Baltic Ring – D4: Support and Funding

Date:	02-09-2011
Author:	Jari Miettinen, CSC/Funet; Juha Oinonen, CSC/Funet; Jani Myyry, CSC/Funet
Document Owner:	Tony Breach, NORDUnet
Security Classification:	Public
Target Group:	Project steering group, contributing partners and the project group
Copyright:	
Version Number:	1.4 (final and reviewed)

Table of Contents

Baltic Ring – D4 Support and Funding

1 Executive Summary

This document is the Baltic Ring pre-study project deliverable number four. The Baltic Ring project was established to investigate available resources, deliver a design blueprint, and describe organisational and operational models for a federated optical network interconnecting the countries around the Baltic Sea. The goal of the blueprinting was to define a prototype solution for the basis of discussion, decision-making and later enhancement.

The project was financed by the Nordic Council of Ministers as part of the strategy to implement a knowledge infrastructure for the Fifth Freedom in the Baltic Sea area [1].

Section 2 describes shortly the questions of support and funding the deliverable is addressing.

Section 3 discusses the background for the work. The basic network structure is introduced and the practical viewpoints are considered. The financing of the research and education networks is described with a long-time overview, examples of current activities and past projects. The financial overview is ended with a summary of financial tools. Section 3 includes also a summary of the current national research and education network (NREN) network operations centers (NOCs) and gives examples of similar operational setups in other projects and activities. The Baltic Ring project work and research methods are described.

Section 4 describes at a high level the operational use cases of the Baltic Ring network. The key requirements of international collaboration are considered and the consequent requirements listed. The requirements for the network monitoring and reporting as well as for communication are listed.

Section 5 contains the cost analysis. A three-level classification scheme for the NRENs is introduced. The structure and content of the capital and operational expenses are explained using this model. The associated capital expenses are considered in detail using two topology options and some methods for optimizing the cost are introduced. The section ends with summaries of the cost.

Section 6 introduces the cost-sharing model by listing the principles and describing their application and outcome in an example and usage scenarios. The financing possibilities for the different items are briefly enlisted. The tariffs are highlighted as the key tool, which is currently missing.

2 Introduction

The purpose of this deliverable is to address the question of support and funding for the prospective Baltic Ring consortium. The task was divided into two subtasks or results, which are:

- Result 6 (R6): Requirements for an operations model.
- Result 7 (R7): Operations cost analysis and suggestions for a cost-sharing model.

The requirements for an operational model means describing and defining the general operational demands, which would exist in the Baltic Ring. The task is to write a compact requirements specification, which would address the key areas for positioning and defining the operations correctly.

The cost analysis includes calculating the cost of establishing the Baltic Ring and describing the items needed. Cost-sharing between the NRENs is requested to be explored and investigated for getting a basis for future work.

These results are judged to lay the economic foundations for co-operation and to provide the starting point for deciding the operational structures.

3 Background and Starting Points

This section describes the proposed structure of the Baltic Ring network, and explains the concept of federation. It then discusses practical aspects that need to be taken into account to ensure the sustainability of the solution, including the differences in the NRENs' transmission systems, taking a gradual approach towards full federation, and the optimisation of domains.

The discussion of financial considerations covers the benefits of recent developments in network technology; existing initiatives that are exploring and promoting co-operation between NRENs; the financial aspects of the collaborative projects SEEFIRE and Porta Optica; and tools for achieving good financial results.

The section goes on to discuss the support structures, particularly Network Operations Centres, that already exist within the NREN partners, and then reviews the operations structures in other federated networks, including LHCOPN, NDGF, EGI and eduPERT.

The section concludes by identifying items intentionally left out of the deliverable, and summarising the work and methods by which the information has been obtained.

3.1 Baltic Ring Federated Network

A federated network means interconnecting resources that are owned by the participating organisations. The organisations assign certain parts or sections of their infrastructure for common use, for which they are compensated. The jointly used resources are monitored and operations performed in a way agreed by the participating organisations.

