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GÉANT Community Strategy for Above-the-Net Services

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Abstract

This deliverable presents the current drivers and key challenges in the Above-the-Net activity's service development and delivery. This is used to analyse different prospective approaches toward a collective GÉANT strategy for Above-the-Net services and is presented to the GÉANT Association governance and the wider GÉANT Above-the-Net stakeholder community to serve as the starting point for a decision-making process on such a strategy.

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Executive Summary

Planning the GN5-1 project work for recommendations for a collective GÉANT Above-the-Net strategy began after the GÉANT CTO workshop in Q4 2021. Initial feedback indicated strong support for collaborative work on building infrastructure-cloud and other services, complementing the successful joint procurement of infrastructure-cloud. However, clear direction and improved understanding between 'buy' and 'build' proponents was needed. The GN5-1, WP4 Task 4 team's strategy development initiative aimed to improve this situation by enhancing collective directionality and fostering productive debate.

Since the strategy work began, significant geopolitical and technological developments have emphasised the importance of digital sovereignty and data autonomy. The war in Ukraine and geopolitical tensions involving Russia, the USA, and China have highlighted the risks of outsourcing and the need for robust digital infrastructures. The European Commission has underscored the critical role of R&E infrastructures in Europe's future, necessitating a balanced and collective approach to building and buying services.

Achieving an agreed, collective, Above-the-Net strategy by the end of the GN5-1 project was deemed unlikely due to the complexity of the subject, varying NREN capabilities and the necessary governance processes involved. However, the goal was to facilitate better-framed discussions and identify productive collective efforts, our analysis of which is presented in this document. The aim of this work is to provide a starting point for a further decision-making process and planning of Above-the-Net work in future projects. This deliverable reviews the main challenges and strategic assets relating to the Above-the-Net activity to analyse five potential options for a collective GÉANT Association Above-the-Net strategy:

0. Continue as-is: Does not solve outlined challenges.
1. Improved enablement of national service delivery and federation: Partially addresses challenges but has limitations.
2. Collective-by-design production and delivery of European 'as-a-Service' R&E cloud services: Fully leverages strategic advantages but requires significant operational changes.
3. Implement a service-sharing framework between NRENs: Increases market size but lacks coordinated development.
4. Stop collective Above-the-Net activities: Leads to fragmentation and does not address challenges.

The analysis identified options 1 and 2 as promising approaches for collective Above-the-Net action. The successful joint procurement of infrastructure-cloud should also be actively further developed to ensure long term sustainability and increased value.

To implement the identified approaches, the following actions are recommended:

- **Expand the current approach** to make commercial services available and advantageous for all European R&E institutions.
- **Decide on a collective path forward** for Above-the-Net service delivery, focusing on federating national deployments and developing collective services.
- **Implement a 'collective-by-design' culture change** in service approaches.
- **Focus on service provisioning for research** as a niche least likely to be commoditized by the commercial sector.

- **Address public values** in service delivery that the commercial sector cannot, such as digital sovereignty and long-term stability.

The GÉANT Association supported by the GÉANT project is well positioned to improve Above-the-Net service delivery to European R&E but must enhance collective efforts to scale effectively and make a meaningful impact. The digital transformation of R&E is a challenge best navigated together, maximising effort aggregation and mitigating the European digital divide for the benefit of all GÉANT members.

1 Introduction

The GÉANT Association[1] has been collectively addressing Above-the-Net challenges through the GÉANT project for more than ten years. One activity pertaining to cloud infrastructure (IaaS, PaaS, SaaS), the joint procurement of framework agreements with large commercial IaaS+ platforms, has gained good traction as measured through usage by institutions and the number of NRENs contributing to the collective effort.

It is evident that a clear collective strategy has emerged for addressing the 'buying' aspect of cloud infrastructure. However, for the aspect of 'building' cloud infrastructure and services on top of it, no such clear collective strategy has emerged, despite many GÉANT members being engaged in this at the national level and a few joint software development activities taking place.[2] The general GÉANT Association consensus is that we can and should achieve more in this area, with several policy and geopolitical developments supporting this view.

The objective of this document is to present recommendations for a collective GEANT Association strategy on how to address the mix of community clouds and commercial clouds for the best interest of the entire European R&E community and to create options for balancing sovereignty with continuing access to world-class data processing for European research. Following the 'Strategy Kernel' methodology, as described by Richard Rumelt [Rumelt], the recommendations are presented through an analysis of the challenge, followed by options for guiding policies and coherent actions.

This document describes changes in the Above-the-Net-related environment (Section 2), identifies the main challenges for the strategy (Section 3), provides an overview of strategic assets (Section 4), options for service strategy development (Section 5), areas for collective work and community focus (Section 6), a review of the current successful strategy for commercial infrastructure-cloud procurement under the OCRE frameworks (Section 7), and finally, conclusions and recommendations (Section 8).

1.1 Methodology

In this document, options for a collective GÉANT strategy for Above-the-Net services are presented in the form of an analysis of the challenge to address, guiding policies ('strategy options'), and coherent actions[3]. The analysis is supported by interviews with several NRENs, the results of which are documented in Appendix A – Results of NREN Interviews.

The purpose of a GÉANT strategy for Above-the-Net services is to focus minds, energy, action and resources. Quoting Rumelt: "That focus, channeled at the right moment onto a pivotal objective, can produce a cascade of favorable outcomes."

[1] GÉANT Association as defined in the GÉANT Association Strategy 2021-2026 [GEANT_STRAT].
[2] Notably FileSender (since 2008, currently self-financed by contributing NRENs) and eduMEET (a development started in the GÉANT project and transitioning to a more self-financed model).
[3] This follows the 'Strategy Kernel' methodology as described by Richard Rumelt.

Community input and validation was sought in the following ways throughout the work on this strategy:

- A Cloud Strategy Forum was established, with members appointed by the GÉANT General Assembly delegates. The forum met ten times, with the last sessions organised as joint sessions with the Cloud Service Delivery Managers to make more effective use of participants' time considering the overlap in group participants.
- Interviews were conducted with representative NRENs, the results of which are summarised in Appendix A.
- Workshops were held at the TNC23 and TNC24 conferences and at multiple SIG-MSP[4] meetings.
- Participation in relevant fora and conferences.

1.2 Scope

This document presents recommendations for a coherent GÉANT Association strategy for Above-the-Net services and future work in the GÉANT project.

The scope of the strategy recommendations in this document is limited to collective action of the GÉANT Association for development and provisioning of mid-tier cloud infrastructure and related services for research and does not cover the full spectrum of Above-the-Net services. The GÉANT Association maintains an annually updated roadmap expressing the direction of collective activity for the Above-the-Net thematic area. This roadmap is implemented through a variety of means of which the GÉANT project is the most substantial.

High-performance computing (HPC) installations and educational services are explicitly out of scope:

- Collaborative strategies for HPC installations are the purview of EuroHPC.
- The challenges of educational services are out of scope due to being deemed sufficiently different. Educational services such as Learning Management Systems, digital exam systems, etc., behave according to such a different dynamic that a collective strategy for these services requires its own process. There is also less policy pull from the European Commission for pan-European approaches *at this time*, although there is the potential for change here as the impacts of the European Learning Area start to be felt, which may require pan-European educational service approaches. This can be tackled in a future update of the Above-the-Net strategy.

[4] The SIG-Managing Service Portfolios is the special interest group for management of service portfolios; more information can be found at [SIG_MSP].

2 Changing Landscape – Observations

As part of this strategic analysis, the WP4 Task 4 team considered their own key observations arising from their work over time as subject matter experts that inform the process of analysis. These landscape observations cover changes in the societal context constituting geopolitics, the technology sector's growing societal influence, regulatory priorities in the European playing field, and the European economic outlook. Changes in the R&E context will be analysed in terms of the changing digital needs of research and education, consolidation within the European R&E space, trends towards pan-European international research, demand for consistent pan-national services, and interoperability and compliance. Finally, changes in the technology landscape will be analysed in terms of cloudification, commodification of services, opportunities and risks in commercial services, the stratification of R&E target audiences, and the trends towards infrastructure as code.

2.1 Changes in the Societal Context

Major global power blocks are diverging and Europe needs to lessen its external dependencies. Political instability is reported as a major concern for countries and individual sectors.

The Act, Align, Accelerate report [AAA] states:

> *"Given a more hostile international environment […,] Europe must step up its investments in its future strength, and it must do so both at national and at EU levels, and both in the private and public domains."*

The developments in high-tech have resulted in a few companies ("Big Tech") wielding significant influence over social and technical discourse, leading to communication bubbles that have been described by officials in North America [Congress_SocMedia] and Europe [EC_DSA] as eroding a shared sense of 'consensual reality' within society. This is accompanied by the risks of opinion manipulation on a societal scale and of applications and platforms that are engineered to lock in users.

On a European level, several high-profile regulatory initiatives in recent years, such as the GDPR, the EU Data Act and the AI Act, shape the regulatory landscape for European research and education. Standardisation institutes such as the European Committee for Standardisation (CEN) work to formulate new ISO standards on data management, data spaces, cloud and edge[5]. In this landscape, the EU is also prioritising future research funding and driving towards a strong European technological infrastructure. Concepts such as a fifth freedom of research, innovation, data and knowledge, referring to the embedding of research and innovation drivers at the core of the EU single market, are driving towards a European industrial policy beyond national confines.

