



GN3plus Open Call: Description of Work (DoW)



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THE SEVENTH FRAMEWORK PROGRAMME

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1 Photonic Level Access to Long Haul Dark Fibre

1.1 Overview

The GÉANT dark fibre testbed is made up of dark fibre (DF) that has become available as a result of the recent GÉANT network migration. Five long haul DF routes are available from October 2013 and can be used until contracts expire at the end of Q2 2015. The DF routes are:

- London-Paris
- Frankfurt-Geneva
- Amsterdam-Frankfurt
- Amsterdam-Brussels
- Milan-Finkenstein-Vienna

This topic seeks proposals that exploit the dark fibre components of the GÉANT testbed. The aim of this topic is to enable proposers to conduct focused research into photonic layer subsystems or systems relating to novel photonic services.

Proposers are expected to make use of the features of the testbed dark fibre to conduct their experimentation/research rather than a lab environment. Proposers should demonstrate that their research results provide added value by using such a facility, i.e. over and above what could be accomplished by a lab environment alone.

Proposers should explain how the work will benefit the GÉANT research and education community.

1.2 Fibre Details and Access

All of the fibre on the majority (intercity) sections of these routes is of the type G.655 (E-LEAF) with local loops at the ends usually comprising sections of G.652 (SMF) up to 20 km in length. The dark fibre routes include amplifier huts typically spaced at 80 km intervals. These huts include Alcatel-Lucent in-line optical amplifiers from Alcatel-Lucent's 1626LM product family. The amplifiers have been optimised for transmission of 10 Gbps using Alcatel-Lucent transponders and include dispersion compensation fibre. Electrical power (48V DC only)

and existing hut space are also provided at no cost to the proposers. More technical details of these fibre routes can be found in Technical Annex A.

The demarcation points of the fibre routes listed above are in a GÉANT Point of Presence (PoP) in the relevant city. If proposers wish to extend given fibre routes to other locations (within the cities listed above or further afield) then this will need to be arranged by the proposers and they will need to meet all of the costs associated with implementing these extensions.

This topic invites proposals for novel uses of the dark fibre testbed. Proposals can broadly make use of two options:

Option 1: Access to the dark fibre only

In this case the proposer may request access to the dark fibre only. The proposer will use their own in-line optical amplifier equipment that they will be responsible for installing at each amplifier site.

This option will suit experiments that need to use their own optical amplification equipment. This may include experiments such as novel optical services for frequency distribution, or novel modulation techniques that need specialised optical amplifiers.

Option 2: Access to both dark fibre and existing Alcatel-Lucent in-line optical amplifiers

In this case the proposer may request access to both the dark fibre and the Alcatel-Lucent in-line optical amplifier equipment available at each of the amplifier sites.

This option will suit experiments that are capable of using the Alcatel-Lucent amplifiers, such as new modulation techniques that can co-exist with native 10 Gbps NRZ services.

In both of the options above there may be the possibility to adopt a multiple (rather than exclusive) access paradigm in which a number of proposers concurrently use a given dark fibre line through a spectrum-sharing arrangement. Proposers should state clearly whether their usage of the dark fibre requires exclusive access. It will not be possible to determine whether fibre-sharing arrangements are required or technically possible until the Open Call bids under this theme are evaluated and selected.

1.3 Objectives

- To demonstrate new and novel photonic services.
- To allow proposers to trial prototypes of innovative photonic technology that would benefit from field trials on fibre in the ground, but are not yet ready for commercial deployment.
- To support adoption of novel services and technologies in the GÉANT network.

1.4 Expected Impact

- To support proposers in their development of innovative photonic technologies.

- To increase GÉANT's understanding of photonic research.
- To speed up introduction of new technologies and services into the GÉANT network.

1.5 Outputs

1. A formal technology trial or demonstration of the photonic systems or services operating on the GÉANT dark fibre testbed.
2. A report outlining:
 - a. Research findings.
 - b. How the technology trial or demonstration has benefited from access to the GÉANT dark fibre testbed.
3. Where possible we expect the key findings of the research to be published in one or more peer-reviewed journals.

1.6 Budget

Up to 3 proposals may be funded. It is expected that each project will have a total budget of between €100K and €300K.

2 Software-Defined Networking

2.1 Overview

In GN3plus one of the facilities available to the GÉANT community will be Testbed as a Service (TaaS). The testbed incorporates many facilities; one of these is the GÉANT OpenFlow-enabled facility. For more detail on the GÉANT OpenFlow facility see Technical Annex B.

This topic seeks proposals that exploit the OpenFlow/Software-Defined Networking (SDN) capabilities of the GÉANT testbed. The aim of this topic is to enable proposers to conduct focused network/application research in areas related to OpenFlow and SDN.

Proposers are expected to make use of the capabilities of the testbed SDN-enabled environment to conduct their experimentation/research rather than an SDN-enabled lab environment. Proposers should demonstrate that their research results provide added value by using such a facility, i.e. over and above what could be accomplished by a lab environment alone.

Proposers should explain how the work will benefit the GÉANT research and education community.

Proposers should be prepared to interact with the GN3plus consortium members in optimising operations and the user interaction with the GÉANT OpenFlow-enabled facility.

2.2 Objectives

- To establish a real-world user base for the GÉANT OpenFlow-enabled facility.
- To demonstrate SDN/OpenFlow capabilities in supporting disruptive research over research and education networks.
- To obtain feedback, requirements and evaluations for the OpenFlow/SDN TaaS offerings of GN3plus with emphasis on usability and operations.

2.3 Expected Impact

- Extend the visibility of research and innovation results, with an emphasis on how specialised SDN-based offerings from research and education networks have contributed to their delivery.
- Strengthen cooperation between research groups and the GN3plus consortium.
- Optimise SDN-related TaaS service offerings in GN3plus project.