NREN1 NREN2 NREN3

The principle is illustrated in Figure 3.1 and Figure 3.2 below. The Baltic Ring would be built in a circular topology, where the different National Research and Education Networks (NRENs) would have either one or multiple Points of Presence (PoPs) along the path. The PoPs are the physical access gateways to the Ring's resources and services. The physical realisation of a PoP consists of networking devices and their interconnections. Sometimes the PoP may also contains servers.

The PoPs are interconnected with fibre optic links, which reach over the national borders to the neighbouring country. If two or more PoPs belonging to different NRENs are situated close or adjacent to each other, the entity is called a federated PoP. The connections between PoPs in different administrative and technical domains (the NRENs) make up the desired network.

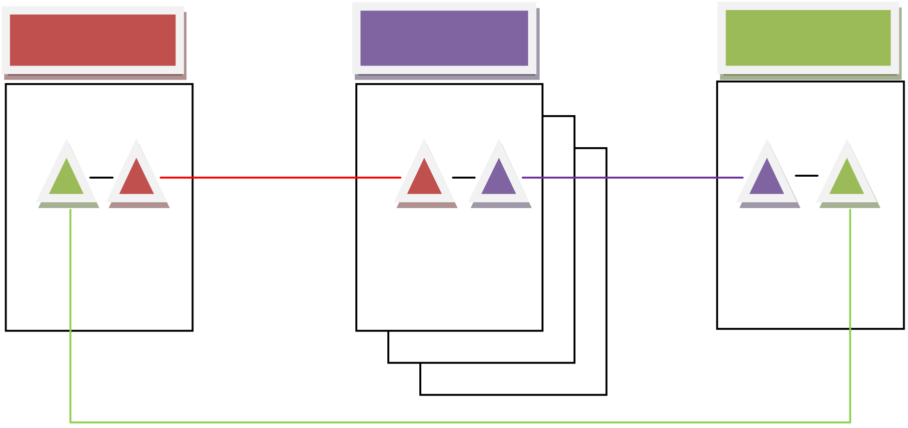

Figure 3.1: Minimal federated ring-shaped network between three NRENs (RING1).

Notes:

- The triangles represent a Point of Presence (PoP).
- The lines represent dark fibre connections.
- The colours indicate the NRENs and the ownership of the devices and connections.
- For practical connection reasons, the NRENs need to host at least one device belonging to their neighbour at their premises or share some other PoP. This is due to simple patch cabling and for assuring the optical transmission quality when interconnecting systems made by different vendors.

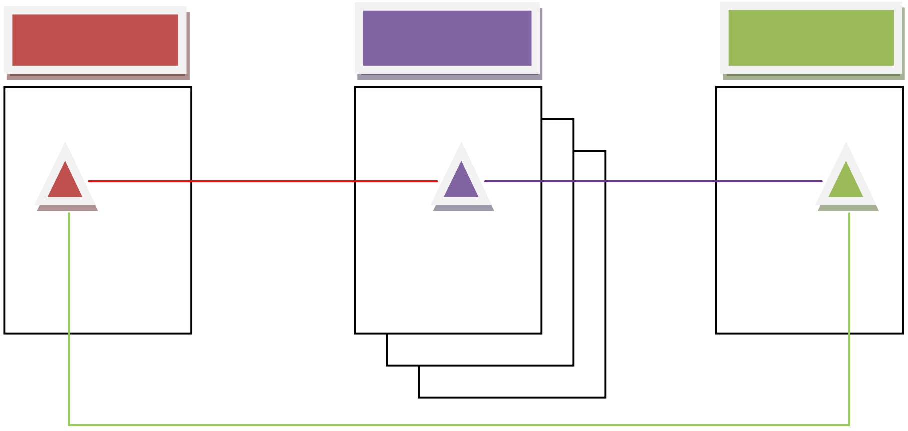

Figure 3.2: Optimised federated and shared network between three NRENs (RING2).

Notes:

- The colours indicate the NRENs and the ownership of the devices and connections.
- The equipment is fully interoperable, so no additional equipment or cabling is needed. The connections are used collaboratively.

