FEDERATED POP: A SUCCESSFUL REAL-WORLD COLLABORATION

Authors:

Milosz Przywecki
PSNC, Noskowskiego 12/14, 61-704 Poznan, Poland
mprzyw@man.poznan.pl

Ivana Golub, Darko Paric
CARNet, Josipa Marohnica 5, 10000 Zagreb, Croatia
ivana.golub@carnet.hr, darko.paric@carnet.hr

Maribel Cosin
RedIRIS, E.P.E. Red.es, Plaza Manuel Gomez Moreno, s/n, Edificio Bronce, 28020 Madrid
maribel.cosin@rediris.es,

Paul van Daalen, Gerben van Malenstein
SURFnet bv, P.O. box 19035, 3501 DA Utrecht, Netherlands
Paul.vanDaalen@surfnet.nl, Gerben.vanMalenstein@surfnet.nl

Peter Kaufmann, Ralf Paffrath
DFN-Verein, Alexanderplatz 1, 10178 Berlin
kaufmann@dfn.de, paffrath@dfn.de

Jari Miettinen
CSC P.O. Box 405 02101 Espoo, Finland,
jpmietti@csc.fi

Paper type

Case study

Case studies describe actual interventions or experiences within organizations. They may well be subjective and will not generally report on research. A description of a legal case or a hypothetical case study used as a teaching exercise would also fit into this category.

Abstract

The purpose of this paper is to provide practical results of the federated PoP established in Hamburg as a pilot case study of three-year long research of JRA1 T3 group, which included three NRENs - PIONIER, SURFnet and NORDUnet. Methodologies used are the establishment of a pilot federated PoP as a testbed for examination of concepts defined in the previous work [1-3], application of proposed models to the real-life example in the

pilot as a proof of concepts, as well as posting guidelines for future similar projects. Findings include practical scheme for establishment of any federated PoP (proving them valid and easily applicable), technical perspective (exact topologies that can be applied universally, and not Hamburg-case-specific), and organizational aspects. It can be used as a practical how-to when considering and starting a new multi-domain or federated Point of Presence.

Because of limited duration of JRA1 T3 work, not all planned services were introduced, nor were all envision parties involved. Future research can include implementation of other multi-domain tools, integration and interoperability of heterogeneous networks and further expansion with other networks, making it a unique kind of Open Lightpath Exchange.

Establishment of the federated PoP in Hamburg is a unique instance of federated network architecture, originally introduced and studied through the work of JRA1 T3 team. Theoretical models are approved and successfully implemented in the real world, with results that can be repeated in any other environment, with any other networking parties making them the main potential users of this work.

Keywords

federated networks, multi-domain networks, federated architectures, dynamic lightpaths

1. Introduction

A successful collaboration of research networks (such as National Research and Education Networks and GÉANT) is clearly visible in Europe for number of years now. From providing basic IP connectivity to advanced services these networks enabled efficient cooperation in many research areas. The GÉANT network and Cross Border Fibre owned by NRENs allow performing cooperation on a pan-European and even global scale. Creation of multi junction facilities - where several networks are interconnecting - may deliver new possibilities for cooperation and provide many benefits in terms of overall cost of network infrastructure and service portfolio.

JRA1 Task 3 of the GÉANT 3 project considered a number of aspects of sharing network resources among multiple independent but collaborating networks and provided a definition for a federated PoP. In addition, in their research, JRA1 T3 team suggested several models and concepts: federated network architecture model [1], operations model for a federated PoP [2], network topology model for establishment of a federated PoP [2]; concept to conduct analysis for needs for federation of networks and resources [1] concepts for contracting and formal agreement between involved parties [2]. The team has also presented requirements and technological issues related to establishing a federated PoP [1], and suggested test cases to prove presented models and concepts.

2. Federated PoP definition and features

The federated PoP is a physical site where several networks such as NREN and/or GÉANT are co-located to offer services in a joint manner. Inside the federated PoP network operations are carried out in accordance with collaborative agreements and equipment is shared where possible by the network entities present in the federated PoP. A federated PoP might be also seen as an extension of Cross Border Fibre (CBF) concept. CBF involve just two parties that interconnect with each other and became a popular way of interconnecting NRENs in Europe as it can be seen in figure 1.