2.4 Outputs

1. A formal demonstration of the use case operating on the GÉANT OpenFlow facility.
2. A report outlining:
 - a. Research findings.
 - b. How the use case has benefited from access to the GÉANT OpenFlow facility.
 - c. Future features or improvements that could be implemented and how they should be prioritised.
3. Where possible we expect the key findings of the research to be published in one or more peer-reviewed journals.

2.5 Budget

Up to 4 proposals may be funded. It is expected that each project will have a total budget of between €100K and €200K.

3 Novel Uses of GÉANT Dynamic Circuits (Bandwidth on Demand)

3.1 Overview

The Bandwidth on Demand (BoD) service (also known as dynamic circuits) has been developed within the GÉANT project for the benefit of the European and global research and education community. The BoD service dynamically provides point-to-point Ethernet circuits with a capacity of up to tens of Gbps on user request. Circuits can be requested by web portal or by API. The GN3plus project builds on the work done in the GN3 project with a focus on service optimisation and global interoperability.

This topic invites proposals for novel uses of the BoD service. The aim of this topic is to enable proposers to conduct focused network/application research in areas related to usage of GÉANT's BoD service.

Proposers are expected to make use of the capabilities of the GÉANT dynamic circuit environment to conduct their experimentation/research rather than a lab environment. Proposers should demonstrate that their research results provide added value by using such a facility, i.e. over and above what could be accomplished by a lab environment alone.

Proposers should explain how the work will benefit the GÉANT research and education community.

Proposers should be prepared to interact with the GN3plus consortium members in optimising operations and usage of the GÉANT dynamic circuit service. For more information on the BoD service see Technical Annex C.

3.2 Objectives

- To demonstrate new and novel uses of the BoD service.
- To increase community usage of the BoD service.
- To obtaining feedback, requirements and evaluations for the BoD offerings of GN3plus from end users.

3.3 Expected Impact

- Increase awareness of the BoD service among the research community.
- Increase BoD utilisation within GÉANT and the NRENs.

3.4 Outputs

1. A formal demonstration of the use case operating on the GÉANT dynamic circuit facility.
2. A report outlining:
 - a. Research findings.
 - b. How the use case has benefited from access to the GÉANT dynamic circuit facility.
3. Where possible we expect the key findings of the research to be published in one or more peer-reviewed journals.

3.5 Budget

Up to 2 proposals may be funded. It is expected that each project will have a total budget of between €100K and €150K.

4 Terabit Transmission Trial

4.1 Overview

The GÉANT consortium would like to support an early field trial of 1 Tbps transmission over one or two of the long-haul DF testbed routes (see Topic 1 for details of these routes and Technical Annex A). This project is intended to enable proposers to field-trial early-development prototype equipment using next-generation (i.e. not currently deployed) technology.

Proposers are expected to make use of the capabilities of the GÉANT dark fibre environment to conduct their experimentation/research rather than a lab environment. Proposers should demonstrate that their research results provide added value by using such a facility, i.e. over and above what could be accomplished by a lab environment alone.

Proposers should explain how the work will benefit the GÉANT research and education community.

4.2 Objectives

- To allow proposers to trial prototypes of innovative transmission equipment that would benefit from field trials on fibre in the ground, but are not yet ready for commercial deployment.
- To build expertise within the GÉANT community on next-generation transmission technologies.

4.3 Expected Impact

- Support proposers in their development of state-of-the-art transmission equipment.
- Increase GÉANT's understanding of developments in transmission technology.
- Speed up introduction of new technologies and services into the GÉANT network.

4.4 Outputs

1. A formal technology trial or demonstration of the photonic systems or services operating on the GÉANT dark fibre testbed.
2. A report outlining:
 - a. Research findings.
 - b. How the technology trial or demonstration has benefited from access to the GÉANT dark fibre testbed.
3. Where possible we expect the key findings of the research to be published in one or more peer-reviewed journals.

4.5 Budget

Up to 2 proposals may be funded. It is expected that each project will have a total budget of between €100K and €300K.

5 Clean-Slate Design for Future Network Architecture

5.1 Overview

Currently, the drivers for moving towards Terabit per second transmission rates in networking largely continue to feature the solutions and techniques used in recent years. Industry and academia have enhanced or developed new network technologies within that framework in order to increase the utilisation of the working assets in combination with their wish to increasing the service offering. GÉANT is seeking an approach that will allow the networking sector to move beyond Terabit per second solutions. Therefore, the question to ask is whether higher bit rates alone are the solution to future growth or whether the network, interface to the network, data format and so on should be redesigned.

Clean-slate network architecture involves rethinking the fundamental assumptions and design decisions underlying current network architectures. Work on this topic is likely to include:

- Survey existing initiatives and liaise with industry and NRENs with regard to initiating Clean Slate Network Architecture research, in order to identify solutions among existing research initiatives.
- Hold a series of workshops in cooperation with JRA1 in order to achieve information exchange between academia and industry.
- Identify possible new clean-slate architecture solutions that can be used in networks within the framework of Horizon 2020. This work could be done in cooperation with public and private research organisations and the industry.
- Demonstrate findings and results via lab trials, preferably using the GÉANT and NREN test facilities.
- Produce a report providing an overview of clean-slate architecture solutions for the R&E networking community and private sector.

The research should consider the challenges presented by various aspects and layers of the network and focus on a clean-slate design that addresses issues in software-defined high-speed networks, optical network virtualisation, elastic network, cloud computing, high-speed switching, traffic engineering, quality of service and network management.

The research requires network modelling and simulation in order to verify the network architecture proposals using the proposed improved protocols and algorithms. The results and findings should be supported by lab trials, with optional demonstration cases.

5.2 Objectives

- To identify new clean-slate architecture solutions that can be used in single and multi-domain network architecture design within the framework of Horizon 2020.
- To provide feasible clean-slate architecture solutions for the R&E networking community.

5.3 Expected Impact

This work is expected to:

- Generate novel and widely accepted ideas for future network research and development.
- Establish a foundation for the future network architecture design of the NREN community, GÉANT and service providers.
- Strengthen research and cooperation between partners in GÉANT and industry.