3.2 Towards Sustainable Solutions – Practical Considerations

3.2.1 General Baseline

The survey of NRENs carried out for "D2: Network Design" confirmed the feasibility of building the Baltic Ring network [2]. Most of the NRENs possess wide area networks, which are based on fibres. The technical expertise, processes and administration are sufficiently developed to provide high-quality services for the research and education community.

The fibre infrastructure cables needed to accomplish the Ring already exist to a great extent and it is also possible to procure. The networking technology is mature enough for operational application.

There are national initiatives in several countries, which aim to develop the e-Science infrastructure. These initiatives provide a practical basis for information exchange and network development. The emerging e-Science research projects would be the real beneficiaries of the new networking possibilities.

3.2.2 Transmission Systems – Differences between the NRENs

There are significant differences between the NRENs, however. The main differentiating factor is the selection of the optical transmission system, where no two choices are the same. Each NREN has made their selection based on their own starting point and this is clearly visible. The differences are clear also in the capacity of the systems.

Technically, the different transmission systems can be interconnected. Practically, this can mean signal regeneration and other special devices in the optical layer, which increase costs. Systems intended for different uses are also problematic to connect in the same chain, as it is the weakest that defines the limits for the joint operations. The capacity required for the Ring operations may also present an obstacle for national connectivity.

Procuring a high-capacity transmission system can be considered a long-term strategic investment. The operational life span of the devices and management systems is easily greater than ten years. Thus it is highly likely that no NREN that has already made a commitment will easily and quickly re-evaluate their decision.

The greatest possibilities for coherence lie in the Baltic NRENs, as they are still planning and considering the need for large-scale deployment. There is a window of opportunity to create a joint and homogeneous technical and operational domain, which could also be economically advantageous.

3.2.3 Arc of Federation Development

It is politically, technically and administratively impossible to jump from the current networks into a completely federated solution right away. The NREN networks are operational networks with clearly defined functions and operational methods. The planning and analysis of the new systems and their interconnections will take time to carry out properly. The same is true of the procedures and arrangements for the maintenance phase.

It can therefore be presumed that the initial implementation of the Baltic Ring will resemble the setup in Figure 3.1. The NRENs are interconnected with cross-border fibres, but the shared setup contains redundant and parallel systems. The apparent deficiencies are necessary for practical reasons. The early Ring will still be usable and advantageous for limited use. Growing demand will highlight areas and reasons for simplifying the systems, e.g. for economic reasons.

One can see a development arc, which reaches from the early interconnections of the current resources to a truly federated inter-NREN network, effecting a transition from the current situation to RING1 and finally to RING2. The gradual, step-by-step development will allow room for refining the operational structures and responsibilities. Economic planning also becomes more manageable and supportable.

3.2.4 Domains

The usage of the Ring is based on co-operation between different technical and administrative domains. The applications need a negotiation and deployment procedure, which is performed between the different parties involved. The efficiency and smoothness of the practical operations are a major success factor. Successful operations usually also mean cost-effectiveness.

An example of the situation is shown in Figure 3.3. Let’s imagine that a research group in NREN3 (green) wants to have a light path, a dedicated communications channel, to their peer research group in NREN4 (orange). The light path is established using the route NREN3-NREN6-NREN5-NREN4. The physical installation requires installation and configuration work in devices in the four NRENs. It may also require actions and negotiations between the four involved partners concerning the economic and administrative layers.

