver could be on a road trip with an electric vehicle. The driver could authorise the vehicle to disclose its current location and battery charge to a cellular network. This information can be used to direct the driver to a charging station that is within range when needed. The charging cost from the local utility could be charged back to the driver's home utility.

Appendix B: Community Input

Survey, Interview, and Participants

Our survey and interviews were informed by the open-ended ``seven-questions'' approach. This originates in the work of the Institute of the Future (Amara and Lipinski,1983), and has successively been refined by Shell (Schwartz, 1991), van der Heijden (1996) and ICL (Ringland, 1998).

A copy of the survey and interview script are available at [Survey].

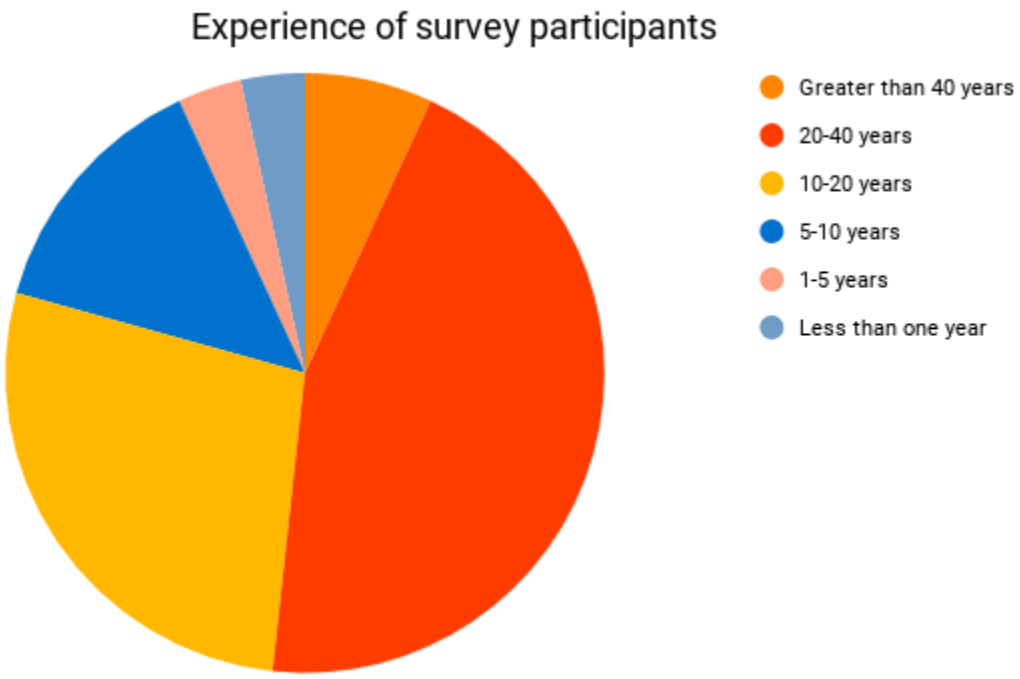


Figure 5.