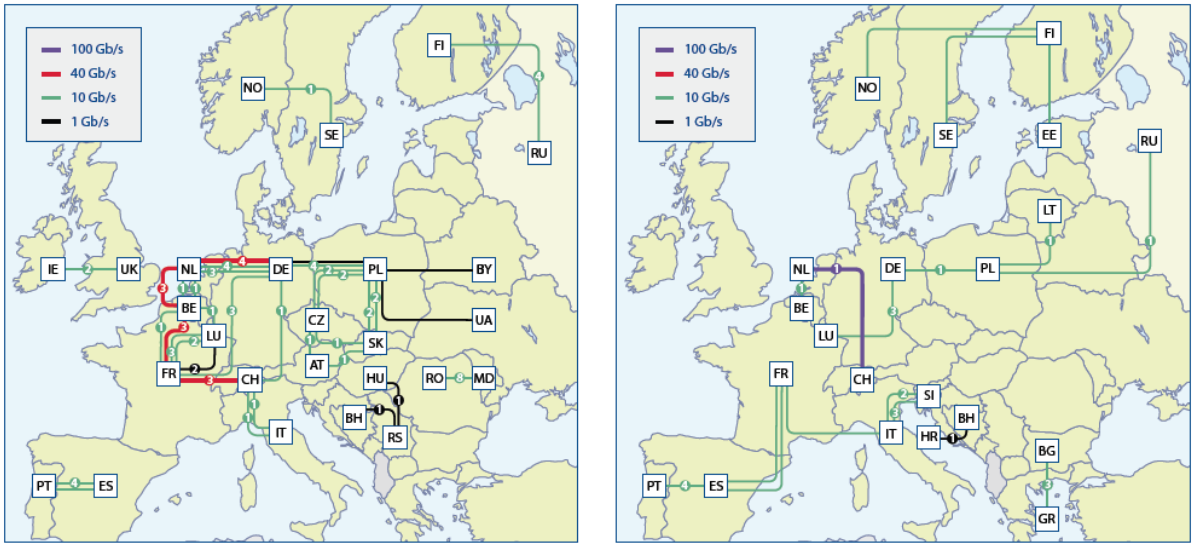

Figure 1: Current and planned cross border dark fibre in Europe [4]

In comparison, a federated PoP extends CBF idea by involving a number of parties that interconnect and agree to provide connectivity and services together. The potential benefits of such federation include cost savings, increased service availability and resiliency as well as improved user experience. The main challenges related to the common management of federated PoP are technological differences, shared monitoring and management, missing standards, cost model and the federation-independent presentation of services.

Generic models for the federated network architecture have been developed as a result of analysis of the existing projects, processes and services that are either potential users of a federated network or that feature some elements of federation. It defines the structure, relationships and dependencies between particular elements of the architecture [1]. The next analysis of different technological possibilities for interconnection of NRENs was done in order to distinguish simple configuration options for building a federated PoP that are depending on available networking equipment. Proposed configuration options include [2]:

- Lightweight (optical only)
- Switching (optical, and switching)
- Routing (optical and routing)
- Full service (optical, switching and routing)

Topology of a federated PoP where four NRENs are interconnected with an Ethernet switch is presented in Figure 2.