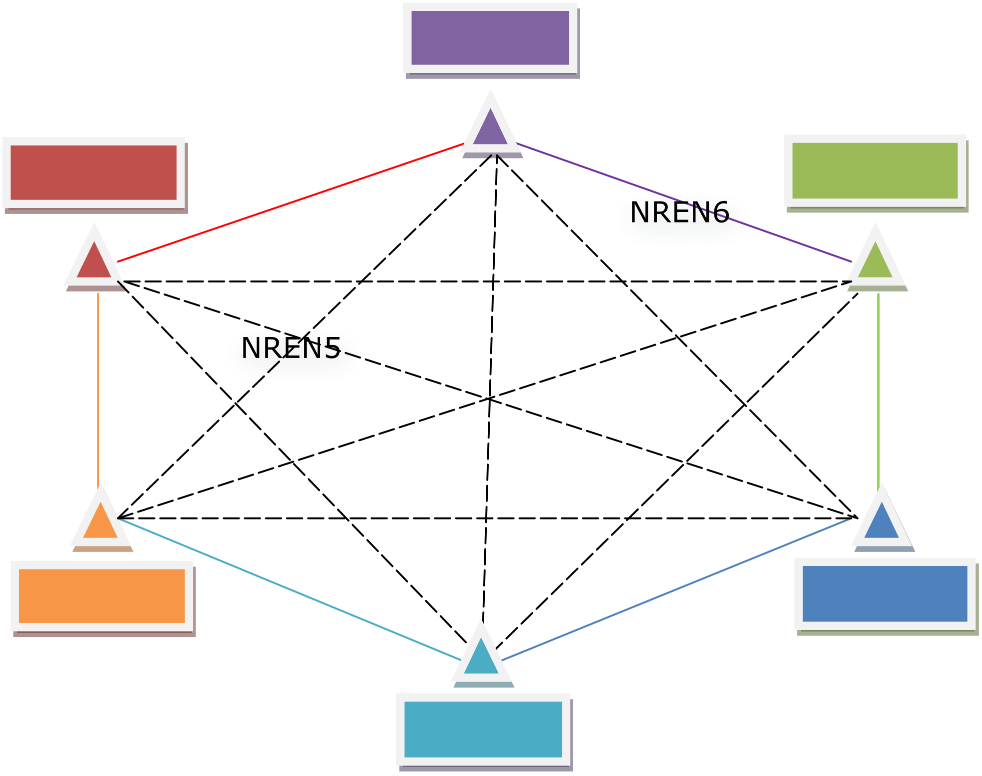

Figure 3.3: A circular network between six domains.

Notes:

- The colours indicate the NRENs and the ownership of the devices and connections.
- The coloured lines represent the optimal path for the desired communication and interaction.
- The black dashed lines form an unwanted full mesh, which corresponds to all-to-all communication between the NREN Network Operations Centres (NOCs).

Mathematically speaking, the complexity of the interaction problem in the worst case is ~ N(N-1)/2, where N is the number of domains involved. The most significant dependence factor here is ~ N^2. This corresponds to a case where, for some reason, all the domains need to interact with one another. At best a linear load might be achieved, where the complexity would reach the value of ~ N. This corresponds to a case where each domain needs to interact only with their nearest neighbours.

Second power is a rather aggressive mathematical function, where the activities required become a significant overhead when N is a large number. This means that, in most situations, the Ring's operations must not require full cross-communication. The optimal situation is represented in Figure 3.3 by coloured lines. The additional communication introduced in the worst case is represented by dashed black lines.

One may also understand the amount of complexity as built-in inertia, which slows down operations. This will be reflected in the number of actions the system can perform in a given time. From the end users' point of view, a complex system seems to be feasible for limited use; however, the profit to effort ratio in larger deployments may be too small. A complex system may also fail to meet timetable requirements, or it may constitute a long and inflexible bar on the critical path in planning Gantt charts. In addition, the complexity may be inherited by subsequent systems and services.

It is tempting to try to reduce the number of domains in the Ring. The optimal number is three (3), as each domain can be reached bilaterally. If redundancy is wanted, the work load is roughly doubled. The three-domain Ring would have all the advantages of the co-operation, with the minimum amount of additional work. A ring with four (4) domains may also be manageable, requiring the maximum of 50% more effort compared to the best case of three.

Optimisation can be achieved by technical and administrative means. Practically, the NRENs can federate their contributions and constitute a single domain; for example, two domains can merge into one. Another strategy could be to adopt a peering approach, with the NRENs present only at the Ring PoPs. Responsibility for constituting the Ring would be left to the other partners. Perhaps a little paradoxically, by staying away from the physical Ring the participating NRENs would optimise the system not only for themselves, but for all the others as well.