5.4 Outputs

1. A set of results from the modelling analysis.
2. A report outlining:
 - a. Research findings which should provide insights into the problems faced by current network architecture trends and provide one or several clean-slate architecture design blueprints.
 - b. How the research and modelling results can benefit the R&E networking community.
3. Where possible we expect the key findings of the research to be published in one or more peer-reviewed journals.

5.5 Budget

One proposal may be funded. It is expected that the project will have a total budget of between €100K and €150K.

6 Flexible Optical Networks

6.1 Overview

This topic will consider the industry development and implementation of advanced modulation techniques, which are paired with coherent technologies. In addition, research will be conducted into more advanced modulations and detection techniques, dynamic grid size, bit error corrections and so on, in order to change the rigid optical systems into a flexible optical system controlled by software.

- The work will deliver a detailed optical network solution, which is able to scale resources up or down according to the capacity demand as well as to the physical properties of the optical layer.
- The flexible optical network should be able to tune the following parameters:
 - Bit rate.
 - Modulation format.
 - Spectrum allocation.
 - Forward Error Correction (FEC) codes.
- The future optical network must be able to support traffic at diverse granularities, e.g. fibre/core, waveband, wavelength and sub-wavelength switching. Therefore a solution with multi-dimensional switching nodes and transponders is required. These multi-dimensional switching nodes and transponders must benefit from programmable and flexible architecture and technologies to be able to support high-bandwidth flexibility and elasticity for mixed and very diverse traffic demands.
- The work should deliver a solution for a sliceable and programmable optical network able to create application-specific and isolated/independent optical network slices sharing the same physical infrastructure.
- The flexible optical network solution should address the following aspects:
 - a. Flexible, programmable and sliceable transponders and switching nodes.
 - Evaluation of technological limitations and proposed novel architectures for transponders and switching nodes that are able to tune on demand to support all aforementioned features including various switching and transport technologies.
 - b. Routing and Spectrum Assignment (RSA) algorithms.
 - Propose algorithms dedicated and optimised for the case of tuning the previously mentioned parameters.

- Evaluate in network simulators (e.g. OPNET modeller, ns-3, etc.) the efficiency and the benefits of the proposed algorithms.
- c. Control plane architecture to support of the flexible optical network including flexible, programmable and sliceable transponders and switching nodes.
 - Propose protocol extensions (GMPLS, OSPF-TE, RSVP-TE) required for enabling automation in the flexible optical network.
 - Evaluate the impact and the challenges presented by adding the protocol extensions based on implementation in network simulator environments (e.g. OPNET modeller).
 - Provide a review of the current standards (RFCs) and approaches (drafts) regarding control planes and frameworks in support of flexible optical networks from IETF or other standardisation groups.
 - Evaluate GMPLS as a control plane proposal for flexible optical networks in comparison with other standard choices (e.g. OpenFlow, NSI).
- d. Lab trial and hardware implementation.
 - Showcase and demonstrate the performance of flexible, programmable and sliceable transponders and switching nodes in a lab trial. This can also include demonstration of performance of control plane architecture. Features to be evaluated will include transmission performance, cascadability, throughput, granularity range and upgradability.
- e. Architecture simulation.
 - Implement the novel architecture in network simulators with the possibility of tuning the different parameters and allow an on-demand simulation of flexible optical network scenarios.
- f. Technology evaluation.
 - Evaluate the implementation of the novel flexible optical network solution on specific NRENS/GÉANT network architectures.
- g. Survivability.
 - As survivability represents a main concern among the network providers, dedicated survivability techniques have to be proposed and evaluated in support of the flexible optical network.

6.2 Objectives

- To investigate the novel concept of flexible optical systems.
- To experiment with the ability to optically transmit data with variable rates reaching Terabits per second, using the capabilities provided by flexible optical systems.

6.3 Expected Impact

The work is expected to:

- Enable R&E network providers to run their optical network with a higher load while minimising the investment capital.
- Provide a solution to cope with the increase in traffic demands as well as variation in the short-to-long-term traffic variations.

6.4 Outputs

1. A set of results from the lab and demonstration cases.
2. A report outlining:
 - a. A summary of the work undertaken and research results.
 - b. An explanation of how flexible optical network solutions can be applied in the R&E networking community.
3. Where possible we expect the key findings of the research to be published in one or more peer-reviewed journals.

6.5 Budget

One proposal may be funded. It is expected that the project will have a total budget of between €100K and €200K.

7 Multi-Domain Optical Modelling Tool

7.1 Overview

In the GÉANT network, both photonic services and alien wavelengths present the challenge of delivering the same predictability and security as regular transmission services. In order to assure this predictability and security, the development of a multi-domain optical modelling tool is now required.

Previous work carried out under the GN3 project should be used as the basis for creating a Multi-Domain Optical Modelling Tool prototype, which can be demonstrated using the GÉANT and multiple NREN networks. The work should:

- Survey and study relevant GN3 JRA1 T2 (Photonic Switching and Experimental Photonic Facilities) work related to modelling optical networks in the area of alien wavelength and photonic services.
- Investigate on a general level how predictability and security can be assured in a GÉANT and NREN network servicing both photonic services and alien wavelengths.
- Study appropriate optical modelling tools that will enable operators to better predict the performance of photonic services and alien wavelengths in the GÉANT and NREN network.
- Identify physical and non-physical bottlenecks (optical signal interference, equipment, architectures, policies, etc.) that are relevant to the GÉANT and NREN network servicing alien wavelengths.
- Establish, through surveys, the potential need and interest for alien wavelength services in the GÉANT and NREN network.
- Establish trial relationships with university partners and NRENS to validate the prototype of the modelling tool.
- Outline and blueprint a vendor/equipment-independent Multi-Domain Optical Modelling Tool capable of handling e.g.:
 - Automatically or semi-automatically picking up the changes to the production infrastructure.
 - Reconciling data with the data stored in the tool and making adaptive or semi-adaptive changes to the network model.
- Develop and deploy a prototype Multi-Domain Optical Modelling Tool using the GÉANT and multiple NRENS as a demonstration case.
 - Verify the modelled network against the physical infrastructure used in the demonstration case.
- Create a report outlining the results, findings and prototype blueprint for a Multi-Domain Optical Modelling Tool.