The need for investment in Europe's economic future coincides with a downturn in the economic outlook. Tighter European and national finances are to be expected, with a somewhat delayed effect on budgets in universities and research institutions. Technology dependencies on other global powers, such as the USA and China, will come at a cost and could impede sovereign research and education in Europe. Reducing that dependency and investing in technology sovereignty for Europe will of course also come at a cost.

[5] Edge computing is a distributed computing model that brings computation and data storage closer to the sources of data [Edge].

2.2 Changes in the R&E Context

Within the context of these societal changes, the digital needs of the R&E community are also evolving. There is increasing demand for proven and certified compliance of services, and as it becomes more mission critical for R&E institutions and collaborations, the services provided by Research and Education Networks (RENs) must evolve to address those needs. Institutions will choose services that look to deliver on quality and cost. NREN services must be competitive or risk becoming irrelevant. Demonstrating superior support for European values might be an advantage that can balance higher costs.

Several factors are driving consolidation in the space of R&E service organisations. In several countries, national policy is driving the vertical integration of R&E organisations, merging low-level networks with HPC and higher-layer software and support organisations. Thirteen GÉANT members have been officially government-appointed as mandated members of the EOSC Association, tasked with coordinating their respective national EOSC efforts. The character of a significant portion of the GÉANT members has changed over the past years towards becoming a 'full-stack' organisation[6].

The European Open Science Cloud (EOSC) is bringing the requirements of and players in European R&E together. The existence of the EOSC EU Node can guide those NRENs engaged with EOSC to align on solutions that deliver a pan European framework of interoperable services [GÉANT_EOSC].

At the same time, research activities are also becoming more and more transnational and pan-European and therefore, need common and interoperable data platforms for collaboration across borders. Implementation of these interoperable service ecosystems requires the integration of resources from European, national and regional-level sources. Building upon what has been proven to work will accelerate the adoption and implementation of the service landscape. Public-private partnerships may be used as an additional vehicle for increased speed and efficiency of implementation. Ultimately, it is intended to work towards integrating research data infrastructures into a Global Open Research Commons [RDA].

Within the R&E space, challenges are better navigated together as a community to achieve the required interoperability and compliance with our service ecosystem. There is a visible scope for 'collective-by design' solutions built in partnership but operated sovereignly, that nonetheless offer the required interoperability. This will deliver services of higher quality and greater compliance to community members than would be available to them individually.

2.3 Changes in Technology

The cloud service model has now become the de-facto expected standard paradigm for delivering end-user services independent of the identity of the provider, be it institutional, community or commercial. The expectation is for 'as-a-Service' delivery through (web) apps.

At the same time, there is an increased commodification of the IT service landscape, meaning that many services that used to require DIY are now available as commercial services for purchase. This promises easier and quicker adoption, especially for community members with more money than staff capability.

There are a number of risks and opportunities in making use of a commercial service portfolio. Commercial services tend to be cheaper, either through loss-leading or by economies of scale and efficiency. Opportunities to be had from using commercial services lie in the short-term cost savings, the rate of innovation, lower maintenance and development overheads, and the quality of service at a certain price point. The risks to be

[6] Well-known examples from recent years are CESNET, DeiC, JISC, PSNC, Sikt, SURF, and GRNET; Finnish CSC has always been a full-stack organisation.

considered consist of making yourself dependent on a provider's cultural value system, risking vendor lock in, making yourself vulnerable to later price or feature changes, and a loss of in-house capabilities. Commercial licensing, usually acquired per enterprise and per country, also makes it difficult for researchers to collaborate across borders, an issue that is avoided by the use of open-source licensing. In the wider R&E community, an increasing use of commercial services may erode the mutually supportive landscape of R&E services, which generate the greatest value when working collaboratively.

From observations made in the Cloud Forum and among the GÉANT Cloud team members, we conclude that those parts of the R&E community where commodity cloud services are available show a strong preference for SaaS delivery, especially among institution staff and administration. The education and teaching community is equally interested in SaaS delivery, but maintains certain requirements that aren't quite as commodified yet, but are being offered by more niche providers. The research communities, on the other hand, have a consistent need for highly customizable research solutions and therefore gravitate toward PaaS solutions which abstract much of the infrastructure management while allowing the required customisability and focus on algorithms and data.

The paradigm of infrastructure-as-code is rapidly evolving the concept of IT infrastructure operations in that it is a feature-set on top of hardware virtualisation that allows scripting and automation of infrastructure configurations. This enables dynamic reconfiguration and reacting to changing environments. It also enables easier portability of infrastructure configurations across service operators within a partnership, and thereby also enables cross-border transferability and interoperability of services. Infrastructure-as-code shares many similarities with multi-party software development, which is a way of working which has been honed over more than forty years and is supported by a rich ecosystem.

The next step in automated infrastructure management is likely to be a combination of AI-driven automation[7] combined with digital twins, pushing the cost of infrastructure operations further towards a model comparable with software: the initial design and implementation are costly, but scaling to a larger hardware pool is relatively easy.

[7] See Bob Friday's presentation at the NORDUnet 2024 conference for more at [NORDUnet_Pres].

3 Above-the-Net Challenges

This section identifies the challenges that are most relevant for a collective Above-the-Net services strategy for the GÉANT Association.

The Task 4 team's analysis of the changing landscape in the previous section leads to one main challenge faced by the GÉANT Association in the Above-the-Net area: no individual European NREN will be large enough to provide Above-the-Net services cost-effectively over time, at ever-increasing compliance, quality and functionality levels. In spite of this, there are strong expectations from national and European NREN stakeholders to do exactly that. Viewed from a ten-year perspective, while there is no imminent danger, the GÉANT Association's approach to Above-the-Net services is at significant risk of slowly declining in relevance.

This main challenge is a synthesis of the sub-challenges detailed below:

1. Limited economy of scale for as-a-Service delivery.
2. Changes in collective NREN customer base and context.
3. Increased expectations at the national and European levels in budget-sensitive times.

1. Limited economy of scale for as-a-Service delivery: Technology and market developments push all Above-the-Net service delivery towards an as-a-Service model, a model which follows a 'bigger is better' approach. IaaS, PaaS and SaaS can bring economy-of-scale benefits, but only at very large scale. For the vast majority of NRENs, national cloud-infrastructure initiatives will always be limited in scale due to the size of each NREN's national market being what it is. Over time this can be expected to result in higher cost and lower quality compared to commercial alternatives, which form the benchmark with which both institutions and governments will compare NREN services. Added to this is the challenge of creating and retaining sufficiently robust teams to deliver at the required quality level over time, considering that quality requirements will increase. In other words: individually, each NREN will struggle to deliver a good-enough service over time at an acceptable price-point because IaaS, PaaS and SaaS are complex undertakings that require large-scale resources to cover the ongoing operational and investment cost inherent in running a high-quality service. At the same time, Big Tech continues to scale.

It is important to note that the dynamics highlighted here will change should a country decide to go for a joint infrastructure approach across the entire public sector, in which case R&E service delivery remains fragmented, just in a different way.

2. Changes in collective NREN customer base and context: As highlighted in the introduction, developments in research and education drive the NREN service portfolio. One major development has been the digital transformation of research – where before, only a few disciplines such as particle physics and astronomy were dependant on digital services, now every research field has become digital, and the amount of data that can be and is gathered has exploded. This development is compounded by recent developments in the AI field. This digital transformation has triggered a major policy drive to ensure better utilisation of European investments[8] in research results – the creation of a data space for sharing research data and services across disciplines, at scale: the European Open Science Cloud (EOSC). Digital transformation has also hit education and administration,

[8] Average EU27 national government spending on research in 2022 was 1.49% of total government expenditure [EU27_R&D].

and as a result the long-term trend is for workloads in these areas to move from on-premise to as-a-Service sourced from either commercial suppliers or national public-sector service providers.

Another key change is the steady integration of research infrastructure across national borders. Many research communities have organised themselves in pan-European research infrastructures, often formalised through the European Research Infrastructure Consortium (ERIC) legal entity form. With research disciplines organising themselves across borders, the NREN community is increasingly confronted by pan-European customers demanding a coherent pan-European approach to contracting, service delivery and billing. This is the case both for older organisations such as ESA and ECMWF and newer organisations such as the EuroHPC JU, but also the many ERICs that can be expected to evolve in this way, especially for Above-the-Net service delivery. In the learning field a similar development may happen, driven by the European Learning Area policy initiative that aims to establish true pan-European university studies through university alliances, of which there currently are 63 in place.

3. Increased expectations at the national and European levels in budget-sensitive times. The roles of many NRENs have expanded, from network providers into national tools for digital transformation and shared service delivery to R&E, and all NRENs are considered to be a key national resource of strategic importance. As such, key national stakeholders increasingly expect NRENs to contribute more to the furthering of national and European policy agendas. Notable examples are the European Research Area policy initiative encompassing Europe's Open Science policies and EOSC, contributions to secure digital infrastructures for R&E, and contributions to industry policy, notably the digital sovereignty agenda. As an example, most of the aggregate consumption on the GÉANT Cloud Framework (OCRE), around €100M in 2023 across 26 countries and having grown 50% a year since 2018, is spent on American hyperscale providers, while there is a European policy desire to contribute to the growth of a healthy, digitally sovereign market in Europe. The Letta report 'Much More Than a Market' [Letta] and the Draghi European competitiveness report [Draghi], both published in 2024, also point squarely towards the importance of R&E for Europe's competitive future, again increasing demands on NRENs to do their part in supporting this.