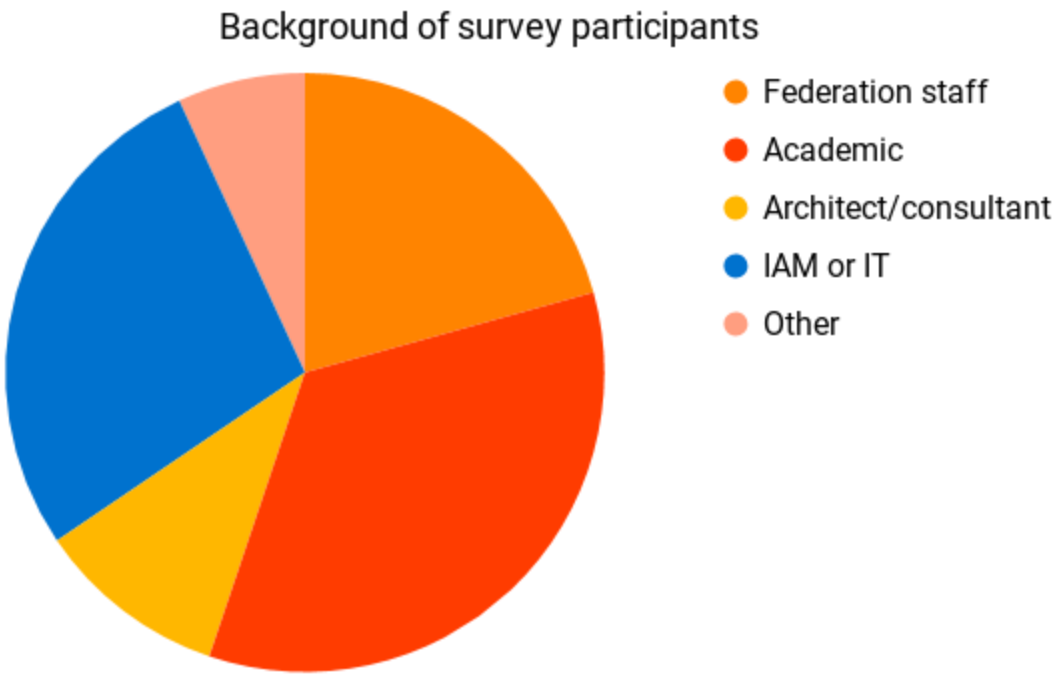


Figure 6.

Community Input: Synthesis of Environmental Factors

The Academy

We are special. We value openness and collaboration, we help each other with common problems. We share and build on each others' work. There's a vibrant tension between competition and cooperation. We know that we are all engaged in a common mission, each with a role to play in forwarding research and scholarship, teaching and learning, and expanding the understandings, tools, and information with which the future of society is built. We appreciate the height of our calling and understand these things about each other, which forms the heart of a sense of community we all share. We see ourselves as a single global community. We trust each other and we are trusted by communities in other sectors.

The Cloud

Large technology companies provide services in the cloud that some believe are a better way to support The Academy than what it can or should provide for itself. There is a wide range of attitudes towards this general development. It's still too early in the life of "The Cloud" to know from experience which beliefs about it are well founded. Cloud proponents have the advantage of not having been proven wrong, and the safety of following trends in other sectors. Cloud opponents are concerned about the business models of those large technology companies and question whether they can be relied on to meet The Academy's needs over the long term. In

between these two extremes, many just want to use cloud services that can readily be adapted to solve problems of The Academy, but also see this as just one more phase in a technological evolution that will continue into the future.

IT Skills Challenge in The Academy

Those large technology companies hire highly skilled people away from The Academy. Universities increasingly view their IT as a cost center rather than as a strategic asset. These two factors make it difficult to maintain skills in our community sufficient to continue to develop and field solutions to common problems.

Political and Societal Instability

Rising nationalism and authoritarianism, together with inaction on climate change, creates the conditions in which limits on academic collaboration and sharing may be imposed by some nations, undermining and fracturing academic activities, and threatening the core academic values of openness and collaboration by imposition of technical and policy barriers and redirecting funding towards other priorities.

Who Pays

There is a common expectation that tools and data for academic work should be provided to academics to do that work free of charge; universities and funding agencies, national and private, should foot the bill. At least, some academics at leading institutions, with leading levels of resources available to them, think so. But funders want to produce science and scholarship rather than pay for on-going operations that provide the infrastructure on which academic work is done, and there's no guarantee that universities will or can continue as before. Moreover, many universities around the world lack the resources to underwrite much of what their academics would like to do.

The question of who pays is also deeply linked to how inclusively The Academy can actually operate.

Identity as Agency

There are diverse views about who should, or does, control the credentials and claims by which people access things online in performance of their academic work. Is it the people themselves? Their (academic) employer? The communities of academics with whom they do much of their work? The operators of the infrastructures on which they do their work? This is deeply connected with both privacy and provenance, themselves inherently in conflict. It is also connected with equity and inclusiveness in The Academy, since suitable credentials are necessary in order to work alongside your colleagues. When viewed as "who should", the question can look like a referendum on personal autonomy. When viewed as "who does", it tends to reflect the variety of authorities that have a stake in who is permitted to access what.