- This work will be done in collaboration with related funding initiative such as the one described in Topic 8.

7.2 Objectives

- To develop a prototype Multi-Domain Optical Modelling Tool and the knowledgebase needed to service both photonic services and alien wavelengths in the GÉANT and NREN network.

7.3 Expected Impact

The work is expected to:

- Enable the network providers to run alien wavelengths in their optical network at an operational level similar to running native wavelengths while minimising the investment capital.
- Provide a solution to cope with the increased work associated with planning, design and operation of alien wavelengths and photonic services.
- Enable cost saving in the running of alien wavelengths.

7.4 Outputs

1. Develop and deploy a prototype Multi-Domain Optical Modelling Tool using the GÉANT and multiple NRENS as a demonstration case.
2. A report outlining:
 - a. The findings and prototype blueprint for a Multi-Domain Optical Modelling Tool.
 - b. An explanation of how the findings can be applied in the R&E networking community.
3. Where possible we expect the key findings of the research to be published in one or more peer-reviewed journals.

7.5 Budget

One proposal may be funded. It is expected that the project will have a total budget of between €100K and €200K.

8 Alien Wavelength over GÉANT

8.1 Overview

Alien wavelengths have been studied, tested and demonstrated by several NRENs and industry during the GN3 project hosted by JRA1 T1 (Carrier Class Transport Network Technologies). However, it still remains to study, test and demonstrate alien wavelengths over long distances in the GÉANT network in order to confirm whether an alien wavelength service is a viable potential service for GÉANT to offer. This work will build on the results from the GN3 project with regard to technical considerations and possible Operation, Administration, Maintenance and Provisioning (OAM&P) solutions.

The work should:

- Investigate the need for alien wavelengths in terms of whether and how it can be replaced by other photonic services.
- Study the impact of alien wavelength services on the GÉANT Infinera production network. Using a test infrastructure is not seen as sufficient, because OAM&P aspects related to alien wavelengths in the GÉANT production environment must be studied as well.
- Develop recommendations that will enable alien wavelengths in the new GÉANT network.
- Set up test cases to conduct practical multi-domain alien wavelength tests, including the use of the GÉANT production network (under the supervision of the JRA1 Activity Leader and DANTE Operations), and investigate the possible interest among NRENs or institutions to be a part of a live alien wavelength setup. Test cases will have to demonstrate that existing services will not be disrupted.
- Set up business case examples investigating the profitability of servicing alien wavelengths in the GÉANT network.
- Establish collaboration relationships with university partners or NRENs, and conduct tests and demonstration cases of alien wavelengths traversing long distances in the GÉANT production network.
- Create a report outlining the results, findings and recommendations for using alien wavelengths as a service across the GÉANT optical production environment.

8.2 Objectives

- To study, test and demonstrate alien wavelengths across the GÉANT optical production environment.

- To report findings and recommendations to enable a decision on whether to add alien wavelength services to the GÉANT service portfolio.

8.3 Expected Impact

The work is expected to:

- Enable the GÉANT network to assess the possibility of developing an alien wavelength service, which can be a part of a multi-domain alien wavelength setup.
- Provide a solution to cope with the potential demand for a GÉANT alien wavelength service.

8.4 Outputs

This project will provide a feasibility report on alien wavelengths over the GÉANT network, supported by tests and a demonstration case.

8.5 Budget

One proposal may be funded. It is expected that the project will have a total budget of between €100K and €200K.

9 Network as a Service (NaaS)

9.1 Overview

GN3plus will investigate a new network management and provisioning model for the Research and Education networking community, based on infrastructure virtualisation and flexible usage of network infrastructures by users. The Network as a Service (NaaS) approach to infrastructure management opens up a new research field in the area of service offerings from both a provider and consumer perspective, making the infrastructure resource the cornerstone of the service workflow.

This project invites proposals for the design and prototyping of experimental service capabilities based on NaaS-OpenNaaS. For example, see the Virtual Customer Premises Equipment use case <http://www.heanet.ie/conferences/2012/files/3/Virtual%20CPE...%20-%20Dave%20Wilson,%20HEAnet.pdf> or design and integration of existing services to work with NaaS platform.

Ability to perform field trials over the GÉANT infrastructure or over collaborating third parties' infrastructure is preferred.

9.2 Objectives

- To create novel and widely accepted usage scenarios for NaaS.
- To strengthen the cooperation between research groups, industry and the GN3plus consortium.
- To design prototypes of NaaS-based functional elements to be utilised in the GN3plus service portfolio.
- To evaluate new service models for NRENs and associated resource access policies based on infrastructure resource capability models (NaaS).

9.3 Expected Impact

- Establish NaaS as a way of delivering and using network resources.
- Evolve Research and Education network management and operations to reduce overall operational expenditure and increase flexibility.
- Build flexible and automated consumer/provider relationships.

- Provide tools for automating service workflows, from the users' entry point down to the infrastructure, or at least provide the infrastructure with a degree of flexibility sufficient to seamlessly interact with cloud computing-like services.

9.4 Outputs

1. A document describing the design of the proposed solution.
2. A software prototype of the proposed solution.
3. A document proposing a service model based on the proposed solution.

Ease of deployment, scalability, maintainability, ease of use are essential characteristics of solutions and prototypes developed for their operational success within GEANT and NRENs.

9.5 Budget

Up to two proposals may be funded. It is expected that each project will have a total budget of between €100K and €150K.