In addition, there is new European legislation in the pipeline that will impact NRENs, such as the Data Act and the AI Act. This is a push from both the EU and national policy levels, which puts more demands on GÉANT members, combined with the fact that these demands are not met with an increase in real budgets given the current budgetary and geopolitical climates. To summarise – we are expected to do more, with better quality, for the same or less money.

4 Strategic Advantages

The GÉANT Association, supported by GN5-1 and previous projects, has developed a number of key strategic assets valuable to Above-the-Net service development and successful delivery.

4.1 Existing Infrastructure

In terms of existing infrastructure, the GÉANT network interconnects all European national research networks and, through extensive global peering arrangements, connects to all major players of the global research community. On top of this a robust and powerful Trust & Identity Federation has been built to support strong authentication and authorisation for the service landscape and which already interoperates with major research efforts around the world. A number of GÉANT member NRENs also have a significant data centre footprint with research data management and high-performance computing capacity, and a national mandate and staff skills to match. All these existing infrastructure elements are a valuable underpinning for any future landscape of community services. This ecosystem of networking and research data centres has developed in order to guarantee a trusted path for research data from instrument to scientist.

4.2 Unique Assets and Skills

The GÉANT Association encompasses a large and diverse group of teams with diverse skills and domain knowledge adding up to a significant pool of important and directly accessible competencies. These include capabilities necessary for software development and infrastructure operations as well as necessary business skills that must be deployed around a technical service implementation in order to make it successful. An example of this demonstrated in action is the globally deployed and recognised collective service eduroam, the technical implementation and successful and stable worldwide governance model of which GÉANT leads. A crucial aspect of the GÉANT model is that it results in a legally robust chain of organisational membership from GÉANT via NRENs to their respective national member institutions. This unlocks a number of favourable pathways for collective procurement, financial transactions, contracting and collective service production & delivery.

4.3 Trust and Commitment

The community that the GÉANT Association represents has spent decades building crucial relationships of mutual trust and commitment as well as relationships of trust between each member NREN and their national stakeholders. In most countries the NREN is the preferred service provider for institutions and is a valued contact point for national policy stakeholders with some influence on EU policymaking. Compared to services procured from the commercial market, the GÉANT Association, supported by projects such as GN5-1, can provide greater stability through sustained service provision. GÉANT is the custodian of a long-running, established working relationship with the European Commission (EC) on a series of EC-funded projects and has been a key enabler for the joint European procurement of commercial infrastructure-cloud by acting as a central purchasing body on behalf of the R&E community towards the commercial market, resulting in a reputation as a trusted partner.

4.4 Track Record

For nearly 30 years, the GÉANT Association has established a track record of notable successes and positive outcomes. GÉANT has also cultivated a highly engaged and stable partnership with international organisations on global network operations and evolution. GÉANT is a leading partner in the global success of services such as eduroam, as well as a strong and reliable partner in the global Trust & Identity Federation governance and operations. GÉANT has led a series of successful public procurements, for example the GÉANT Cloud Framework (OCRE), as well as large-scale router and server hardware procurement. GÉANT has demonstrated a track record of continuing excellence in delivery on EC-funded projects, all of which have contributed to high levels of stability and predictability in the funding available for operations and development.

4.5 Ability to Achieve Scale

GÉANT also offers great opportunity to generate and deliver value via economies of scale in a number of activities. The GÉANT membership represents almost all of the publicly funded research and higher education sectors of EU/EEA countries. The total aggregate capacity in terms of staff in all GÉANT members is at least 3,000.[9] The GÉANT Association represents an estimated 10,000 institutions and their people across Europe. Out of the pool of GÉANT and NREN employees alone it is possible to bring together highly skilled teams with significant capacity to deliver innovative and valuable developments, given the will to do so. Through its membership structure GÉANT can bring to bear significant collective demand aggregation and bargaining power. Through its pervasive networking and other infrastructure, GÉANT connects all elements and players of the research data lifecycle in Europe, creating a highly capable substrate for universal R&E service delivery.

[9] GÉANT Compendium of NRENs, 2023 data. Covers staff and contractors. [COMPENDIUM]

5 Above-the-Net Service Strategy Options

As summarised in Section 3, the main challenge facing the GÉANT Association is that no individual European NREN will be large enough to provide Above-the-Net services cost-effectively over time, at ever-increasing compliance, quality and functionality levels. In spite of this there are strong expectations from national and European NREN stakeholders to do exactly that. Viewed from a ten-year perspective, while there is no imminent danger, the GÉANT Association's approach to Above-the-Net services is at significant risk of slowly declining in relevance.

In this section the following options for a collective Above-the-Net service strategy are presented to address this challenge:

- Option 0: Continue as-is.
- Option 1: Improved enablement of national service delivery efforts and federation.
- Option 2: Collective production and delivery of Europe-wide as-a-Service R&E cloud services.
- Option 3: Service sharing – enable NRENs to use other NRENs as service providers.
- Option 4: Stop the collective Above-the-Net activities in the GÉANT Association.

Each option is described with a 'guiding policy' and a set of coherent actions to operationalise that policy. These two together effectively make up a strategy option, as per the Strategy Kernel methodology. For each option a brief analytical discussion is included.

Option 0: Continue as-is

Guiding policy:

Continue the current strategy towards commercial IaaS+ suppliers – a joint procurement of framework agreements. The rest of the Above-the-Net challenge is addressed by each NREN individually at the national level without any concerted collective action other than to facilitate sharing ideas and experiences.

Relevant actions as part of this strategy:

- Sustain or improve the current joint procurement engine for infrastructure-cloud.
- Use Special Interest Groups (SIGs) to facilitate the sharing of ideas and exchanging experience, along with facilitating potential coalitions of the willing and able. Examples of this are SIG-CISS for infrastructure-cloud and SIG-AI.
- Facilitate further maturing of the eduMEET collaborative development.

Discussion:

This option does not address the main challenge facing the GÉANT Association regarding the production and delivery of Above-the-Net services, and as such, does not seem to be a viable way forward. Pursuing this strategy would effectively force those GÉANT members willing and able to do more together on the Above-the-Net area to act outside the GÉANT Association.

Option 1: Improved enablement of national service delivery efforts and federation

Guiding policy:

Expand the current Above-the-Net activity with a systematic and long-term effort to collectively support national service delivery of a portfolio of Above-the-Net services of sufficient collective interest, federating services where this makes sense to achieve a collective European visibility and user experience. This implies both a community engagement and organisation activity and the supporting of the common elements of technical service production and service delivery.

Relevant actions as part of this strategy:

- Agree on a portfolio of particular Above-the-Net services that are of sufficient collective interest to warrant collective effort.
- Agree on tangible collective work to improve national service delivery of the portfolio of particular services, e.g. deployment templates, joint action towards open-source software, security compliance, data privacy policies and data-processing agreement templates, etc.
- Establish a simple per-service federation framework to knit autonomous national deployments of commonly deployed Above-the-Net services together in an NREN federation for that particular service. This is done to present the combined deployments as a collective European service with standardised presentation and policy where appropriate, complemented with a technical federation where this is useful, potentially starting with FileSender and eduMEET.
- Implement a “collective-by-design” culture change as part of the federated approach.

Discussion:

This option does not fully address the main challenge, but it does put the GÉANT Association on a systematic collective approach for a common set of Above-the-Net services. The economies of scale will likely be limited. Firstly, because a federated service approach is unlikely to be as integrated and as standardised on technical, operational and service delivery levels as is possible with a collective-by-deign approach, and secondly because this approach likely leads to serial collective optimisation steps, each of which has to be imagined and then implemented, leading to significant overheads and delays in the realisation of any benefits.

However, this approach is a viable way to deal with a community where organisations are at different stages for a particular service. It also allows the retrofitting of “collectiveness” to a de-facto collective service offering. By systematically federating autonomous national deployments, pan-European visibility of NREN aggregate service capability to key European and national stakeholders would be achieved. Pan-European coherent service delivery could be achieved, depending on the appetite for synchronising the different service elements. This approach is easier to organise and finance than a full-on collective service production and delivery approach, as the collective risks are limited. Experience shows that it is unlikely that this model can include all GÉANT members for all relevant services – there will always be occasions where national implementations or policies cannot be made compatible, usually for reasons to do with the national context (existing community expectations) or finances (cost of change outweigh the benefits). Over time, smaller countries will be at a disadvantage with a federated model, as it in principle assumes autonomous national deployments of services with the associated overhead.

Examples of services where this model may be a good fit include FileSender and eduMEET. FileSender is *de facto* a pan-European infrastructure for transferring files up to 1TB, with collectively developed software deployed by almost all GÉANT members [FileSender Map]. While there is a long-standing collaboration on developing the software, there is currently no systematic collaboration on the deployment side, which leads to multiple deployment scenarios across NRENs, and invisibility of the achieved aggregate functionality from the point of view of the European Commission and the wider R&E community stakeholders. eduMEET is another candidate service that could benefit strongly on a technical level from federation. There are other services outside of

Above-the-Net that would likely have a similar trajectory. Rather than each service having to figure out how to build a federation, this approach would create a simple service-federation framework and share non-technical resources between different service collaborations: communication, community building, IPR competence, etc.

Retrofitting collectiveness will achieve fewer benefits than a collective-by-design approach, but there are different collective-by-design approaches possible.