3.3 Financial Considerations

3.3.1 Long-Term Financing of e-Science Connectivity

The NREN networks of the early 2000s were based on routers that were interconnected with leased capacity. Router networks still exist, but now they usually utilise transport networks that are owned by the NRENs themselves. Previously this capacity was leased from the operators.

Fibre optic networks developed rapidly in Europe during the first decade of the 2000s. This changed the availability drastically. A previously scarce resource was now a commodity. During the same period, the first applications that used the network capacity massively were introduced: a single scientific application could generate more traffic than all the other users combined. The NRENs were faced with the question of whether to purchase leased capacity with linear cost growth or to have their own transport systems.

Having ownership of the transport systems would also open up new possibilities in the network design. The underlying networks could be planned using the application criteria, not solely in accordance with commercial terms and conditions. The transport systems would introduce additional control and flexibility, which would otherwise be out of reach.

The answer was clear, particularly as the economics of introducing new connections in the transport networks is so favourable. After the break-even point in the number of links, the difference between the approaches grows rapidly. Without the transmission systems, the large-scale application of dedicated e-Science infrastructures wouldn't be economically feasible.

As the use of special, application-specific networks became more widespread, another fact became apparent: the application networks could be built with affordable commodity network equipment and using simple plans. This means savings both in the investment budget and in work time, which is beneficial to the e-Science projects. The same reasoning applies also to any ordinary distributed and large-scale IT system in the universities. Every application can benefit from the economics of simplicity.

3.3.2 Existing Co-operation in Network Operations and Service Economics

The core of the co-operation between the NRENs can be found in the large international networking projects and joint initiatives. The main initiatives are discussed in “D3: Organisational and Operational Model” [3]. Their results are operational networks for the use of the research and education community. Operational events and problems are managed through well-defined hierarchies, in which responsibilities are clearly assigned and delegated.

There are several task forces, based on an NREN work group model, which are exploring and promoting co-operation between research and education networking organisations in Europe. TERENA [4] has task forces on the Management of Service Portfolios (TF-MSP) [5] and Network Operation Centres (TF-NOC) [6]. The NORDUnet community contains Inter-NREN service provisioning [7] and Operational Forum work groups [8].

The charter for the TERENA working groups limits them to two years, after which time the mandate must be revisited and either renewed or the group disbanded. The NORDUnet community groups exist for an indefinite period. The co-operative working groups have been valuable forums for information exchange and discussions. Not all the Baltic Ring participating NRENs have been active in these groups.

3.3.3 Financial Aspects of Selected Previous Projects

3.3.3.1 SEEFIRE

South-East Europe Fibre Infrastructure for Research and Education (SEEFIRE) [9] was an EU FP6 IST project, which worked on the development of research and academic networks in the area of South-East Europe. The economic analysis [10] was ground-breaking and contributed to the GÉANT2 project. The analysis suggested two different calculation models: one for rough analysis and a second for comparing different offers. The SEEFIRE models were used for calculating a deployment budget for fibre optic networks in the target area.

The SEEFIRE rough model (Model 1) calculates the combined cost by taking into consideration fibre acquisition and maintenance cost, equipment acquisition and maintenance cost, and equipment co-location cost. The results are calculated for 1-, 5- and 15-year periods using the fibre distance and pricing information. Five (5) years is suggested to be the optimum period for comparison in real applications.

The SEEFIRE precise model (Model 2) uses a set of route offers and a per-route demand scenario as primary data inputs. These figures are used to search for the optimal combination, which takes into account the estimates of the assumed utilisation. The precise model is a good tool in a call for tenders procedure, with the advantages becoming more apparent if the number of offers is large.

3.3.3.2 Porta Optica

Porta Optica [11] was also an EU FP6 project. The goal of the project was to stimulate and consolidate the initiatives to deploy dark fibre-based research and education networks in the Eastern Europe, Baltic States and Southern Caucasus region. The project included an NREN survey, requirement specification, legal and political survey, a suggested agreement, and economic analysis.