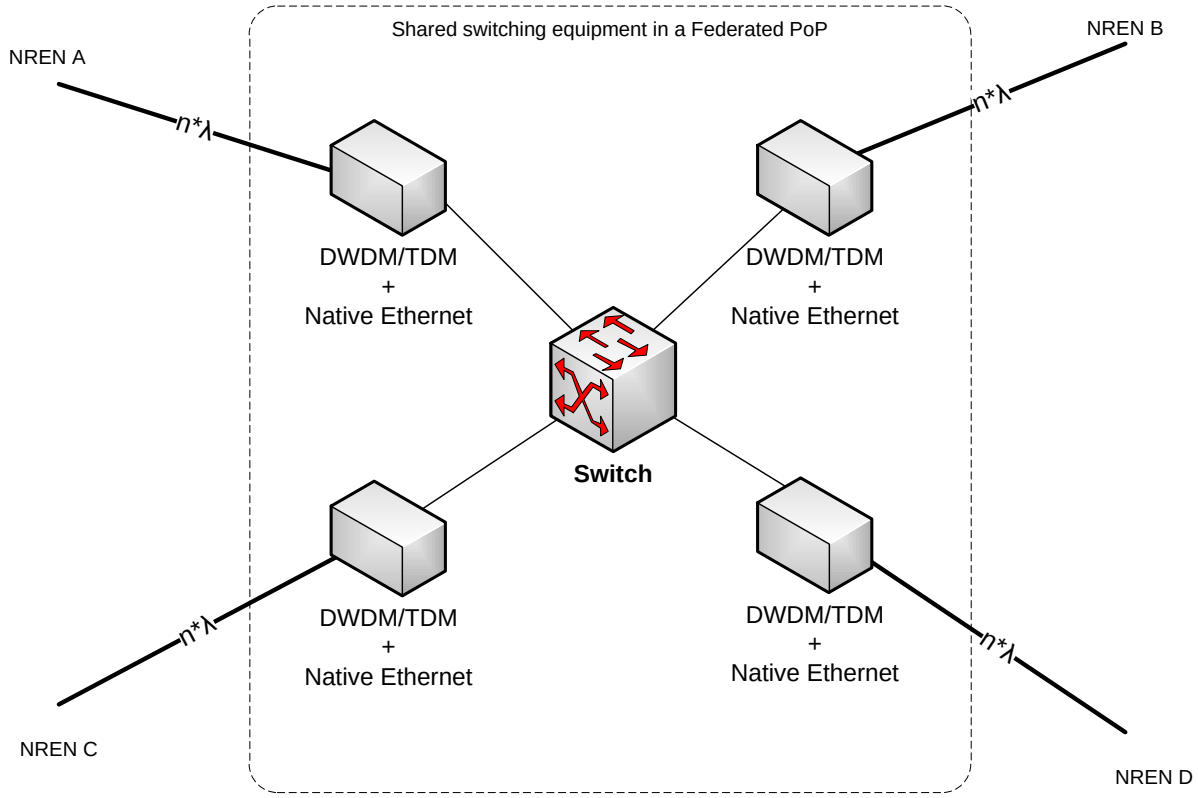

Figure 2: Switching federated PoP with 4 parties [2]

In case of switching and routing there is also a possibility that one of the parties comes into the federated PoP with a managed service instead of a leased dark fibre. Depending on the configuration, a different set of network services can be provisioned due to different capabilities of hardware.

3. Federated PoP in Hamburg

To date, four NRENs have their infrastructure in the city of Hamburg: DFN, NORDUnet, PIONIER and SURFnet. NORDUnet, PIONIER and SURFnet are already present in two nearby co-location centres (located in the same building).

Using the similarity between Hamburg and JRA1 T3 working team - that representatives of PSNC/PIONIER, SURFnet, NORDUnet and DFN are, among other, participating at both - as well as taking advantage of NREN's Cross Border Fibre and given their presence in Hamburg it was decided to set up an experimental federated PoP to interconnect these NRENs and to verify concepts described within JRA1 Task 3 of the GÉANT 3 project.