Option 2: Collective-by-design production and delivery of European as-a-Service R&E cloud services

Guiding policy:

Leverage the aggregated capability and strategic assets of the GÉANT Association, combined with the European policy push [ERA] for an integrated European market for research data and services, to produce European-scale Above-the-Net services which are collective by design, delivering each service from a collectively built and operated, single technical service platform through NRENs to all European R&E.

Relevant actions for this strategy:

- Agree on a portfolio of particular (opportunities for) Above-the-Net services that are of sufficient collective interest to warrant collective effort.
- Establish top-level support for this collective-by-design approach within the GÉANT Association.
- Move NREN service design from national-first to collective-first and collective-by-design.
- Make the collective Above-the-Net roadmap an explicit and clear part of directing collective effort and establish transparent governance and update processes.
- Develop and test the capability to collectively build, operate and deliver European-scale Above-the-Net services through the planned service concept development in GN5-2 for a large-scale European object storage service for research data repositories, data movement infrastructure and common Virtual Research Environment software stack. The result of this work should be viable governance, technical and business approaches.

Discussion:

This option complements our current federated service production and delivery model with a collective as-a-Service production and delivery model. The essence of this model is that service production and delivery is a collective affair; is organised as such along the lines of governance, financing, strategy and deployment; and the approach is fundamentally a collective one: *collective by design*. Collective software production[10] shares many of the characteristics of this model but delivers fewer benefits as it does not address the optimisation of collective European-scale deployment.

The GÉANT Association would provide the European R&E sector with a single experience across all countries, creating economies of scale through collective service production and leveraging NRENs as distributed service delivery chains. This approach mirrors that of big as-a-Service providers: striving for large-scale service production and standardised delivery to achieve a higher quality at a lower price-per-unit-produced. The service would be collectively produced; one technical platform instead of 40 independent national deployments, delivered by a coherent (virtual) team. Changes regarding financing, risks and responsibilities would need to be investigated.

[10] Examples of collective software production involving GÉANT: eduMEET, eduVPN, FileSender, perfSONAR, and ResearchCloud (planned).

This option would allow for fully leveraging the strategic advantages the GÉANT Association has at its disposal, and takes full advantage of the new opportunities generated by the single market for research data and services as implemented by EOSC, part of the ERA policy agenda.

Current service development efforts in the GÉANT Association assume a service follows the same path as the network: a federated approach with full autonomy for the national deployments. We know from existing experiences that this leads to issues regarding 'delivering a service as one entity' to pan-European customers. Alternatively, a service is produced and delivered by the GÉANT organisation, which requires an increase in staffing of the GÉANT organisation for every new major service development and does not leverage the aggregate capabilities of the GÉANT Association. Collectively developing and delivering a standard service to all institutions and pan-European customers from a single technical platform is a different approach.

The collective effort to establish joint framework agreements with commercial infrastructure-cloud providers is effectively an implementation of this strategy: the activity acknowledges that it **must** be done together because the desired result simply cannot be achieved individually. However, this activity required more than ten years to organically grow to where it is now, not a recipe that scales very well to multiple services. It also has yet to undergo several further maturing steps, and did not require a technical platform to be implemented to get started.[11]

The GÉANT Association's collective service production and delivery capability needs to mature beyond the confines of the GÉANT project to be able to fully realise the benefits of a collective-by-design approach: economy of scale, robust virtual service production teams and delivery of a single experience in all European countries.

Through the Above-the-Net roadmap process, three promising collective-by-design service concept development activities were identified in the fall of 2023, which will be pursued through the GN5-2 project starting in January 2025: large-scale European object storage service for research data repositories, data movement infrastructure, and a common virtual research environment ('ResearchCloud') software stack allowing for cross-resource workload orchestration.

Option 3: Implement a service-sharing framework between NRENs

Guiding policy:

Enable NRENs to use other NRENs as service providers. Services would be produced by single NRENs, with the GÉANT organisation acting as a marketplace broker between consuming and producing NRENs. Economies of scale occur at the producing NREN. From the point of view of a European ecosystem, economies of scale occur through the 'invisible hand of the market.'

Relevant actions as part of this strategy:

- Establish an inter-NREN marketplace to deal with transaction support for cross-border service delivery. Coordinate this with ongoing EOSC developments.
- Test the strategy on practical service developments to establish viable governance, technical and business approaches.

Discussion:

This strategy option would partly address the challenge. The GÉANT Association would, potentially through the GÉANT project, facilitate a marketplace-approach for service sharing, but not be involved with the services

[11] At this point in time, however, there are non-trivial administrative and technical components required to sustain the service 'framework agreements'; notably a standard contract, tooling to automate the evaluation of large numbers of bids, and tooling to automate the processing of quarterly reviews to give an adequate overview of aggregate usage of the agreements.

themselves. The marketplace can be expected to require a reciprocal approach – those NRENs that want to offer services to the institutions of other NRENs need to open up their national market to services offered by other NRENs as well. There are multiple ways in which a marketplace of this kind could be implemented, depending on how services are to be consumed: directly by institutions or via the NREN representing the consuming institution. The latter scenario enables – if so desired – a certain level of control over access to the market represented by the NREN and looks to be implemented through the fledgling EOSC Federation, albeit there is currently no mention in the EOSC Federation of transaction support mechanisms. DFN has been running a marketplace like this for many years for German institutions, providing the framework that facilitates service delivery from one institution to many others. The framework facilitates the contractual side and DFN handles the financial flows between consuming and producing institutions [DFN Cloud]. Regardless how such a marketplace is organised, it will have to deal with the political sensitivity of changing the current geographic division of the European R&E market and with spending funds made available in Country A on services produced in Country B.

This strategy option does increase the size of the potential market for the NREN producing a particular service but does not lead to a coordinated (continuous) collective development of particular Above-the-Net services, unless the producing NREN implements mechanisms for involving other NRENs in the governance, financing and production of the service, in which case the strategy scenario becomes different to the one described above. This option does not leverage the aggregate capability and capacity of the GÉANT Association, as the producing NREN retains full autonomy in service production. This option does not lead to more robust teams at multiple organisations, but rather to strong teams at a particular organisation, which becomes a single point of failure. Consuming NRENs would thus be exposed to potential strategic reprioritisation at the producing NREN, which has happened several times in the past decade, in some cases triggered by something as sudden as a change of a government.

Option 4: Stop the collective Above-the-Net activities in the GÉANT Association

Guiding policy:

Focus the GÉANT Association's energy on network connectivity, trust & identity, security, joint procurement and other endeavours.

Relevant actions as part of this strategy:

- Discontinue Above-the-Net as a thematic area along with the related special interest groups (SIGs).
- Continue the joint procurement collaboration for IaaS+ but position it as collaborative procurement rather than a collective Above-the-Net activity, making it part of GÉANT's joint procurement thematic area and related GÉANT project work.
- Recommend that GÉANT members address the Above-the-Net infrastructure-cloud collaborative activities through other pan-European e-Infrastructure collaborations, e.g. EUDAT and EGI.

Discussion:

This strategy does not address the challenge, it simply defers addressing the challenge until later. Most GÉANT members will still want and need to address the Above-the-Net service spectrum; dropping the activity altogether merely means eroding the GÉANT Association's aggregate capability and create additional levels of complexity for NRENs.

There are good reasons why GÉANT members wish to work together on the Above-the-Net area: GÉANT members have a mandate for national service delivery and broadly reach all R&E institutions in their country, even if not all members are active in the same service spectrum. The GÉANT Association is a well-governed membership organisation which instils long-term trust and follows membership-driven priorities; and last but not least, the GÉANT Association has many mature capabilities that are essential for successful collective Above-the-Net activities.

6 Promising Areas for Practical Collective Above-the-Net Work

There are a number of promising areas for practical collective Above-the-Net work that operationalise the most promising strategy-guiding policies outlined in Section 5. The following is a brief overview of collective Above-the-Net service production and delivery work that is already ongoing or planned in the GN5-2 project, and results directly from the work described in this deliverable.

6.1 Collective-by-Design Service Production and Delivery

In the context of collective-by-design building and delivery of European 'as-a-Service' R&E cloud services, the Above-the-Net work package in the planned GN5-2 project will develop investment proposals for three service concepts that are assumed to make most sense if they are collective-by-design.

A collective software stack for a Virtual Research Environment PaaS research cloud targeting researchers in the long tail of science with the ability to expose any infrastructure-cloud (commercial, NREN, institutional) for researchers in a coherent way. This includes integration with NREN Trust & Identity infrastructure (authentication, group management) and with relevant research data services, anchored in the R&E trust ecosystem and with federating capabilities.

This is a service developed and delivered at several R&E organisations and, thanks to the EOSC Federation buildup phase, is receiving attention from the wider community. Rather than ending up with a hundred suboptimal implementations, it seems prudent to strive for one well-maintained and well-resourced collective one. This work focuses on the orchestration side of making infrastructure-cloud available. It targets the research community, as it is one of the most promising communities to serve with infrastructure-cloud in the long run. The current hypothesis is that the existing software stack of one of the GÉANT members can be collectivised, thus leveraging an existing 5-year investment and making it collectively available.

A data movement infrastructure aims to make large transfers of significant size (i.e., sub-CERN, 0.5TB–1PB) trivial for any researcher by integrating available tooling and protocols into a coherent, widely deployed, easy-to-use and secure infrastructure that goes where the network goes. It simplifies many of the challenges around point-to-point data transfers, allowing users to move on from bits and files to managing datasets. This infrastructural approach will enable all researchers to fully leverage the available network capabilities, which is currently only possible with specialised support as the available tooling is simply not user-friendly enough, not widely deployed, and scales poorly. Scaling this capability to the entire European research community is essential as all research becomes reliant on digital infrastructures and the amounts of data being dealt with increase.