The Porta Optica economic analysis deliverable [12] discusses the cost of the dark fibre network in detail. Special focus is also put on the cost of the transmission systems, where novel programmable photonic systems are seen to introduce savings. A dark fibre network cost model is introduced and is applied to the project partner NRENs. Finally, the PIONIER management system is given as an example for organising a NOC in an NREN.

3.3.4 Tools for Achieving Financial Results

Tools for achieving good financial results in international collaborations include the project model, project direction, cross-border co-operation, and non-financial transaction types.

The project model has proved to be effective in international collaborations. The limited timeframe and well-defined workflows of the project methodology have resulted in long-lasting structures and success stories. The negative results have been equally important, as they have shown some ventures to be too difficult. The financial considerations, however, have often been limited to keeping only the budget of the project itself in order: the long-term financing and sustainability aspects have been overlooked. This tendency should be avoided in the coming Baltic Ring development projects.

Direction of the project is equally important. The participating institutions of the proposed Baltic Ring consortium [3] provide a natural base from which to form the steering group. The consortium shares the project goals, so it can guide the actions according to shared guidelines for mutual benefit.

Cross-border co-operation offers opportunities for a new kind of joint financial planning. The collaboration can be extended to joint procurements, of the networking equipment and connectivity, for example. The Ring services will be shared by definition, which means savings in service development. At least some parts of the service marketing and communications can be done in co-operation, which will again introduce savings and may lead to increased quality. All these benefits can be seen as originating from economies of scale.

The collaborative nature of the consortium suggests that barter trading and swaps may be used. In barter trading, commodities are exchanged for other commodities with no accompanying financial transactions. Examples of targets for swaps include light paths and PoPs. The swaps can be temporary, with ownership not being transferred and the arrangement resembling more a lease agreement. There may be some fundamental restrictions to bartering due to the NRENs' statutes, so the legal aspects should be carefully investigated before application.

3.4 Available Support Structures – NREN NOCs

All the NRENs have a Network Operations Centre (NOC). They serve as a single point of contact for all operational matters concerning the services. The concept of the NOC resembles the Service Desk defined in the Information Technology Infrastructure Library (ITIL) IT service management framework [13], although the NRENs do not necessarily follow this particular specification. The ITIL Service Desk is a first-level help desk offering end-user support, while the NREN NOC can be either a pure level-two help desk, supporting site networks managers only, or a combined first/second-level help desk.

The NOC serves as the initial owner of service requests. It may have some means to handle certain requests autonomously until they are completed, but for covering all the tasks some delegation measures are usually available. The NOC can assign tasks to other processes, which assess and handle the cases until they are finished. The tasks are communicated and documented using electronic ticket tracking systems.

The service request can also be generated internally. The NOC is normally equipped with monitoring systems, which give an overview of the general situation of the services as well as the status of the technical systems, such as the hardware components in routers. The service anomalies generate alarms, which are investigated and taken care of.

Both internally and externally generated service requests produce communication needs, either to a specific user base or to wider audiences. Communication is an essential part of the work of the NOC, and is supported by user registries. All the work carried out by a NOC needs to be performed in a strictly defined and correct way, which is possible only with extensive documentation and operational guides.

The NOCs in NRENs have a long history, which means that the operational practices are well-established. There are differences, however, such as in hours of operation, tools, expected response times, operations processes and policies in general. The federated systems should follow similar practices, which involves local customisation on a case-by-case basis.

The requirement for similar practices is not an obstacle, however, as it is common to have different Service Level Agreements (SLAs) for different services: the NOCs already act differently with regard to the services offered. The federated services would be just one additional task, with its own characteristics.

There are examples where the NREN NOCs have provided services to projects with operational needs. This has saved the projects the effort of establishing a NOC of their own, and has allowed them to concentrate on their research. Four examples are described in Section 3.5. Exactly the opposite decision to diversifying also exists, where the NRENs have outsourced their NOC. One example of this is SUNET, which has outsourced its activities to NORDUnet.