10 Open Grid Forum Network Service Interface – Compliance Testing Suite

10.1 Overview

The Network Service Interface (NSI) protocol has been standardised within the Open Grid Forum (OGF) as a multi-domain circuit provisioning protocol. GÉANT successfully participated in interoperability trials of NSI Version 2.0. GN3plus now aims to continue its successful participation in the development of the NSI framework and protocols. This will enable a further expansion of support for worldwide multi-domain Bandwidth on Demand (BoD). In order to ease and boost the adoption of NSI by RENs, this topic invites proposals to design and develop a conformance test suite (CTS) for BoD systems to test their adherence to the OGF NSI framework.

The CTS should be run against NSI v2.0 protocol stack to ensure that the features implemented are functional in accordance with the specification. Load testing by the CTS would also be recommended.

The CTS is intended to be used as a formal reference implementation to verify that a certain level of functionality has been implemented in the target stack and that it is consistent with other implementations.

10.2 Objectives

- To provide documentation of scenarios and tools for NSI protocol conformance testing.
- To provide a validation tool for BoD systems in use within the GN3plus community environment.
- Promote the adoption of NSI.

10.3 Expected Impact

- Decreased time-to-market for BoD systems under implementation.
- Improved interoperability of different BoD systems.
- Improved BoD user experience.
- Reduced deployment and operational costs.

10.4 Outputs

1. A document that describes the design of the CTS.
2. A software prototype of the CTS.
3. Documentation on how to use the CTS.

Ease of deployment, scalability, maintainability, ease of use and test coverage (i.e. proportion of NSI functionality tested) are essential characteristics of solutions and prototypes developed for their operational success within GÉANT and NRENs.

10.5 Budget

One proposal may be funded. It is expected that the project will have a total budget of between €100K and €130K.

11 Content Delivery Network Capabilities for Research and Education Networks

11.1 Overview

GN3plus is seeking to investigate the specific needs of the R&E community in relation to content delivery – specifically how the Research and Education Networks (RENs) can be engineered to address Content Delivery Networks (CDNs), especially when referring to concepts such as ‘Science CDN’ or ‘Big Data’ distribution.

This topic addresses:

- Identification of use cases, business opportunities and specialised requirements for CDN services and capabilities from the R&E network user community, with emphasis on multi-domain service requirements.
- Technologies (such as named data networking) and technical capabilities required by RENs in delivering specialised CDNs/CDN services.
- Prototyping of a proposed solution over GÉANT and interested NRENs.

Ability to perform field trials over the GÉANT infrastructure or over collaborating third parties’ infrastructure is preferred.

11.2 Objectives

- To identify how REN capabilities can be engineered to support CDN services and, as a result, investigate the possibilities for adding CDN-related offerings to the GÉANT-NREN service portfolio.

11.3 Expected Impact

- Establish a foundation for novel CDN-related service offerings by the GÉANT-NREN community.
- Strengthen research synergies and cooperation with partners in GÉANT.
- Engagement of R&E communities with CDN service requirements.

11.4 Outputs

1. A document describing use cases, business opportunities and any specialised requirements for CDN services in the R&E community, as well as relevant technologies.
2. A trial of a prototype or pre-existing (but customised to R&E community environment) proposed solution over GÉANT and interested NRENS.

Ease of deployment, scalability, maintainability, ease of use are essential characteristics of solutions and prototypes developed for their operational success within GEANT and NRENS.

11.5 Budget

One proposal may be funded. It is expected that the project will have a budget of between €100K and €200K.

12 High-Availability Networking

12.1 Overview

High-availability networking entails tight integration of persistent services with network capabilities in the backbone such as fault tolerance mechanisms, optimisation of latency issues and network-topology-conscious services, all in the context of the multi-domain environment of campuses, NRENs and GÉANT. It is particularly valuable for the support of cloud services. High-capacity, high-performance and high-availability support in the backbone for user/campus persistent services such as storage and streaming is identified as an area of interest for GÉANT-NRENs.

Among the topics of interest requiring further investigation are:

- Using routing protocols to signal instance availabilities.
- Horizontal scaling.
- Support for physical and geographical distribution of data and instances in a way that is congruent with the physical network in an intelligent way.
- Support for continuous replication of data.
- Support for seamless and rapid handover and recovery.
- Support for forgiving and self-repairing synchronisation mechanisms

12.2 Objectives

- To explore and research high-availability methods/technologies.
- To port one or more applications to multi-instance versions for high-availability demonstrators.

12.3 Expected Impact

- Establish a foundation for novel high-availability service offerings by the GÉANT-NREN community.
- Strengthen research synergies and cooperation with partners in the GN3plus consortium.
- Engage R&E communities with high-availability service requirements.

12.4 Outputs

1. A report describing the relevant technologies (for example: high availability architectures and protocol extensions, fault tolerance mechanisms, optimisation of latency techniques, network-topology conscious capabilities).
2. A high-availability demonstrator involving the porting of at least two applications to multi-instance versions.
3. Where possible we expect the key findings of the research to be published in one or more peer-reviewed journals.

Ease of deployment, scalability, maintainability, ease of use and test coverage (i.e. proportion of NSI functionality tested) are essential characteristics of demonstrators, solutions and prototypes developed for their operational success within GEANT and NRENS.

12.5 Budget

One proposal may be funded. It is expected that the project will have a total budget of between €100K and €150K.

13 New Protocol for Dynamically Building Trust in the R&E Community

13.1 Overview

Federated access management has become increasingly popular not only in the R&E community but also in the commercial sector. Users are now able to use one of their social media accounts to book and review hotels and so on. However, whilst in the commercial sector this approach is limited to a small number of service providers (SPs) and identity providers (IdPs), in the R&E sector the number of IdPs and SPs involved in the process is much bigger.

To date, whenever users wish to access a service using their federated access, the service needs to have a prior knowledge of where the authentication of the users will take place. Agreements are in place between SPs and IdPs to ensure that SPs know which IdPs to trust for the authentication and to agree on the attributes to exchange.