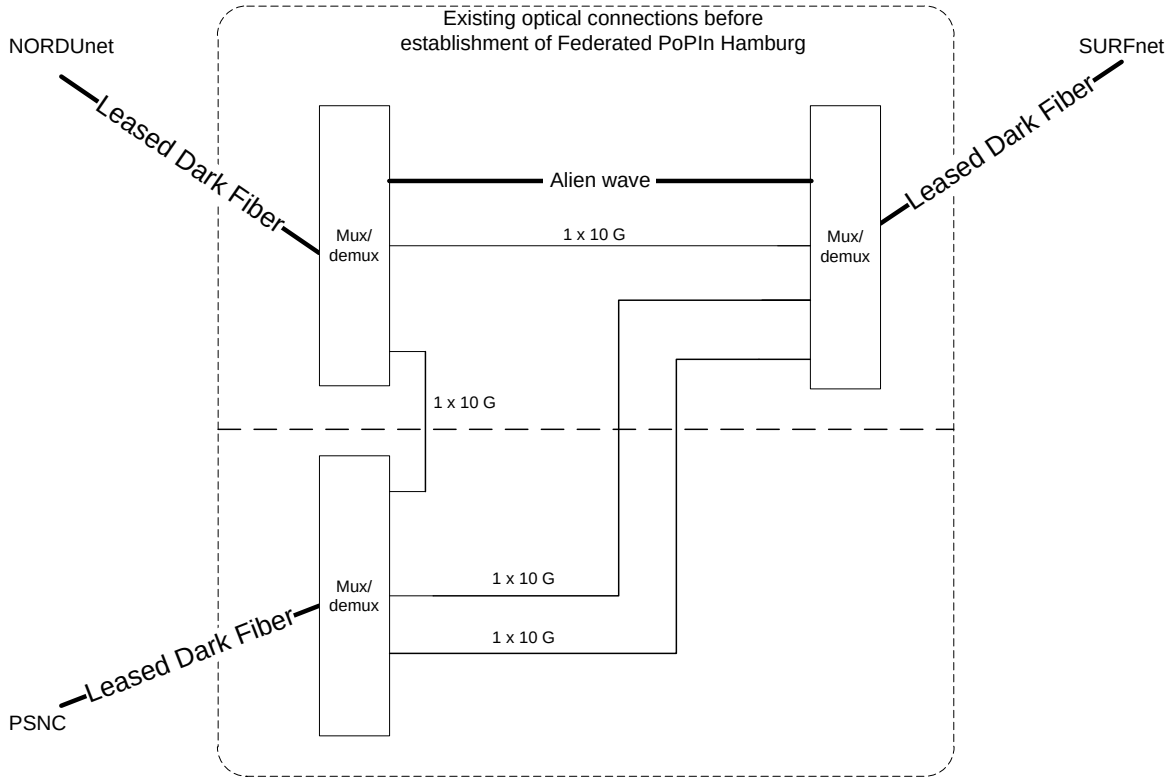

Figure 3: Optical network configuration in Hamburg before establishment of F-PoP

Federated PoP in Hamburg thus provides interconnectivity between three networks - PIONIER, SURFnet and NORDUnet.

Since all NRENs were connected at only the optical layer, a solution enabling provisioning of connectivity at the higher layer was proposed. An advanced switch with routing capabilities and eight 10 GbE interfaces was provided and installed in Hamburg by PSNC. This choice was driven by available hardware and its configuration correspondence to the 'switching' configuration option described earlier. Network topology of the Hamburg F-POP is presented at figure 4.

The exact topology of the established network that presents how three networks are actually interconnected in this pilot is presented in figure 4. During the test phase interconnectivity and performance has been tested with iperf [4]

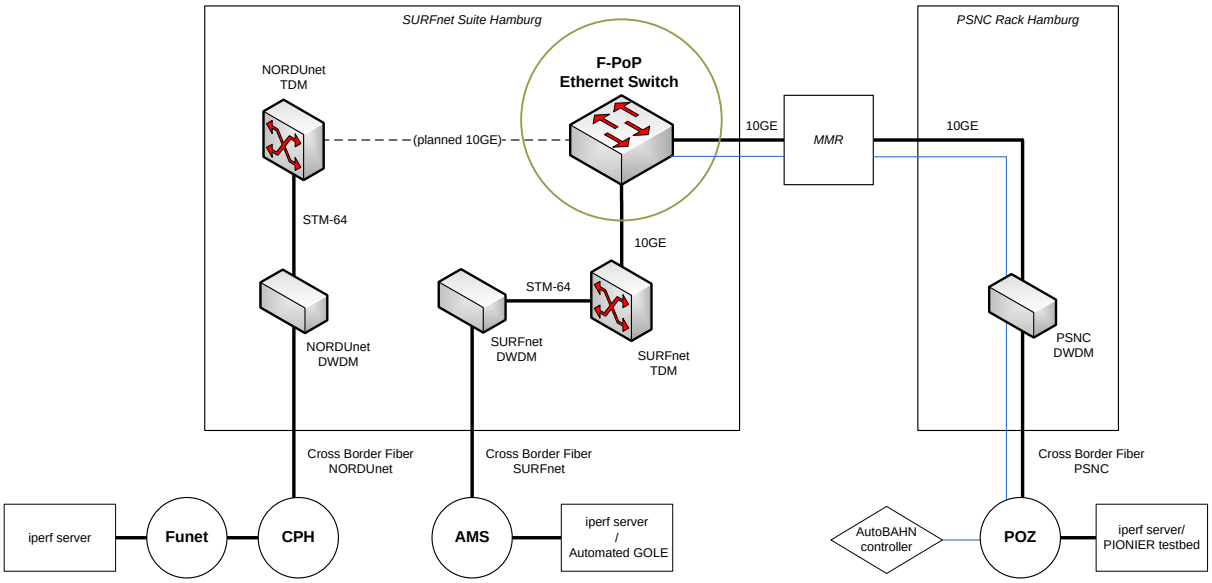

Figure 4: Hamburg federated POP pilot network scheme

CPH = Copenhagen, AMS = Amsterdam, POZ = Poznan

Each NREN covers the cost of establishing and maintenance of their connection to the co-location centre in Hamburg. Additionally, PSNC provided the equipment and covered operational expenses for installation and configuration of the switch for the establishment of the Hamburg federated PoP pilot while SURFnet is covering the costs for maintenance of the equipment in SURFnet's cabinet. The switch management is in-band and initially is performed by PSNC.