Importance of Wise Governance

The scenarios constructed for the Federation 2.0 effort tend to have a cautionary tone, often expressing negative outcomes within each of the working group's four quadrants of potential future environments, based on the degree (abundant or limited) of resource availability and the degree that external (e.g., political) issues affect academic endeavors (directed or autonomous) in each of these quadrants.

As one might expect, it's hard to do well with limited resources. Wise policies and governance, linked with community advocacy, however, can change most scenarios' outcomes from negative to positive. For example, small changes to the Multiply and Divide (Directed-Limited) scenario to foster collaboration, pooling limited resources, can result in a much more positive outcome. Analogously, a requirement to use open access licensing can mitigate many of the negative aspects of the Mission Accomplished (Directed-Abundant) scenario.

Community Input: Suggested Actions

Service Centers

Move operation of distributed infrastructures to a more centralised or coordinated form, so that fewer skilled people are needed across the deployed footprint compared to each organisation needing to have those skills in-house in order to operate its piece of the overall infrastructure.

Untapped Funding

Pursue partnerships with commercial organisations that have added public benefit to their mission, in addition to their bottom line.

Harness R1's

Get all R1's (a designation for research intensive universities in the US) to contribute funding to and integrate with federated service platforms, reducing the need to rely on big commercial cloud providers.

More Standards

We need more of them to help Academic Interfederation better deliver value to The Academy. Mature REFEDS into a real standards defining organisation and fund community experts for their time in developing those standards; don't rely so much on volunteerism.

Cloud Pragmatics

Put things like IdPaaS (Identity Provider as a Service) and SPaaS (Service Provider as a Service) in places like Azure, Google Cloud Platform, and AWS so it's easier for services built in those ecosystems to participate in Academic Interfederation.

Transition To Practice

Establish a process to identify software and services developed with grant funding that are especially good at amplifying the value of federation, and sustain at least some of them by integrating them within the operation of at least some individual R&E federations.

Global Metadata Registry

The current system of individual R&E federations for each nation is too complicated and uneven from a service provider perspective. Establish a single global process to register entity metadata in which entity operators can indicate in which federations they wish their entity to be exposed.

User Intermediation

Enable intermediation of libraries in “their” users’ federated access experience to protect them from encroaches on privacy. The opposite idea was also suggested: Intermediaries are less likely to understand the consequences of their choices for users.

International Baseline Expectations

Define a set of “core” policies that all individual R&E federations adhere to so that key values of Academic Interfederation, such as ease of on-boarding, good user experience, global interoperability, attribute release, and security, become ubiquitous.

New Federation Use Cases

Apply the expertise of the Academic Interfederation community to improve academic workflows with an essential trust component, such as peer review or scientific workflow automation.

Appendix C: Future Scenarios

Multiply and Divide

It wasn’t always like this, I was educated as a chemical economist . During “the before” I studied like everyone else, and was excited about doing research to figure out how companies had benefited from our current environment. We were so young and naive. We were completely taken by surprise by “the freedom”. Everything was taken away from us - “the others” closed themselves off and we were left with nothing.. There was no more money to do any research - everything was about survival, and you couldn’t think about anything else. My dreams about a future in the agri-chemical industry turned to survival. I knew that life could be better, so I ran for office with the goal of making our world better.

I got to work in the Government creating a system of policies, applications, and processes that helped to make basic living easier. It completely worked - the system anticipates practically every need. My colleagues were brilliant in pulling this all together. Now students are trained in the system at an early age, and are taught how to be creative and innovative in making things even better for us. They learn how to analyze data and how to use this system to improve things, how to develop processes and policies to make our lives even easier. All research and education is designed to benefit us. My daughter, Else, and her friend Rasmus were educated in this system. Rasmus has been working on a cure for this terrible disease that has been plaguing our country over the past 5 years. We are definitely in a much better place now - who needs “the others”?