Efforts are ongoing to agree a defined set of attributes that can meet all services requirements, although it is clear that it will be impossible to find a one-size-fits-all solution and consequently there will always be services that need more attributes. The eduGAIN Code of Conduct offers a first step to defining a minimum set of attributes that all IdPs should be able to provide while preserving the users' privacy.

To make this process more scalable, it would be desirable if the user could be in charge of initiating the trust process among the SPs and IdPs. To make this possible, however, a new communication process (protocol) between IdPs, SPs and users is needed, which is not available at the moment.

The proposer should be able to demonstrate knowledge in the area of Federated Management Access, Security Assertion Markup Language (SAML) technologies and Account Chooser, and should be able to work in a collaborative environment.

13.2 Objectives

- To seek solutions to define a new trust model where the user plays a more central role in establishing the trust relationship between the user's IdP and the various SPs. There may be different ways to support the flow of information between the user, IdPs and SPs.

- Part of the work should also look at ways to integrate Account Chooser, which offers support for users' multiple accounts (i.e. users are asked to add the list of the accounts they would like to use to log in to a specific site).

13.3 Expected Impact

- Make the current Identity Federations model more scalable, particularly in large federations.
- Enable support for e-Science use cases that are difficult to address in the current situation.
- Broaden research horizons in the GÉANT project and seek cooperation with non-GÉANT partners.

13.4 Outputs

It is expected that the output of this work will lead to a new protocol proposition that will be submitted to the IETF to initiate the standardisation process. In light of this, the final output should be:

- Protocol specifications to enable a dynamic trust model where the users play a more active role, rather than delegating all the functions to the IdP. Support for integration of Account Chooser will be a plus, if in line with the specifications.
- Early engagement with the IETF to find the right working group to host the work (or to create a new one) and submission of a first Internet Draft.
- Proof-of-concept(s) of the proposed protocol(s).

The output of this call will be used by GN3plus Joint Research Activity 3 Identity & Trust Technologies for GÉANT Services. It is expected that the work initiated in this Call will be continued in the GN4 project or, alternatively, in one of the TERENA Task Forces when the GN3plus project ends.

13.5 Budget

One proposal may be funded. It is expected that the project will have a total budget of between €100K and €200K.

14 Authentication Mechanism Supporting Higher Level of Assurance

14.1 Overview

Authentication is the process of verifying a person's identity based on the credentials offered, typically a password or a token. The process of issuing credentials to individuals varies depending on the service. For instance, social networks (e.g. Facebook) do not require any proof of identity (information is self-asserted by the users) before a credential is issued. In contrast, a bank would require a client to present an ID card before creating an account. In the case of R&E Identity Federations, the user's institution vouches for a user.

The process followed to verify a user's identity before issuing an account to a user (also known as authentication level of assurance (LoA)), determines how much confidence a third party has that the credential presented is in the possession of the person whose identity is being asserted.

This topic seeks to investigate whether it would be possible to increase the LoA associated with an account (e.g. Google account) by using the same model followed by Pretty Good Privacy (PGP) [PGPWebTrust]. For instance, if person A says something about a Google account B, and person C knows person B, would what A says about B add more value?

There are already ideas on how to implement such a system. However, no concrete protocols have yet been proposed.

The proposer must be able to demonstrate knowledge in the area of Federated Management Access, level of assurance and multi-factor authentication, and should be able to work in a collaborative environment.

14.2 Objectives

The objectives of this topic are:

- To present one or more ways to implement the PGP web of trust model to increase the LoA associated with identities.

- To evaluate stronger authentication mechanisms, including multi-factor authentication, and their usability in identity federations.

14.3 Expected Impact

- Enable existing Higher Education Identity Federations to support services that require stronger LoA, such as eGovernment, health care and so on.
- Broaden research horizons in the GN3plus project and seek cooperation with new partners.
- Make it easier to use social identities in the R&E community.

14.4 Outputs

1. A report evaluating authentication mechanisms, including multi-factor authentication implementations to support higher LoA.
2. A protocol to implement a PGP web-of-trust model to increase the LoA associated with an identity.
3. Provide proof-of-concept for the proposed protocol.

The output of this call will be used by the GN3plus Joint Research Activity 3 Identity & Trust Technologies for GÉANT Services, specifically by Task 2 (Identity & Trust Technologies).

14.5 Budget

One proposal may be funded. It is expected that the project will have a total budget of between €100K and €150K.

15 Building Support for External Attribute Authorities in Higher Education Federations

15.1 Overview

There is general consensus that the model to manage attributes, where all attributes are provided by the users' IdP, does not scale. A better model would be to enable research communities or third parties in general to maintain specific and additional information about the users. These third parties would work as an attribute Authority. The European Strategy Forum for Research Infrastructures (ESFRI) community has on different occasions expressed an interest in operating attribute authorities. However, we see a challenge in the practical implementation and the introduction of attribute authorities in the current Higher Education (HE) Identity Federations and consequently in eduGAIN.

There are several ways to add attribute authorities in the context of existing HE Identity Federations, each one having pros and cons.

The proposer must be able to demonstrate knowledge in the area of Federated Management Access, attributes and authorisation models.

15.2 Objectives

This topic seeks proposals that analyse possible ways to implement attribute authorities and evaluate their strengths and weaknesses. The following aspects must be considered:

- Differing technical implementations, including the underlying technology.
- The impact on existing HE Identity Federations: how will the regulatory framework apply to the attributes provided via an attribute authority? And what will be the implications of namespaces on attributes?

A proof-of-concept must be built for the preferred model, with an explanation of why this particular model has been selected.

15.3 Expected Impact

The results are expected to ease the deployment of HE Identity Federation. There are known use cases, such as e-Science, that would benefit from this approach.

This topic is intended to broaden research horizons in the GN3plus project and seek cooperation with new partners.

The project provides an opportunity for external groups to submit a bid and to work to develop a solution in collaboration with existing Identity Federations. This solution, which will be built on open standards, can then be reused by different groups with similar needs. The results of this work will be disseminated to the relevant communities.