In particular, the following steps were needed to establish federated PoP in Hamburg:

- A strong will to interconnect with other NRENs
- Establishing connectivity (either via dark fiber or through a managed service) between NREN's network and Hamburg co-location centre
- Establishing required connectivity between two sites in Hamburg where NRENs have their cabinets
- Overcoming formal and technical difficulties – finding a technology that suit needs of all participants, making sure that all requirements like power, space can be fulfilled for the proposed hardware
- Installation of the switch and patching
- Allocation of resources that are required to maintain the connection. As NRENs were already present in Hamburg responsibility for maintenance of federated PoP connectivity was added to groups of people who already are dealing with NREN's connectivity to Hamburg
- Selection of services to be deployed in the federated PoP. This is strictly related to the hardware installed in the federated PoP. In this case AutoBAHN [6] has been chosen to control the equipment.
- Allocation of resources and necessary manpower to run, manage and monitor the services. An agreement on sharing responsibilities is also needed.
- Agreement on operation of federated PoP

Apart from costs related to connectivity and deployment of necessary hardware of a federated PoP in Hamburg does not seem to require many additional efforts in terms of manpower since operation is handed over to people in NRENs who already are taking care of maintenance of the infrastructure and services.

The suggested model for the solution that is implemented for the federated PoP in Hamburg is modular and scalable. By its design it opens the option to include any national, pan-European or even world-wide network whose infrastructure passes through Hamburg into the federated PoP architecture.

4. Federated PoP in Hamburg - proof of concepts

Within three-year long research in GÉANT 3, JRA 1 Task 3 team was focused on federated network architecture design and implementation. Starting from the definition of a federated PoP through the investigation of potential benefits and drawbacks that arise from establishment of federated PoP the team identified most important factors that have to be taken into account [1,2]. Results from investigations allowed considering potential test cases. During the research phase of the project, four practical applications of conducted research were suggested as possible test case. Those are:

- Using CBF for GÉANT PoP-to-PoP connection. The main idea is to use resources owned and operated by NRENs to replace dedicated GÉANT capacity needed to connect GÉANT PoPs,
- Using CBF as an element in regional links to reduce cost of connecting NREN to a GÉANT PoP,
- Federated PoP. The main idea was to serve several NRENs that are present in one place in the same PoP and use NRENs resources (CBFs) to provide the connectivity. This case can be also seen as an opportunity to build a federated GÉANT PoP which can serve several NRENs.
- Remote IP backup with CBF where the goal is to increase resiliency by using CBF to connect to GÉANT PoP in other country.

Federated PoP was chosen as a test case to validate the federation concept. Hamburg has been selected as a place for the first F-PoP, because since 2007 several NRENs, participants of the GÉANT3 project already have their presence at this location. These NRENs are all connected to the Hamburg PoP through leased dark fiber so their presence should keep stable for predictable future.

4.1. Hamburg federated PoP building blocks

As it was introduced in [1], federated networks architecture consists of three basic building blocks. Those are: network technologies, operations and services.

In Hamburg federated POP, network layer consisted of cross border fibers and interconnections between NRENs. As already mentioned, each of participating NRENs, namely NORDUnet, PIONIER and SURFnet, were already interconnected at the optical level. Introduction of additional equipment for purposes of federated PoP required adding an additional 10G wavelength from each NREN to Hamburg.

Operations are based on the existing tools and procedures in NRENs. In particular, the F-PoP physical infrastructure is monitored and managed by PSNC. The switch will be monitored by internal PSNC monitoring system. A decision to deploy AutoBAHN [6] to support dynamic allocation of connections between the NRENs has been made. PSNC as one of the main developers is responsible for deployment and maintenance of the instance, which is managing the F-PoP switch. F-PoP members are communicating to agree how the information about possible incidents and problems in the network as well as planned maintenance should be.

Currently automatic (Bandwidth on Demand - AutoBAHN) and manual configuration of the switch is foreseen to provision Ethernet-based connectivity. BoD is foreseen as a service that will be implemented in F-PoP in the first step.

4.2. Hamburg federated PoP pilot operational model

At this moment, participating NRENs have not signed a formal contract for participation in establishment and maintenance of or traffic exchange in the federated PoP in Hamburg. It is up to those three NRENs to decide whether they will make a formal contract that will be signed by all three parties - will it be two- or three- lateral agreement, and what will be the form of this contract. Since this is the first, and for now the only such example, it is too early to talk about formal procedure of how to enter such a federation, nor it can be set up as a rule for all other F-POP intentions.

It is very important to notice that the installation phase of the Hamburg F-PoP has just been finished. Therefore, it is still too early to determine the final operations model of the Hamburg F-PoP. It is only possible to describe how the operational model was set up during this pilot phase. After this F-PoP enters the fully production phase

and becomes standard part of the network of all involved NRENs, only then should the final operational model be defined and confirmed from all involved parties.