A pan-European, sovereign object storage for research data aims to achieve a pan-European infrastructure for research data storage. Baseline requirements include a collectively procured, built and managed technology platform that offers simple object storage interfaces, deployed in a distributed way that satisfies digital sovereignty requirements. This targets research data repositories with the promise of providing better and cheaper low-level storage than institutions or national service providers can achieve individually by leveraging

European-size R&E economies of scale. A key challenge will be to manage the organisational and technical complexity involved of building a collective, European infrastructure while addressing national digital sovereignty concerns. The approach exploits a key weakness of the commercial infrastructure-cloud providers: 24/7 workloads tend to be too expensive. It is difficult for the GÉANT Association to compete with commercial providers on their rich portfolio of compute-related services and high rate of innovation supported by annual investment measured in billions of euros, but storage services have a different dynamic. In addition, storage is not an ephemeral service like compute; it is the place where the most valuable assets of an organisation are stored, and it is considered a practical problem by practitioners in the field: providing cost-effective, high-quality storage over time is a difficult proposition. Last but not least, the majority of the required sustainable funding is likely already in the ecosystem – research data is accruing and European and national policies increasingly push it towards research data repositories, of which there can be expected to be a manageable number in the GÉANT member countries. The emerging of a European single market for research data and services is a key enabler for this approach as it allows the GÉANT Association to address the market in an aggregated pan-European way.

These three service concepts are envisaged to be valuable additions to GÉANT's infrastructure portfolio, uniting existing standalone NREN activity into a singular, collective effort. Collectively, these service concepts also cover functionality that many NRENs are expecting to need to provide in the emerging EOSC Federation. Rather than immediately starting to build and thus risk becoming stuck at a scale smaller than required to reap the benefits of economy of scale, a choice was made to first produce a good investment proposal highlighting the consequences of seriously engaging in producing these services as a collective-by-design effort.

6.2 Improved Enablement of National Service Delivery Efforts and Federation

FileSender and eduMEET are two pieces of collectively developed open-source software. FileSender is a self-financed effort by the GÉANT membership and currently not part of the collective GÉANT Above-the-Net roadmap. eduMEET originated in the GÉANT project and is explicitly mentioned in that roadmap.

While the development of the software is a collective endeavour, the deployments are done by each GÉANT member in an autonomous fashion. The eduMEET and FileSender services would benefit from a more collective deployment approach, but retrofitting a collective-by-design deployment strategy will be complicated and costly. FileSender is deployed in most European countries and has been ongoing for 15 years. Hence, they make good candidates to develop a framework for a federated approach, putting them on a path towards collectivisation over time. The discussions to scope such a framework have begun in Q4 2024.

It would be beneficial to make the collective efforts explicitly visible on the Above-the-Net roadmap of activities. If it is not visible there, the GÉANT Association risks key stakeholders failing to recognise the existence of the effort, potentially leading to undesirable fragmentation, i.e., project calls to address an issue that has already been addressed. There are other collective software development efforts in other thematic areas that might benefit from a similar approach, but these are not addressed here.

7 Current Strategy for Commercial Infrastructure-Cloud

The collective procurement of infrastructure-cloud is a resounding success, with the third iteration of the framework (OCRE 2024) having just been finalised by the WP4 team of the GN5-1 project, covering the period 2025-29. Almost a thousand European R&E institutions in 28 countries are using the agreements as of the end of 2024 and the revenue flowing through the agreements has increased by 50% year-on-year since the first agreements were established, hitting the €100 million mark in 2023. Since 2016, a supplier- and NREN-facing delivery chain has been built with virtual teams consisting of employees from key stakeholder NRENs and the GÉANT organisation, ensuring a healthy dynamic where European and national perspectives are balanced on a daily basis. The procurement exercise itself has become steadily better organised and more automated, and the underlying documentation (procurement text, contracts) has improved in each iteration. At this point, the joint procurement has become a repeatable and much more predictable exercise that the GÉANT Association knows how to execute.

As the following subsections explore, the five-year validity of the OCRE 2024 agreements gives time to address several areas for improvement and the opportunities to be considered in order to further mature the joint procurement capability, increase the year-on-year practical value the R&E community gets from the joint procurement, and keep it relevant over time.

Ensure the agreements are used as widely as appropriate

The primary rationale for demand aggregation is exactly that: aggregate demand to achieve sufficient scale to get a better deal. While 1,000 institutions in 28 countries is a good result, it did take 8 years to get to that point. Stimulating the uptake of commercial cloud services by R&E institutions is not a goal per se, but when an R&E institution wants to use commercial cloud services this should preferably go through the collective European R&E agreements, to make the demand aggregation as large as possible. In several countries there are competing national agreements, sometimes for the R&E sector but increasingly for the entire public sector.

The logic for framework agreements is straightforward – more usage means a better position to get the best deal for R&E institutions. Effort should be made to ensure relevant national actors recognise that a sectoral pan-European approach for R&E leads to a better result for the R&E sector. Continuous effort should be made to ensure that in those countries where the OCRE 2024 agreements are the vehicle for commercial cloud usage, all service usage is contracted through that vehicle.

Increase the value of concessions

The profit margin for suppliers on the OCRE 2024 agreements is low, but as long as major platforms write their profit margin in double-digit numbers, there appears to be room for improvement. However, increased concessions from the supplier-side will require increased up-front commitment from the GÉANT Association.

Maturing the governance of the demand aggregation organisation

As the use of the agreements increases (measured both in the number of institutions using them and the monetary value flowing through them), their relative importance increases as well, both for NRENs and institutions. This requires the governance of the service to steadily mature as well – as a service becomes more critical, those organisations not intimately involved in managing the service will have the expectation of being involved in strategic direction and decision making, and vice-versa there will be an expectation for GÉANT members to engage strategically in the collective effort.

The establishment of the Cloud Strategy Forum in GN5-1 was a positive step. One of its goals was to provide a systematic channel for the procurement team to consult with officially appointed NREN representatives on key strategic decisions.

The future service governance should have a decision-making mandate. This will contribute to an increased ability to financially commit the GÉANT Association to certain levels of spending on the agreements, which would in turn increase the collective bargaining position. More mature governance can also be leveraged to contribute to the strategic relationship dialogue with major platforms and suppliers, ensuring the collective procurement activity can truly be considered to represent all of European R&E. A practical step would be to send a delegation of NREN representatives to talk with major platforms and suppliers from time to time.

Preparing for organising the next procurement

So far, there has been little time between the different procurement iterations. The three-year validity period of the agreements ensured work on the next procurement effectively had to start the moment the current one was deployed. Also, a small core of key people has been involved from the start and could transfer key knowledge to new core participants. For the fourth iteration, the situation will be different. The OCRE 2024 agreements have a validity of five years, so preparing the next procurement needs to start in earnest in three years' time. It is likely a different core team will be required to conduct the fourth procurement and this needs to be planned for, especially considering the significant degree of process automation that's required to conduct the procurement.

Prepare the service for the next phase in its lifecycle

The joint procurement activity is now entering the third state in its service lifecycle; after the startup phase of going from nothing to something, the second phase was one of scaling up and scaling out. The service has now become a critical part of the GÉANT Association's collective service portfolio with increasing demands for professional service delivery. As such, it enters a phase of consolidation. The virtual team supporting the joint procurement and its results consists of employees from both NRENs and the GÉANT organisation and is financed by the GÉANT Project iterations.

As the activity becomes more operational in nature, it becomes prudent to prepare the service for a potential life outside the GÉANT Project context. The non-monetary value NRENs strive for on behalf of the public R&E sector should continue to be articulated in the business model: contributing to digital sovereignty, promoting European values in service delivery, and practical collective risk-mitigation strategies to mitigate unilateral changes imposed by powerful suppliers[12], as we deal with increasingly powerful platforms.

Establish a position in the European Open Science Cloud community and increase usage in research

EOSC will become the integrated European market for (public-sector) research data and services. The GÉANT Association has contributed significantly to the exploration of providing access to commercial services in an EOSC context. The second joint procurement was conducted through the OCRE project, part of the EOSC effort, which made the GÉANT Association's joint procurement activity directly visible to the European research (infrastructure) community. The OCRE project had adoption funding available which was used by dozens of research projects to clearly demonstrate the tangible positive impact that commercial infrastructure-cloud can have on research results. Or in other words: the OCRE adoption funding made the demand for commercial infrastructure-cloud by researchers very visible and impossible to ignore.

In the EOSC Future project, further work was conducted around the notion of how to create and maintain a portfolio of agreements with research-relevant commercial services, and how to get the services made available through those agreements most effectively to the end-user needing them. The EOSC Future work concluded that the **GÉANT Association is effectively the only organisation at this time that can facilitate joint procurement of commercial services for the entire European R&E community**. After the EOSC Future project ended, the engagement of the GÉANT Association with the EOSC community on this topic also ended. The current delivery chain reaches the central-IT and procurement functions within the R&E institutions, but the research community is still insufficiently aware the OCRE 2024 agreements exist. It would be advantageous to

[12] A recent example is the 2024 challenge with the commercial supplier of the GÉANT TCS Service.

develop the EOSC community as a marketing & communication channel for the agreements, such as by leveraging EOSC Association and its 200+ members. This could be as simple as a series of webinars to inform that community.