3.5 Operations in Other Federated Networks and Systems

3.5.1 LHCOPN

The Large Hadron Collider Optical Private Network (LHCOPN) is an optical private network, built for transferring data between tier sites of the Large Hadron Collider (LHC) [14]. LHC is a very large scientific instrument for high-energy physics, which is located underground near Genève, Switzerland. The experiment produces large quantities of data which is distributed around the globe. The scope of LHCOPN is restricted to interconnecting the main sites, which are called Tier-0 and Tier-1 in their terminology [15].

Although LHCOPN is devoted to a single application running on top of IP, it has many similarities with the Baltic Ring. The physical setup consists of light paths and physical connections, which are provided by GÉANT, NRENs and other partners. Ownership of the hardware and networking elements is also distributed among the partners. The operational challenges consist of maintaining the operations level, fault isolation, fault management, debugging and fixing in a federated system.

The challenge is solved by establishing a separate LHCOPN help desk and L2 NOC for supervising the actual connections that constitute the LHCOPN network. The role of the help desk is to monitor the network for faults and initiate actions using, for example, a ticketing system. The L2 NOC completes the role of the help desk with the capability to configure the networking elements of the LHCOPN.

The operation of the network is supported by the partners with router operators and applications specialists, and data GRID contacts on each site. The local support personnel can quickly diagnose or rule out the very basic types of incidents, which aids in fault isolation. The typical problems are seen to exist between two sites, where the router operators and GRID contacts can effectively solve problems by interacting together with the help desk. The operational model is described in detail in [16].

The changes required in the LHCOPN are assumed to be limited. They assume that the network will grow to a certain extent, but operations are thought to be restricted to deployment of new connections and rerouting. Servicing of faulty equipment may involve a field service, which is again supported by the named on-site staff.

The LHCOPN consortium has solved the operations of the federated infrastructure effectively and reliably. The procedures provide a model for shared operations and responsibility sharing.

3.5.2 NDGF – Nordic DataGrid Facility

The Nordic DataGrid Facility (NDGF) is a production-grade GRID facility, which is provided collaboratively by Denmark, Finland, Norway and Sweden primarily as a Worldwide LHC Computing Grid (WLCG) Tier 1 distributed data centre. The services are provided using the Advanced Resource Connector (ARC) and although not supported, the services can also be used with the gLite GRID middleware. NDGF doesn't support individual users directly, but expects the users to constitute virtual organisations (VOs). The virtual organisations own the GRID resources; the role of NDGF is to provide the GRID interface for sharing them [17].

The harmonisation and sharing of the middleware layer helps bring the user groups and service providers together. The ARC servers are distributed and share tasks so, that the whole service base is generally still operational even in the event of severe problems in some sites. The approach is rather open-minded in other respects as well, as there is no central database for the virtual organisations' resources. Rather, control is concentrated on access management, which is based on certificate administration. The middleware provides the means for submitting and monitoring jobs, resource information services and basic data management [18].

The middleware service is monitored 24/7 by a duty operator during office hours and by first-line support outside office hours. The duty shift is rotated among the national site administrators in four (4) week rotation basis. The site administrators constitute an international virtual group, which shares expertise on the system. The problems are analysed by the operator. Depending on the outcome of the analysis, the operator is authorised to contact the system administrators of the various GRID resources. The problems are solved co-operatively.

The support structure includes the role of the technical coordinator for interacting with the special user groups. The CERN co-operation is a special case and is handled by the CERN coordinator. The software coordinator liaises with the parties developing the middleware. Both the CERN coordinator and the software coordinator report to the technical coordinator [19].

The NDGF approach to organising the GRID operations is neutral with regard to services or users. The introduction or withdrawal of services is a relatively straightforward procedure, which gives scope for the development of communities. The mixture of conventionally and virtually manned network operations can be regarded as a very well secured and distributed management system.