But yesterday, Else told me about a really disturbing situation. She and Rasmus have been doing some side analysis based on some resources that she found at the library where she works. They have found that one of my colleagues in the government has been compromising our opportunity to cure the disease that has been challenging our citizens. There is a plant that only grows in the Solmstas region. It seems that the reason that this region is so special is because of the composition of the soil which is rich in a lithium cobalt salt - a rare substance that can be used in advanced battery technology. The Minister for Agriculture apparently has created a side deal with “the others" to mine this area. Even more disturbing is that it looks like they have done it for their own financial benefit. All of my work to make our country and lives better is likely to be compromised because of their greed.

Mission Accomplished

The year is 2030. The citizens of Earth realise we are running out of energy. Traditional avenues (fossil fuel, solar) fall short of ever increasing demands. AppleGoogle (AG), the new mega multi-trillion dollar corporation has decided to solve the world’s energy problem by directly investing in fusion research to power the planet for the next millennium.

The news captures the imagination of the world population. To bypass the bureaucracy and delays, AppleGoogle establishes massive research centers around the world, directly recruiting research talents in multiple disciplines to work on projects. Researchers respond to the call to action, with large-scale defections from traditional higher learning institutions to work in these research centers.

Further, AppleGoogle establishes learning institutes starting with K-12 in order to develop the next generation of digitally-skilled talents. After a couple of years a key breakthrough is made which requires massive investment from several startups and a large cottage industry. At the same time AG receives indications that the US govt is considering eminent domain to ensure that critical IP does not fall into enemy govt hands. A small group inside the AG executive team takes quick action and publishes the core findings on multiple public repositories and places the

IP in a Swiss trust with a non-compete, non-litigation clause and the stipulation that derivative work from the IP must be shared with AG. This action makes the research immediately public.

Very quickly India, China and the EU spin up research and development projects to take the fundamental research to products. This causes a massive increase in public funding directed back at the traditional academic institutions and a series of VC investment efforts to create products.

AppleGoogle valuation soars on the news, generating even more revenue to fund further research.

Basic research in traditional institutions shifts completely to these new research centers, depleting traditional academic research organisations. After the IP holder foundation is created a second wave of applied research creates a renewed interest in publicly funded academic research at traditional institutions. However theoretical physics which created the initial breakthrough is decimated (they are all AppleGoogle executives living in Hawaii) and doesn't recover for several generations. Applied physics sees a major increase in interest and captures the imagination of the generation.

Publicly funded research survives but they have to deal with a new reality of obtaining licence agreements with key IP holders in the future. Researchers are supported by AI and deep learning engines to continue research breakthroughs. This replaces the current conflict with journal publishers who no longer hold a key role in research. As a result libraries and open access publishing finally wins.

Research infrastructure is caught by surprise by the initial development phase at AG but quickly adapts to providing services during the applied phase. They are, however, all tied into the IP scheme established by AG and after the initial phase of work are pressured (gently at first) to buy the majority of their technology from AG that increasingly is referred to as "The Company" by the public.

Learning fundamentally shifts as well. Online/e-learning technology is now mature. With teachers (researchers) now concentrated in specialised research centers, students learn not from completing coursework from a single institution, but through a collection of purpose-specific, likely international online learning centers.

Tinder for Collaboration

Setting: A Holodeck of Collaboration

Actors:
Established collaborators (creators of all flavors (science, engineering, art, etc))
Students.

Once upon a time (in the not too distant future), in a Holodeck far far away, there was a stream of young collaborators searching for their perfect collaboration match. These collaborators are young, energetic, and confident. Around them are so many opportunities, so many choices. Will they find that perfect match… only time will tell…

(good outcome)
In the first and most positive example, Angela is interested in pursuing a global societal problem. She ponders her passions and searches for problems that interest her. She enters the basic parameters of her interests into “Tinder for Collaboration” to find collaboration partners. She virtually meets with her collaborators regularly in the Holodeck. Her institution provides her with the resources and tools to make the collaboration successful. Three years later the collaboration develops a cure for the common cold.

(failed outcome)
Poor Roger on the other hand is trying to create a collaborative sculpture with a diverse global team. Several attempts are made together in the Holodeck but many collaborators are unsatisfied with the results. Despite regular use of the Holodeck, the coordination has not resulted in a shared vision for the sculpture that is sufficient to actually produce it. The team ultimately abandons the work and each pursues their own creative visions separately, having learned from the experience.