15.4 Outputs

The outputs are expected to be:

1. A report that includes analysis (including strengths and weaknesses) of possible ways for HE Identity Federations and eduGAIN to support external attribute authorities. Feedback on these findings will be provided by the JRA3 Identity & Trust Technologies for GÉANT Services as well as by the Research and Education Federations (REFEDS) group.
1. Guidelines for HE federations to support third-party managed attributes authorities, based on the selected model(s). These should cover both the technical aspect (namespaces, protocols and so on) and the legal aspects, particularly concerning the data protection issues.
2. One (or more) proof-of-concept for one of the proposed model(s). The proof-of-concept should be demonstrated first with a couple of national HE Identity Federations and later with eduGAIN.

The outputs of this work will be used by GN3plus Joint Research Activity 3 Identity & Trust Technologies for GÉANT Services, specifically by Task 1 (Attributes and Groups).

15.5 Budget

One proposal may be funded. It is expected that the project will have a total budget of between €100K and €200K.

16 IEEE 802.1X and EAP – Improving Implementation Completeness and User-Friendliness

16.1 Overview

The wireless access industry is making widespread use of the IEEE 802.1X standard in many use case scenarios, including access to wireless enterprise networks, network roaming consortia, securing access to wired ethernet LANs. In addition to this, the main payload protocol used in IEEE 802.1X, the Extensible Authentication Protocol (EAP), is seeing increased use in other related contexts, e.g. for authenticating to web-based resources (IETF ABFAB Working Group [ABFABWG], Project Moonshot [Moonshot]). The extensibility of EAP and the authentication options in the various EAP methods introduce many requirements and complexity for implementations: a multitude of EAP types to support on the wire, the challenge of presenting a useful, simple and yet complete User Interface (UI) to end users, and last but not least a means to configure all the EAP parameters for an end-user in an easy-to-understand process.

Existing implementations differ significantly in their user interface, manual configurability, automatic provisioning capabilities, and technical completeness (EAP-type coverage).

The proposers must be able to demonstrate knowledge in the area of Federated Management Access, attributes and authorisation models.

16.2 Objectives

The primary objective of the topic is to ensure that all important EAP methods are properly supported by the mostly used supplicants.

This topic has the following objectives:

- To establish a forum of experts setting out minimal requirements for a user-friendly implementation of IEEE 802.1X supplicants, EAP peers and EAP servers. For example, a requirement for a supplicant is that it needs to expose all the parameters to establish unambiguous/mutual authentication to the user; e.g. it is not enough to make the EAP Server's Certification Authority configurable – also the EAP

Server's Expected Server Name needs to be configurable. The current user interface for the supplicant in KDE¹ fails this.

- To work with as many implementers of IEEE 802.1X / EAP as possible with the goal of improving the existing implementations to meet the minimum requirements. For example, Firefox OS has no User Interface for IEEE 802.1X configuration at all right now, whilst it would be desirable to have one.
- To create a knowledge base with tips and checklists for future implementers to lead them to interoperable, user-friendly and complete implementations.

16.3 Expected Impact

The results are expected to raise the usability of IEEE 802.1X and EAP industry-wide to a new level. The project will create a knowledge base with background on, reasoning for, and tips regarding the different aspects of EAP and IEEE 802.1X implementations.

This work also has implications for the usage of the Configuration Assistant Tool (CAT). CAT can only work if the underlying supplicants work well with different EAP types and this is not the case to date. This limits the usage of CAT to a limited number of supplicants and to a limited number of EAP types.

16.4 Outputs

1. A reference checklist to describe the minimum level of usability and implementation completeness. This would lead to the creation of a quality label "User-Friendly & Complete IEEE 802.1X supplicant", "Interoperable EAP server for EAP Types x,y,z".
2. A reference implementation, supported by one or more proof-of-concept(s).
3. Improved supplicant software from many implementers of such software.

The output of this call will be used by GN3plus Joint Research Activity 3 Identity & Trust Technologies for GÉANT Services, specifically by Task 1 (Attributes and Groups).

16.5 Budget

One proposal may be funded. It is expected that the project will have a total budget of between €100K and €350K.

¹ KEA is one of the two main GUI's for Linux.

17 Scalable Ubiquitous Access to Networks and Cloud Services

17.1 Overview

The world of ICT is rapidly changing to one in which services are no longer offered by the enterprise but rather in the cloud, and users are no longer static but are now able to work with increased mobility. This requires a new set of control points for managing access to services and networks.

Federation technologies play an important role, but at the same time these federation technologies largely assume a web-based model whereas the applications and network services use other native protocols. Work in projects like Manticore/Mantychore (successor of the initial Manticore project) [Manticore], NOVI [NOVI] as well as in Project Moonshot [Moonshot] lay a foundation for this new paradigm.

Proposers must be able to demonstrate knowledge in the area of Federated Management Access, attributes and authorisation models.

17.2 Objectives

This topic aims to investigate the use of emerging protocols such as the one under standardisation within the IETF Working Group ABFAB [ABFABWG] for the scalable and secure ubiquitous access to cloud services and network functions.

This topic aims to address the following use case: a researcher roams from one place to another and wishes to get access to infrastructures and services that are located in different administrative domains, including Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). Building on the results from the ABFAB WG and Project Moonshot, this research work aims to enable a researcher to authenticate once and to get access to any type of services that are available to him/her. To date this process is not seamless and in many cases it requires the user to authenticate multiple times.

17.3 Expected Impact

The results will contribute to the use of applications and network functions beyond the web and introduce new ways to access applications beyond those commonly used today, i.e. VPN, federated access, etc.

The proposal will provide middleware layers that can be used to support different types of cloud services, spanning from those offering storage to those offering network virtualisation capabilities.

17.4 Outputs

The output as a minimum should consist of a prototype deployment plus a guide on applying ABFAB to cloud services.

The output of this topic will be used by GN3plus Joint Research Activity 3 Identity & Trust Technologies for GÉANT Services, specifically by Task 1 (Attributes and Groups).