Work should also be undertaken to ensure that the GÉANT Association is recognised by the EOSC tri-partite Governance (European Commission, EOSC Association, EOSC Steering Board representing the Member States) as *the* entity capable of organising access to commercial services in an EOSC context. This in turn ensures that this access *is* organised; increases the scale of the demand aggregation effort; and ensures that the joint procurement effort is not needlessly fragmented.

Lastly, work should be undertaken to find a good and scalable way to assess demand for other potential candidates for joint procurement, especially in the research community. The experience of the EOSC Future project shows that this is very much non-trivial, but if the GÉANT Association's demand aggregation engine further matures, it should be possible. This would further increase the relevance of the joint procurement work and would allow the R&E community to better support European industry policy by having far better control over the directing of its aggregated cloud services demand.

8 Conclusions and Recommendations

Planning the GN5-1 project work for recommendations for a collective GÉANT Above-the-Net strategy began after the GÉANT CTO workshop in Q4 2021. Feedback from the first Above-the-Net CTO workshop clearly indicated support for collaborative work on building infrastructure-cloud and other services, with great interest shown by at least half of the GÉANT member NRENs. The initiative complemented the (at the time, already successful) activity for joint procurement of infrastructure-cloud. At that time no clear direction of the aims of such a collaboration on 'building' could be identified. In addition, there was a low level of mutual understanding between the 'buy' and the 'build' proponents in the community.[13] The work on a collective strategy for Above-the-Net services, in particular for infrastructure-cloud, was intended to address this and lead to both a better understanding of a fruitful collective directionality and to a more productive debate. As such, our analysis of prospective collective strategies on Above-the-Net services aims to guide the next GÉANT project and serve as the starting point for the GÉANT Association to embark on the decision-making process for such a strategy.

While conducting the strategy work, a lot has happened in the context of the GÉANT Association. Some trends have been clearly visible, in particular the trajectory of Big Tech. While geopolitical developments had already put more emphasis on digital sovereignty (such as the first US Trump administration 2016–20 and developments around China), the start of the war in the Ukraine in Q1 2022 really drove the message home: geopolitics matters; outsourcing comes with risks that we may not always wish to carry; and modern society requires quite a lot of complicated digital infrastructure to function. Fast-forward to 2024 and digital sovereignty and data autonomy have become key issues for national and European policy makers, further cemented by recent geopolitical developments around Russia, the USA and China. It has also become clear that digital sovereignty has several meanings and there is by no means an easily agreed-upon answer to its challenges. The European Commission has made it clear that R&E is at the heart of our European future, and our infrastructures have a crucial role to play. Those infrastructures will by necessity involve a combination of building and buying. We want our community to fully leverage the advantages and pace of innovation of the commercial services, but at the same time we need to keep a keen eye on mitigating the risks of vendor lock-in. We need a long-term view on digital sovereignty and the R&E sector's contribution to EU policies for developing strong European players.

At the start of GN5-1 it was recognised that achieving a fully agreed collective Above-the-Net strategy by the end of the project would be unlikely. The subject matter is complicated, and our landscape analysis has shown that the ability to "build" or "buy" while pursuing digital sovereignty varies from NREN to NREN.

This document presents the analysis of the main challenges facing the GÉANT Association in the thematic area of Above-the-Net services, the description of the strategic assets we can leverage, and a sketching-out of five different approaches to address the challenges. The following graph indicates the estimated costs and benefits of each of the approaches:

[13] The CONNECT interview with Claudio Pisa from GARR provides a good background of the buy vs. build discussion in our community [CONNECT_GARR].

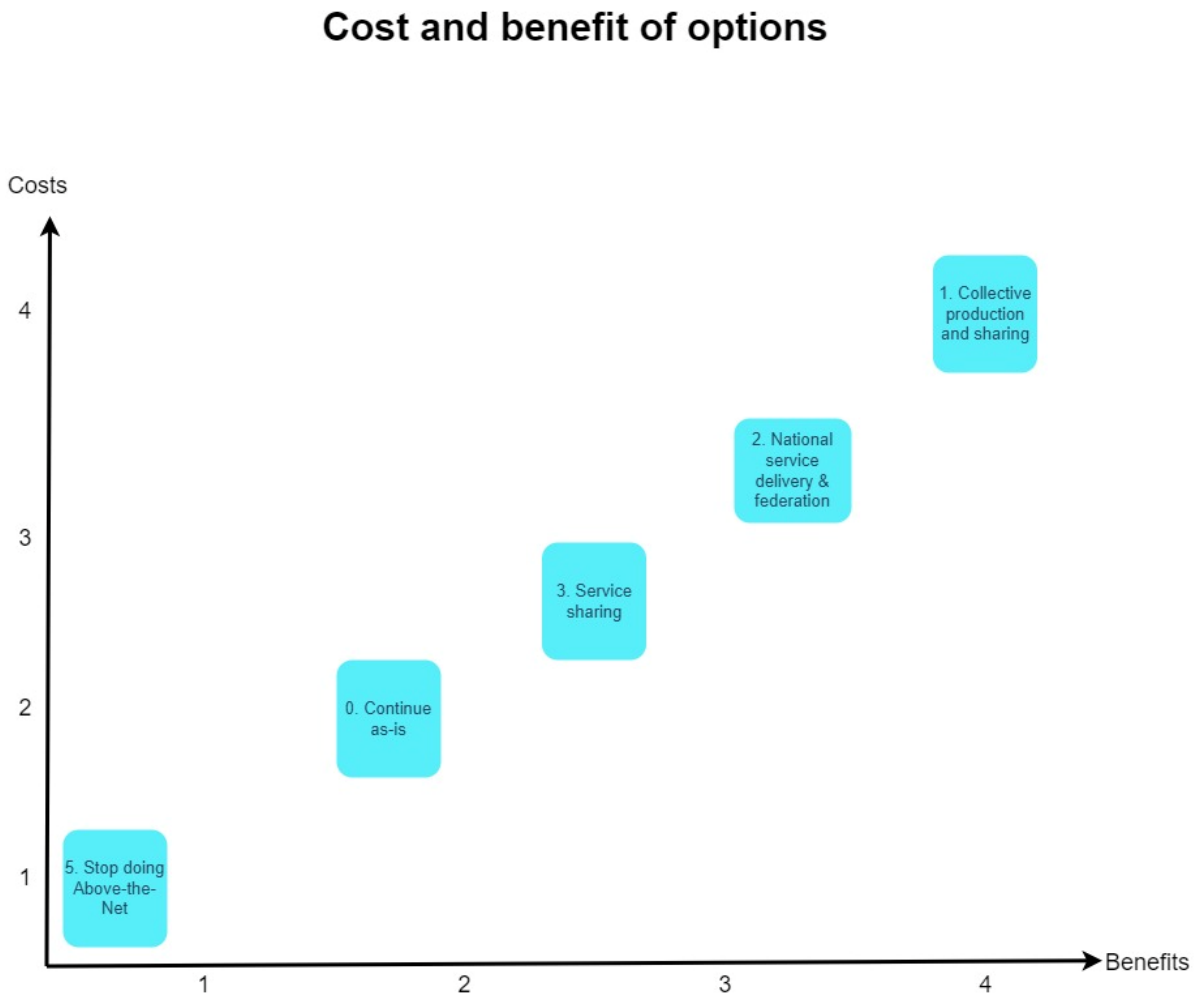

Figure 8.1: A cost-benefit estimate of the different approaches discussed in this deliverable

Of the five possible options outlined here, three have significant drawbacks associated with them. Continuing as-is solves none of the outlined challenges, while dropping Above-the-Net as a thematic area forces those GÉANT members that want and need to work together on this topic to conduct such a collaboration outside the GÉANT Association. That leads to fragmentation and is not considered a useful way forward. Pursuing a service-sharing framework might partly address the challenge, but so far, the appetite to take this direction has never been sufficient to trigger a 'coalition of the willing and able' to start implementing this. The fact that the topic will be part of the EOSC Federation starting in 2025 might change the current assessment of this path, but at the moment it is not the one to put our collective effort towards.

The collective procurement activity delivering the OCRE Frameworks has proven highly successful and valuable, and collective demand aggregation also opens the way toward adjusting the procurement criteria from one procurement to the next. This also permits the steering of community demand toward market solutions that fulfil future requirements around sovereignty and data autonomy.

The two most promising approaches for complementary collective Above-the-Net action, given the current state of our community and the maturity of the GÉANT Association's collaboration fabric are firstly to increase support for, and the federating of, national deployments of commonly deployed services. Second is figuring out how to collectively produce and deliver Above-the-Net services as a single European "*Something*-as-a-Service". For the latter, a follow-up activity has been set in motion: the GN5-2 project will produce investment proposals for three service concepts that will thoroughly explore how to collectively produce a single service. The former activity

could be supported by the GÉANT Community Programme, complemented with targeted, externally funded effort for specific work items.

Recommendations for the GÉANT Association

1. Continue with and expand the current approach to make commercial services available, compliant, and on advantageous terms to all European R&E institutions.
2. Discuss and explicitly decide on a collective path forward to approach collaboration on Above-the-Net service delivery. The recommendation is to focus on two particular approaches:
   a. Develop the capability for increased support for, and the federating of, national deployments of commonly deployed services.
   b. Develop the capability to collectively produce and deliver Above-the-Net services as a single European '*Something*-as-a-Service.'
3. Implement a 'collective-by-design' culture change for approaching Above-the-Net services.
4. Focus on service provisioning for research as the niche that is least likely to be commoditised by the commercial sector.
5. Focus on those public values pertaining to service delivery that the commercial sector will not or cannot address, e.g., digital sovereignty, long-term portfolio stability, and cost-effectiveness for 24/7 workloads.
6. Actively further develop the collaborative delivery of joint procurement of infrastructure-cloud to ensure long-term sustainability and increased value over time.