(rare problems not being addressed)
Felicity has a rare allergy to sunlight. She searches Tinder for Collaboration for anyone with a similar allergy or researchers working to address it. All she finds are a few other sufferers and people posing as collaborators who actually want to take advantage of their plight. Because there is no coordinated research program on the topic, bona fide researchers are not drawn to the work.

(duplication of results --)
John from the Moon University and Jason from Lower Texas State university have searched Tinder for Collaboration, established teams, and worked for five years to solve the issue of potable water on the Moon. While they are aware of each other’s efforts, because they have plenty of resources, they choose not to collaborate. They both get results and publish them in different venues, only later discover their results are virtually identical and each suffers from small inconsistencies that the other has solved. Lack of coordination results in duplicate efforts and that damages the reputation of each.

(grand challenges not being addressed)
The problem of successfully colonizing Mars is not making any progress because of a lack of a unified vision and leadership. While many want to see it happen, the scale of the logistical challenges requires significant coordination and planning that is not occurring. The sum of the parts being produced does not equal the whole needed to solve the problem.

(Impacts on Society)
Society benefits from lots of innovation, entrepreneurial spirit, opportunity, and freedom to pursue one's passions and talents. However, there is difficulty getting to a rational research program, and critical mass in grand challenge types of problems. Also, those who require more support and direction may be left behind leading to increasing disparity. Resources are not used optimally in the presence of plenty.

(impacts on Institutions)
Institutions are also confronted with both the opportunity to thrive in the presence of adequate resources but the risk of falling behind and losing reputation for lack of real innovation… too much competition.

(impacts on infrastructure/services to support this vision)
Infrastructure is increasingly virtual and distributed. Access management and identity proofing are key to individuals using these resources. New technologies and techniques are rapidly tested and deployed when these infrastructures are adequately resourced.

I Will Survive

Version 1

Jenny is an archaeologist and she's a heavy drinker. She's got a good gig, working in American Samoa analysing stone tools for shape, size, use, marking. You start to get the idea why she drinks.

And one night at the pub she met a geologist. They both got talking about what they do and both thought "What a great idea" I'll give you my tools I've found if you can tell me where the stone is from. This person's called Alfred. Now Alfred had a look at the tools and realised the stone wasn't from that island. So he went to the shore and pulled a favor from a boat owner and sailed across to the other island. He met Angela who is a geologist over there. And this went on a couple more times.

But he was really missing the pub. He thought "I need a better way of doing this". So he asked the boat owner who was going to the islands anyway to pass on a message to his friends for help. Via this boat, they started collaborating. They just used what they had available. And they started to agree on how the data was to be organised across these different disciplines. They managed to build the tools that they needed through consensus. And they all spent many more nights at the pub.

Version 2

Jenny is an archaeologist at an institution in the continental US. Her research area is in American Samoa, specializing in stone tools. She is able to secure enough funding to travel to American Samoa to work in the field once every couple of years. Her institution isn't able to provide any support. However, she is able to store her collected data in G Suite using her institution provided account.

One night at the pub, she was chatting with a geologist from another institution, Alfred. One of her research questions is where the material for the stone adzes originated from. Alfred was quite willing to help out. Luckily, Alfred's institution is also G Suite. However, when Jenny went to share her Google Drive folders out, she found out that to "protect the institution", she wasn't able to share her material with an account external to her own institution. In order to collaborate with Alfred, she had to copy all of her work over to a personal Google account so that she could add Alfred.

Alfred was able to trace the source of the material to islands nearby. However, this now brings up the question of how the material made it from one island to another. Jenny knows a researcher specializing in those islands, Nurul. Nurul is happy to collaborate. However, her institution has her storing all of her research materials in Office 365. This puts our three collaborators on different platforms, with various sharing rules, and some requirements to create personal or additional accounts.

A local, Lolo, finds an interesting adze. However, since he doesn't know the researchers working in American Samoa, he finds it difficult to figure out who to talk to. Once he gets Jenny's contact information, it is difficult to fully collaborate with her as she is still storing her data in whatever format was easiest for her on a Google Drive shared out of her personal account.

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