17.5 Budget

One proposal may be funded. It is expected that the project will have a total budget of between €100K and €200K.

18 Innovation in a Multi-Domain Research and Education Networking Environment

18.1 Overview

The primary objective of this activity is to enhance the ability of the GÉANT and NREN networks to provide world-class connectivity and services to their user communities and to push the state of the art in Research and Education networking. Projects in this thematic activity also aim to raise GÉANT's profile in the area of networking research through the publication of research results. It is expected that the work carried out will demonstrate high levels of innovation and provide the GN3plus project with new and novel research results that can be applied to a multi-domain networking environment.

Examples of topic areas covered by this theme include, but are not limited to: hardening network management, deterministic behaviour of multi-domain networks, and networking without borders. The aim is to enable proposers to conduct focused research into innovative new technologies that will demonstrably support the Research and Education networking community and lead to new technologies and services being applied in a multi-domain context.

Examples of Topic Areas

- **Hardening network management:** the aim is support research into new and novel technologies and methods that will improve the resilience and stability of the combined GÉANT and NREN network domains. Monitoring can be included in the broadest sense and could include monitoring by network providers for the purposes of maintenance, as well as to allow users to monitor their services. Work in this topic can include, but is not restricted to:
 - Multi-domain network monitoring and management.
 - Multi-domain virtual private network user monitoring.
- **Deterministic behaviour of multi-domain networks:** the aim is to support research into new and novel technologies and methods that will enhance the performance of the GÉANT network (both packet and circuit based). This can include, but is not restricted to:
 - Routing protocols and architectures (including clean-slate routing approaches, protocol routing extensions, provably correct routing behaviour, meta and namespace routing, and novel constraint-based routing behaviour, e.g. routing for CO₂ reduction).

- Programmability of networks and associated control planes (e.g. to realise hybrid distributed/centralised control plane architectures, network programmability and elasticity, integration of virtualised connectivity, computation and storage).
- Hardware development based on commercial off-the-shelf components and enabling very high-speed, low-cost, open and flexible communication platforms for Research and Education.
- **Networking without borders:** the aim is to support research into novel technologies and methods to improve the mobility of research and education networking. This can include, but is not restricted to:
 - Improved security, authentication and provisioning mechanism, especially in a virtual environment operating in a multi-domain environment.
 - Innovative use of remote data access for high-performance computing applications.
 - Integration of eScience clouds with multi-domain reservation and provisioning services.
 - Integration of Resources on Demand (reservation and provisioning) across instruments, networks and eScience services.

Proposers should demonstrate that their research results provide added value for the Research and Education community in terms of innovative services and standards.

Where appropriate, proposers may choose to make use of the GÉANT testbed facilities described in thematic activities 1 and 2 (DF testbed, OpenFlow facility). More information can be found in Technical Annex A and Technical Annex B.

18.2 Objectives

This thematic activity has the following objectives:

- To build on GÉANT's profile as a leader and enabler of network research through publication of research results, i.e. peer-reviewed academic articles and standards.
- To enable proposers to carry out innovative research and development in the areas of, but not limited to, hardening network management, deterministic multi-domain based networking and networks without borders.
- Support future services and technologies in the GÉANT and NREN networks through research and experimental validation of innovative ideas.

18.3 Expected Impact

- Support proposers in their development of innovative network technologies.
- Speed up introduction of new technologies and services into the Research and Education networks.
- Increase visibility of innovation results within the Research and Education network environment.
- Strengthen cooperation and research excellence between academic and industry research groups and the GÉANT-NREN consortium.

- Generate novel and widely accepted ideas for future network research and development.
- Establish a foundation for future innovation within the NREN community, GÉANT and service providers.

18.4 Outputs

1. A report, which usually includes experimental validation, outlining:
 - a. A summary of the work undertaken and research results.
 - b. An explanation of how this work can be specifically applied in the R&E networking community.
2. We expect the key findings of the research to be published in one or more peer-reviewed journals with acknowledgment of GÉANT.

18.5 Budget

It is anticipated that up to 5 projects may be funded with a total budget of between €100k and €250k. Projects with a higher total budget (up to €350k) may be considered where a project is able to demonstrate very strong innovating technical excellence and impact.

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Glossary

API	Application Programming Interface
BoD	Bandwidth on Demand
CAT	Configuration Assistant Tool
CTS	Conformance Test Suite
DF	Dark Fibre
EAP	Extensible Authentication Protocol
ESFRI	European Strategy Forum for Research Infrastructures
FEC	Forward Error Correction
GMPLS	Generalised Multi-Protocol Label Switching
HE	Higher Education
IaaS	Infrastructure as a Service
ICT	Information and Communication Technologies
IdP	Identify Provider
IETF	Internet Engineering Task Force
JRA	Joint Research Activity
JRA1	GN3plus Joint Research Activity 1 Network Architectures for Horizon 2020
JRA3	GN3plus Joint Research Activity 3 Identity & Trust Technologies for GÉANT Services
LAN	Local Area Network
LoA	Level of Assurance
NaaS	Network as a Service
NREN	National Research and Education Network
NRZ	Non Return to Zero
NSI	Network Service Interface
OAM&P	Operation, Administration, Maintenance and Provisioning
OGF	Open Grid Forum
OS	Operating System
OSPF-TE	Open Shortest Path First – Traffic Engineering
PaaS	Platform as a Service
PGP	Pretty Good Privacy
PoP	Point of Presence
Q	Quarter
R&E	Research and Education
REFEDS	Research and Education Federations
REN	Research and Education Network
RFC	Request for Comment
RSA	Routing and Spectrum Assignment

RSVP-TE	Resource Reservation Protocol – Traffic Engineering
SaaS	Software as a Service
SAML	Security Assertion Markup Language
SDN	Software-Defined Networking
SP	Service Provider
TaaS	Testbed as a Service
UI	User Interface
VPN	Virtual Private Network