However, during the pilot that was performed within GÉANT 3 JRA1 T3 project, it can be concluded that operations model followed the model B, as defined in [1].

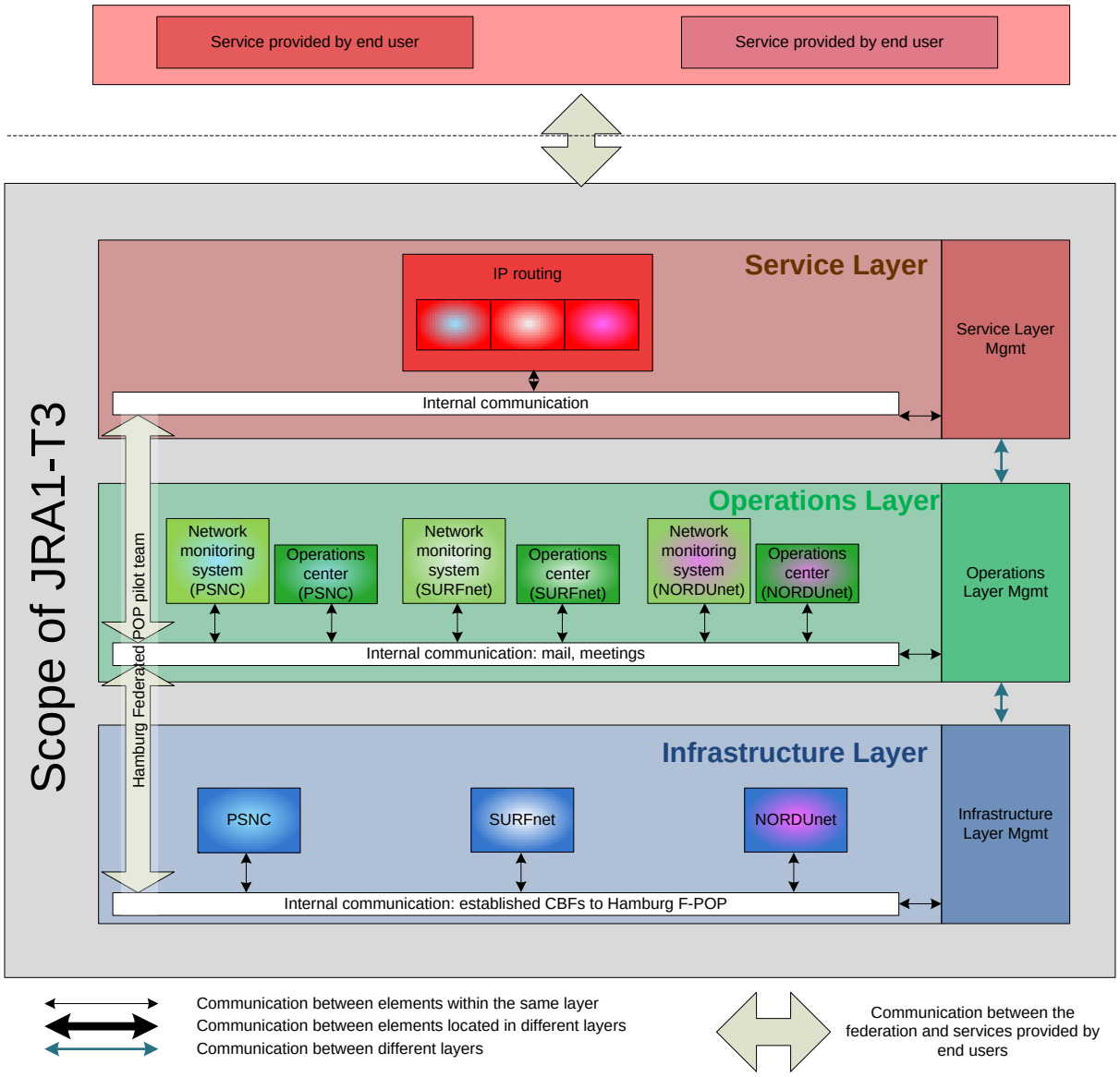

Figure 5: Federated network architecture for Hamburg Federated PoP pilot

Additionally in [2] three roles for entities participating in the establishment and operation of a federated PoP were defined:

- **F-PoP owner** who provides all necessary facilities (e.g. space, electricity etc)
- **F-PoP host** who coordinates communication between F-PoP members and F-PoP owner who is not participating in the service offering
- **F-PoP member** – a party interested in interconnecting in the federated PoP