Relevant recommended actions:

- Agree on a portfolio of particular (opportunities for) Above-the-Net services that are of sufficient collective interest to warrant collective effort.
- Establish top-level support in the GÉANT Association for this collective-by-design approach.
- Move service design from national-first to collective-first and collective-by-design, supported by robust cross-organisational teams.
- Make the collective Above-the-Net roadmap an explicit and clear part of directing collective effort and establish transparent governance and update processes.
- Develop and test the capability to collectively build, operate and deliver European-scale Above-the-Net services through the planned service concept development in GN5-2 for a large-scale European object storage service for research data repositories, data movement infrastructure and a common Virtual Research Environment software stack. The result of this work should be the development of viable governance, technical and business approaches.
- Agree on tangible collective work to improve national service delivery and the sustainability of the portfolio of particular Above-the-Net services. This could span from building methodology for governance and maintenance to exit plans. On a practical level it could include deployment templates, joint action towards open-source software, security compliance, data privacy policies, data-processing agreement templates, etc.
- Develop a simple per-service federation framework to knit autonomous national deployments of commonly deployed Above-the-Net services together in a NREN federation for that particular service. This should be done to present the combined deployments as a collective European service with standardised presentation and policy where appropriate, potentially complemented with technical federation where this is useful. This could be operationalised by starting with the creation of simple service federations for the current FileSender and eduMEET deployed R&E footprints.

There is a great deal of Above-the-Net activity underway at both the national and European levels. The GÉANT Association, supported by the GÉANT project, is in a good position to improve Above-the-Net service delivery to the R&E community, if it further matures its capability to work collectively, because with Above-the-Net service delivery, scale matters. The digital transformation of R&E is a challenge better navigated together to maximise effort aggregation and mitigate the European digital divide by lowering the barrier for the benefit of all GÉANT members.

Appendix A Results of NREN Interviews

Five GÉANT members were interviewed in the first half of 2024 to get more information about the drivers and decisions behind their current infrastructure-cloud efforts and portfolios: GARR, ASNET, CSC, DeiC, and Switch. These specific NRENs were selected based on their knowledge and experience of the subject.

A.1 NREN Assets and Capabilities

From the interviews held with the aforementioned European NRENs, information was obtained on how they created their cloud infrastructures, starting with the objectives and requirements generated by their national stakeholders, along with which technologies and technological stacks they adopted for the creation and implementation of their cloud infrastructures. In some cases, the reasons why it was decided to adopt a technology and/or methodology for the implementation of the cloud infrastructures were also given.

NRENs provide their communities with different types of services based on their stated needs. In cases where it is not possible to offer every requested type of services to their research communities from within their self-built portfolio, NRENs may choose to procure certain services, which they themselves do not provide, via commercial clouds and also through the OCRE Framework agreement.

The R&E community is particularly mindful of data sovereignty, which continues to lead to the development of their own infrastructures. In fact, some NRENs require that data processing and saving take place on the national territory or on infrastructures under their control, also preferring the use of open-source tools for greater control and more direct maintenance of the code. Other NRENs also exploit commercial clouds, increasing their level of security by making use of the sophisticated security mechanisms available on leading platforms, such as encryption and user access control to effectively limit access to data and maintain a high level of sovereignty.

A.1.1 Building Blocks

Getting into the technical details, many of the NRENs' cloud infrastructures are based on open-source technologies and platforms to provide services such as IaaS, Object Storage and services based on container platforms. Often the choice for opensource technologies is made for greater control of the platform itself and to simplify code maintenance.

Many of the NRENs interviewed have their own cloud infrastructure distributed over several data centres on their territory. Attention is paid to the importance of maintaining sensitive data within the boundaries of the national territory and storing data in suitable infrastructures over which there is direct control. The following subsections break down the building blocks of cloud infrastructure as they apply to NRENs.

Open source

The adoption of open-source technologies has benefits for NRENs and their community. The open-source model allows for greater control and simplified management and maintenance of software that proprietary tools often do not provide.

One of the main features of open source is the potential for code accessibility, allowing open-source tools to be flexible and easily adaptable to the specific needs of NRENs. As long as this potential is actually acted upon, open

source improves safety and reliability through the contributions of the open-source community, which regularly acts to resolve vulnerabilities as they emerge.

In the research context, an additional potential benefit of adopting open-source tools is the resulting collaboration among the various NRENs and their communities, promoting the diffusion of knowledge and exchange of innovative solutions to common problems.

Platform commonality and interoperability

Infrastructure on the hardware level needs a software 'platform' for the provision of virtualization for IaaS and Object Storage services, along with support for the provision of services at a higher technology stack such as PaaS or SaaS services. The use of a platform increases the flexibility of the cloud infrastructure for sharing resources and facilitating the delivery of cloud services to individual users in dedicated and securely separated units. In cases where separate cloud infrastructures use the same or interoperable platforms, a higher level of integration and mutual interaction becomes possible. This can enable mutual backups, load balancing, data interoperability, or other forms of beneficial partnering. Also, an established base of competency on common solutions allows community mutual support beyond the technical layer.

Containerising eases deployment and adoption

Containerisation goes a step beyond virtual machines, taking the separation of infrastructure resources into discrete chunks to an even more granular level, and firmly integrating the principles of automation and remote orchestration into the management of virtualized infrastructure. Implementing automated infrastructure configuration using the principle of 'Infrastructure-as-Code', containerisation technology offers advantages such as code portability, isolation of the environment in which it operates, and ease of scaling as needed. This use of open standards and interfaces improves the service management interoperability and flexibility of using and deploying applications. Many research infrastructures and researchers use containerised workloads.

Adhering to security standards

NRENs pay a lot of attention to the security of their services and the data that is stored on their infrastructure. During the process of infrastructure and services development, the issue of security is always taken into consideration. In some cases, there are national requirements that narrow the scope of service delivery, for example, restricting data processing and data storage to a defined national area or environment that is classified as safe. The research community also requires a high level of security, especially in the medical field where large amounts of sensitive data is processed.

All parties need to adhere to safety standards to attain relevant certifications for providing certain services but also to strengthen internal processes that constantly guarantee the safety of the services offered. Examples of this adherence are running security tests and internal security audits.

Many NRENs adhere to the ISO 27001 standard in their data centres, and in some cases, the research community requests ISO 27001 compliance from the NRENs storing their data. In addition, there are also European directives to which NRENs must adhere, such as NIS2 on network security and resilience and GDPR for the protection of their users' personal data.

Some example solutions in use

OpenStack is an established suite of open-source server software that allows the platform management and virtualization of large amount of computing, storage and network resources for service provision and offers external communication through the use of APIs and a web interface. In the European context, OpenStack has been adopted by NRENs including GARR, ASNET and CSC, improving the management of their cloud infrastructure to simplify the provision of cloud services to their research community. It also facilitates collaboration among research institutions and/or universities, allowing them to share resources and data in a

flexible and scalable way. Since it is an open-source technology it allows a more open exchange among its users. NRENs such as GARR and ASNET have collaborated and held roundtables that saw OpenStack as the focus for sharing methodologies and solutions to address common needs and issues.

Kubernetes is a common tool used by European NRENs for containerization, either internally or to provide services to their communities. Research users also prefer in many cases a platform such as Kubernetes to avoid having to manage the underlying infrastructure layer of cloud resources, such as the virtualization layer.

A.1.1.1 Interviewed NRENs – Details

GARR

GARR, for its cloud, use two different technologies: OpenStack and VMware. OpenStack is used to provide IaaS and Object Storage services to the Italian research community, while VMware is used to manage and provide SaaS services, both internally and for the GARR community. In addition, Kubernetes clusters are deployed on OpenStack and VMware infrastructures to allow service provision.

The OpenStack storage infrastructure was created and is managed via the Ceph distributed storage system.

GARR's OpenStack platform comprises the following:

- 5 data centres: 2 medium sites (4 racks) and 3 small sites (1 rack); one of the small sites is used as a test environment
- Cores: 11,500
- RAM: 90TB
- Storage: 16.3PB

ASNET

In the last three years, ASNET has been dedicated, in collaboration with various European partners, to the development of IaaS cloud services on OpenStack infrastructure for its research community. ASNET uses a hybrid approach for its services by exploiting the OCRE Framework agreement for the use of commercial cloud services. Currently, ASNET does not provide a hybrid cloud; their users choose between either community cloud or commercial cloud solutions. A goal of ASNET is to integrate both solutions into a true hybrid cloud.

ASNET's central infrastructure is composed of 800 cores, allowing the creation of VMs with up to 64 cores. At the moment, ASNET is creating an HPC cloud for its community with 25,000 cores.

CSC

CSC, the Finnish NREN, has a system called Pouta which consists of the OpenStack IaaS service. There is also the *ePouta* system, a secure environment for VMs (PaaS).

For the containerization part they have Rathi, CSC's container orchestration system that runs on OKD, the community distribution of Kubernetes that powers Red Hat OpenShift. This container orchestration infrastructure is based on Kubernetes. For the storage part, they use the Ceph distributed storage system for both the filesystem and the Object Storage service.