In case of Hamburg federated PoP roles are more distributed. NRENs are present in two external co-location centres so F-PoP owner role is distributed to two entities. PIONIER DWDM equipment is located in one centre while switching equipment is located in the second centre. F-PoP owners are not participating in providing

connectivity but provide physical space, electricity, air conditioning and fiber between co-location centres. Role of F-PoP host is also distributed as NRENs had to communicate with owners of their co-location centres in order to arrange connectivity. Each NREN has its own DWDM equipment in their own cabinet located in one of the above mentioned co-location centres. Switching equipment is located in SURFnet's cabinet so SURFnet is responsible for communication with co-location centre owner in order to make all necessary arrangements regarding installation and operation of the equipment. At the time of F-PoP establishment communication between NRENs was carried out through JRA1T3 team. Each involved NREN performs the role of F-PoP member. Switching equipment is provided by only one F-PoP member (PSNC) and is shared among all F-PoP members.

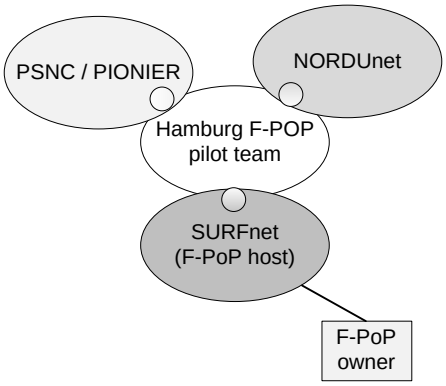

Figure 6: Communication model for operation in the Hamburg Federated POP pilot

Formal communication through management layer was complemented with additional communication channel established within JRA1 T3 project team.

5. Opportunities and future work

Federated PoP in Hamburg has potential to become a standard node in three networks - in the network of PIONIER, SURFnet and NORDUnet. Established physical and logical connectivity and traffic exchange has so far fulfilled the main goal of federation - common use of resources that enables scalability and costs saving. Following steps might include spreading multi-domain tools such as AMPS, perfSONAR, iSHARE, and many others developed through GEANT projects, or other projects and initiatives. This, and any other potential federated PoP is also a suitable platform for multi-domain services and cooperation.

Established infrastructure can now be a good basis for future stronger collaboration between involved NRENs. In addition to other projects that those NRENs participate in, Hamburg federated PoP can present for itself a platform for future research of integration and interoperability of heterogeneous topologies, technologies networking solutions for systems and services.

Once the federated PoP has been established, made scalable and open for growth, knowing that there are other NRENs that also reside in Hamburg, this federated PoP in Hamburg can expand further with the aggregation of other NRENs and possibly pan-European network GÉANT. On this way, the federated PoP in Hamburg can become unique kind of Open Lightpath Exchange.

6. Conclusions

The model for Federated PoP that has been examined and described in previous work of GEANT 3 JRA1 T3 group has been used as a starting point in establishment of the federated PoP in Hamburg. Initially, three NRENs have already been present in Hamburg with their network infrastructure and a participation in the federated PoP was seen as an opportunity to increase efficiency, decrease costs and use the advantages of multi-domain services for network operations and monitoring. The federation has been established through interconnection and the first service that has been provided is a switching service, enabled on the advanced Ethernet switch provided by PSNC. The benefits of multi-domain services have been proven with the selection of AutoBAHN, chosen to control the switch. With efficient coordination, technology examination and operational accordance most main challenges have been overcome.

In addition the paper presents the list of necessities that should be defined and fulfilled in order to establish an F-PoP that can be used as a guideline for any further federated PoP case projects.

7. Acknowledgements

This work is partially supported by the European Commission's Seventh Framework Programme (FP7/2007-2013) project GN3.

This work is partially supported from the Polish funds for science and education granted for execution of international project.

8. References

[1.] B. Belter, M. Cosin, P. van Daalen, L. Fischer, I. Golub, A. Hanemann, M. Kaat, M. Przywecki, B. Radojevic, S. Tyley, S. Vukovojac, "Deliverable DJ1.3.1: Architecture Considerations for Federated Backbone Networks Study" http://www.geant.net/Media_Centre/Media_Library/Media%20Library/GN3-09-250%20DJ1.3.1v1.0%20Architecture%20Considerations%20for%20Federated%20Backbone%20Networks%20Study.pdf

[2.] M. Cosin, P. van Daalen, I. Golub, A. Hanemann, P. Kaufmann, G. van Malenstein, J. Miettinen, D. Paric, M. Przywecki, "Deliverable DJ1.3.2: Architecture Considerations for Federated Backbone Networks Study. The Federated PoP" http://www.geant.net/Media_Centre/Media_Library/Media%20Library/GN3-11-074_DJ1.3.2_Architecture%20Considerations%20for%20Federated%20Backbone%20Networks%20Study_v1.pdf

[3.] L. Fischer, B. Belter, M. Przywecki, M. Cosin, P. van Daalen, M. Kaat, I. Golub, B. Radojevic, S. Vukovojac, A. Hanemann, , "Building federated research networks in Europe", Terena Networking Conference 2010, Vilnius, Lithuania, 2010.