In the future, CSC wants to move towards container-only services, as they are more manageable and lightweight. CSC has also noticed that its users prefer to be able to use a specific service directly instead of having to manage the IaaS part as well.

CSC's OpenStack cloud infrastructure has 15,000 cores and 18PB of storage.

DeiC

One of the goals of DeiC was to have full control of the technology platform for their research data repository. DeiC gives a lot of importance to sensitive data; in fact, one of the key requirements for its research data repository was to have architectures suitable for the handling and storage of such data. Another key requirement was that any solution to be adopted supports the FAIR principles [FAIR] and, in the future, can support a CoreTrustSeal certification. This led to the choice of Dataverse, an open-source solution. Commercial solutions for the repository were not considered and the costs for scalability and maintenance are not yet known.

Switch

Switch has a cloud infrastructure based on OpenStack called SWITCHengine.

This infrastructure is provided by an external partner (Phoenix) that is responsible for maintaining and managing the entire technology stack up to the OpenStack level. This choice was made by Switch to allow more focus on creating and providing services above the OpenStack layer for their universities. The services provided are deployed on a Kubernetes platform above the OpenStack layer.

Switch's OpenStack platform is deployed in three data centres (with multiple power supplies and cooling systems). There is a redundant system that allow staff to work on the platform's configuration without taking it offline. The platform allows them to improve security, develop it for sensitive data management, and be ISO27001 compliant. To ensure the service provisioning remains under the governance of the Switch foundation, Switch acquired a 49% ownership in its Swiss partner, Phoenix.

A.1.2 Findings from Interviews

One of the main scopes of NRENs in the cloud domain is to provide cloud services to support the research community. NRENs focus on supporting their national communities by providing services that are as suitable as possible for their objectives. Many of the NRENs interviewed interact with their communities to ensure that the services they provide are tailored to their users' needs. The cloud services provided are IaaS, in most cases using OpenStack; PaaS, such as Kubernetes and Dataverse; and SaaS offerings.

In the provision of these services, great care is taken to ensure the security and sovereignty of the data by also ensuring that data is kept within the NRENs' national territories or, as in the case of Switch, in cloud regions over which the NREN has control. This is an important factor on which NRENs focus their efforts, and in some cases, it is an specific requirement from research communities. It is an aspect that is essential especially when sensitive data is processed and stored.

In such cases, for NRENs, the use of commercial clouds is not always suitable since the commercial partner could change their strategic objectives or no longer be able or willing to fulfil their contractual obligations on digital or data security.

Interviews revealed that NRENs do not avoid the use of commercial clouds. In some cases, attempts are made to arrive at a hybrid approach, gaining access to commercial cloud services that NRENs are unable to provide.

The following table specifies the cloud technologies used by each of the NRENs interviewed:

NREN	OpenStack	Kubernetes	Open Cloud / Nextcloud	Dataverse	OCRE
Switch	X	X			
DeiC			X	X	X
GARR	X	X	X		
ASNET	X	X			X
CSC	X	X			X

Table A.1: A breakdown of the cloud technologies used by the NRENs interviewed for this deliverable

Some NREN example implementations

As can be seen in the preceding table, in many cases the platforms in use by NRENs are often based on open-source technologies such as OpenStack and Kubernetes.

In some cases, OpenStack is used to provide IaaS and Object Storage services, as with GARR, while in other cases it is used as a basic layer for providing services or platforms to a higher technology stack such as Kubernetes. Kubernetes itself is used as a containerization platform to allow better management and greater flexibility of the services provided to the research community.

There are also NRENs services based on Nextcloud (e.g., GARR's ownCloud) that provide a collaboration and file synchronization platform, and in the case of DeiC, Dataverse is provided to its community as an open-source sharing and archiving service for research data.

Some NRENs use, or have used, the OCRE Framework agreement to provide their research communities with other services that they themselves do not offer and that their community benefits from through OCRE.

Stakeholders set the boundary conditions

The NRENS interviewed were all centrally placed in their respective national governance models for R&E. The NRENS were generally seen by the whole R&E community as the central place to find and apply relevant domain expertise on IT in R&E. This is especially the case in emerging technologies such as cloud-based infrastructure and services, artificial intelligence, and quantum computing.

The NRENS to various degrees supplied cloud-based services to all their connected institutions. Some NRENS controlled all aspects of the infrastructure from the data centre over the software stack to the governance mode. Other NRENS had fewer significant community cloud offerings and primarily chose to facilitate the purchase of commercial cloud products.

The following are a few major demand-side drivers for NREN cloud choices encountered in interviews:

- **Geopolitics**: The NREN may reside in a geopolitically turbulent area that makes it attractive to place infrastructure in cloud infrastructure that resides outside of its territory. Since the ability to perform large-scale cross-border transactions between NRENS is challenging, the choice of commercial cloud solutions may appear to reduce this challenge.

- **Sovereignty**: The opposite reasoning may apply when sufficient skills and scale are deemed to be present. For instance, we have witnessed statements such as “Swiss research data should reside on Swiss soil” or a softer approach with the same outcome: “Finnish cloud services should be run from data centres that comply with bespoke Finnish standards.”
- **Societal scope**: Some NRENS have a leading role outside the R&E sector. For instance, some NRENS supply the same or similar services to the national health sector and/or to elementary schools. This gives these NRENS a much more important national, societal role and puts heavier demands on the reliability of the service and the degree of control over the service and data that the NREN must maintain.

Working in the scope of the possible

This motley collection of cloud offerings across the NREN landscape came about due to a wide range of reasons.

The following are a couple of major supply-side drivers that emerged in the interviews:

- **Existing skill sets**: NRENs may for various reasons have access to competencies on a particular infrastructure cloud platform such as OpenStack and wish to capitalise on this by offering services based on this platform.
- **Access to qualified staff**: NRENs may for various reasons have very limited access to staff qualified to build and maintain community cloud services and may therefore opt for a less burdensome solution in the form of facilitating access to commercial clouds.

Organisational disconnect and non-functional distribution of responsibilities

The main organisational disconnect in R&E institutions uncovered during the interviews was that of central IT vs. research support. The NRENs are an important provider of network and cloud services to research institutions. In many cases, researchers do not have direct contact with the IT team, but in general services are still contracted through central IT. This can cause a lack of understanding and addressing specific needs for a given research group or project. One of the issues researchers face is service management. Often this task is left to a specific and centralised IT team.

NRENs must also satisfy heterogeneous needs, which leads to the implementation of more generic and standard solutions. Some NRENs have been in contact with universities or research institutions to better understand their needs and better respond to their requirements. The information obtained has increased NRENs’ awareness, allowing them to implement and update their infrastructures and services as required.

To increase the efficiency of the service provided, it would be useful to have constant interaction between the research groups and IT groups of NRENs and to obtain feedback from the users. It is important to use solutions that are easily extendable and flexible to new demands to satisfy different requirements that vary over time.

References

[AAA]	https://op.europa.eu/en/publication-detail/-/publication/2f9fc221-86bb-11ef-a67d-01aa75ed71a1/
[COMPENDIUM]	https://about.geant.org/nrens/nren-compendium/
[Congress_SocMedia]	https://www.congress.gov/event/117th-congress/house-event/111407
[CONNECT_GARR]	https://connect.geant.org/2023/03/20/interview-with-claudio-pisa-cloud-devops-at-garr-and-member-of-sig-ciss
[DFN_Cloud]	https://www.dfn.de/dienste/cloud/foerderierte-cloud-dienste/
[Draghi]	https://commission.europa.eu/topics/strengthening-european-competitiveness/eu-competitiveness-looking-ahead_en
[EC_DSA]	https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/digital-services-act_en
[Edge]	https://en.wikipedia.org/wiki/Edge_computing
[ERA]	https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/our-digital-future/european-research-area_en
[EU27_R&D]	https://assets.gov.ie/280956/024870f5-213b-4ce1-a5a8-7ca8d5e6ac57.pdf
[FAIR]	https://www.go-fair.org/fair-principles/
[FileSender_Map]	https://filesender.org/2024-nren-filesender-deployment-map-update/
[GÉANT_EOSC]	https://eosc.eu/wp-content/uploads/2023/09/Position-paper-GEANT-and-the-NRENs-have-a-long-history-in-scalable-federated-environments-that-can-support-the-creation-of-EOSC-Nodes_.pdf
[GEANT_STRAT]	https://resources.geant.org/wp-content/uploads/2022/02/GEANT_Association_Strategy_2021-2026.pdf
[Letta]	https://www.consilium.europa.eu/media/ny3j24sm/much-more-than-a-market-report-by-enrico-letta.pdf
[NORDUnet_Pres]	https://video.nordu.net/media/Wednesday+Plenaries/0_ytlktt4c/706759
[RDA]	https://www.rd-alliance.org/global-open-research-commons-model-adoption-and-next-steps/
[Rumelt]	https://archive.org/details/goodstrategybads00rume
[SIG_MSP]	https://wiki.geant.org/display/msp/SIG-MSP+homepage

Glossary

CEN	European Committee for Standardisation
EOSC	European Open Science Cloud
ERA	European Research Area
FAIR	Findable, Accessible, Interoperable, Reusable
GDPR	General Data Protection Regulation
IaaS	Infrastructure as a Service
NREN	National Research and Education Network
PaaS	Platform as a Service
R&E	Research and Education
REN	Research and Education Network
SaaS	Software as a Service
SIG	Special Interest Group
SIG-MSP	Special Interest Group – Managing Service Portfolios