[4.] TERENA Compendium of National Research and Education Networks In Europe, Edition 2011, http://www.terena.org/activities/compendium/

[5.] Iperf network tool, http://sourceforge.net/projects/iperf/,

[6.] AutoBAHN, http://autobahn.geant.net

9. Author Biographies

Milosz Przywecki received the M. Sc. degree in Electronics and Telecommunications from Poznan University of Technology in 2003 and joined the Network Division of Poznan Supercomputing and Networking Center as a Networking Systems Analyst in 2005. He is involved in the 'Federated Network Architectures' task of GN3 project where issues related to sharing resources among multiple independent networks are investigated. He actively supports international networking collaboration by contributing to other international projects (e.g. Porta Optica Study project in the past and currently ORIENTplus project). His main interests are also in advanced networking technologies, network protocols and services.

Ivana Golub is a Deputy CEO at CARNet, in charge of the Network Infrastructure Department, which is responsible for designing, building and maintaining the CARNet network and network services. She received her B.Sc. and M.Sc. degrees in Electrical Engineering at FESB, the University of Split. During the last 10 years Ivana has worked in networking, in areas ranging from LAN to WAN, and in positions ranging from architect to manager. Ivana is involved in the GN3 JRA1 activity related to federated networks.

Darko Paric is a Service Manager at the Network Infrastructure Department in CARNet. Darko is involved in designing, building and maintaining the network and networking services in CARNet network. Darko received his B. Sc. in Electrical Engineering Faculty – FESB at the University of Split. During the work in CARNet Darko has actively participated in many projects such as building and maintaining the infrastructure for broadband access services, building optical cable networks and many others.

Maribel Cosin works in the Network department at RedIRIS, which is responsible for designing, building and managing the RedIRIS network. She completed her B.Sc. in Telecommunications Engineering in 1996, at the Universidad Politécnica de Madrid, and joined RedIRIS eleven years ago. She has participated in the deployment of the current network infrastructure (RedIRIS-10) and is collaborating on the design of the new one (RedIRIS Nova), based on dark fibre. Since January 2005 Maribel has been responsible for the Level 1 Operations Team at RedIRIS. She is also responsible for the DNS service and the RedIRIS Réseaux IP Européens (RIPE) interface.

Paul van Daalen joined SURFnet in January 2009 as a Senior Network Planner. Prior to this he was Director of the Information group at Leiden University for 8 years. During the last 25 years Paul has worked with various kinds of telecommunication and IT systems and structures. As an IT professional he was employed for 17 years by Delft University, where he was responsible for Network Development and Operations.

Gerben van Malenstein received his M.Sc. degree in System and Network Engineering from the University of Amsterdam in 2007, to date he works as Network Manager within SURFnet's Network Services department. Within his roles as project manager and technical product manager, his focus is on the development of Open Lightpath Exchanges, such as NetherLight, SURFnet's GLIF Open Lightpath Exchange (GOLE) in Amsterdam. Alongside this work, he is involved in automated bandwidth-on-demand provisioning, both within SURFnet and internationally through NetherLight.

Dr. Peter Kaufmann is technical manager in the branch office of DFN-Verein (Deutsches Forschungsnetz). He has been responsible for the planning of advanced projects within DFN. Currently he is involved in several EU-funded projects. He received his Ph.D. in 1980 in Theoretical Nuclear Physics from the Free University Berlin.

Ralf Paffrath received his diploma in computer science and computational linguistics at University of Koblenz (Germany) in 1993. He is working with the DFN e.V. (Deutschen Forschungsnetz) since 1996. From 1996 until 2002 he was in charge of about 20 advanced DFN teleteaching and telelearning projects on high speed networks. In 2002 he planned, implemented and managed a new service called DFNRoaming/eduroam within DFN. His main interests are focusing on advanced network technologies, network security and novel network services.

Jari Miettinen is a service manager for the Funet services in CSC, the Finnish IT Center for Science. Jari received his M.Sc. degree from the Helsinki University of Technology department of technical physics in 1998. He is a long-time employee at the CSC with experience on several layers of service management, production and development. His roles and positions have varied from an expert to a development manager. During the recent years his special interests have been public-private partnerships and the development of the inter-NREN services.