3.5.3 EGI Global Grid User Support

Global Grid User Support (GGUS) is a help desk originating from the needs of Enabling Grids for E-Science (EGEE), an EU FP7 IST project [20]. GGUS is the mechanism for handling support requests for European Grid Infrastructure (EGI) [21]. The challenge is to respond to the demands of the GRID community on a global scale. For example, EGI lists 51 participating countries with 338 resource centres in their utilisation figures (June 2011) [22].

The solution was to distribute the task regionally under the coordination of the centralised help desk, GGUS. Regional Operations Centres (ROCs), VOs and even single users can access the centralised service portal, where the requests are classified and assigned to the proper handler and solver. Responsibility for tracking the cases belongs to GGUS. User certificates play a central role in authentication and request acceptance.

The GGUS system is run by the University of Karlsruhe, Germany. The service hours are during office hours. For operations, housekeeping the ticket database and maintaining the documentation, a separate Ticket Process Management (TPM) team is defined. The TPM teams are a collaboration between Italy and Germany, and work in one-week shifts. The GGUS documentation [23] is very thorough and extensive, while still maintaining usability. It serves as a model and baseline.

3.5.4 eduPERT

eduPERT [24] is a federation of level 3 help desks supported by GÉANT. The goal of eduPERT is to optimise the use of the network end-to-end. This is a very challenging task, which requires expertise not only in the networks and networking equipment in all the layers, but also in the disciplines themselves. The discipline experts are called Subject Matter Experts (SMEs).

eduPERT is a federated effort, involving a national Performance Enhancement and Response Team (PERT) in each of the participating countries. Up until 2008, the activity was coordinated by the duty Case Manager (person) and the tasks were handled using a shared ticketing system, the PERT Ticket System (PTS). The coordinator role was then ceased and the ticketing system closed. They were replaced by a national PERT contact information catalogue, which transformed the operations into a very loose federation model [25]. There are 17 national PERT teams in Europe (2011) [26].

End users can request help from the national PERTs, which in turn can escalate cases to other NRENs if necessary. The cases are related to Quality of Service (QoS) problems. The eduPERT services are diagnostic, consultancy and direct configuration and equipment advice. There is also a public knowledge base that is available for self-help and autonomous problem-solving.

It should be noted that due to the federated nature of the activity, the eduPERT members can influence and assist other NRENs and international research and academic backbone networks to isolate and fix problems in their systems. This result is achieved with a loose federation, where the partners have decided to follow common guidelines.

3.6 Out of Scope

The SLA specification has been left out of this deliverable. It is assumed that the different alternatives for establishing the Ring will affect the exact definition considerably, and room for negotiating the content should be left accordingly.

Pricing and marketing aspects could be seen as belonging to the cost-sharing model, since they might bring additional insight to the services of the Ring. However, these have been left to be investigated in the later work. Cost recovery is briefly discussed in Section 6.6 on page 38.

“Productisation” – the packaging of services as products – is an interesting approach, which is touched on in Deliverable 3, Section 4.3 Service Portfolio Complexity. The scope defined for the Ring suggests a simple portfolio, which in practice means that the answer can be found by examining the existing NREN service sets. The Ring can both introduce improvements to the existing services and provide opportunities for offering completely new services. These discussions have been left out of the deliverable.

The related agreements and the agreement framework are discussed in [3, Section 5]. As well, the description of the network supervisor (NOC) and other organisational issues are discussed in [3, Section 6].

3.7 Project Work and Research Methods

The information in this deliverable is based on industry literature and web sources, visits to NRENs and personal interviews. The literature and web sources were identified by reviewing recent work done in this field, and were supplemented and updated by the visits to NRENs.

The NREN visits also revealed the local needs and preferences in each country. Personal interviews and correspondence were used to clarify issues and details.

4 Requirements for the Operational Model

This section describes at a high level the operational use cases to which the Baltic Ring network should be able to respond, structuring the discussion on the ISO FCAPS model of network management. It then considers specific aspects that arise from the requirements of international collaboration. It goes on to discuss network monitoring and reporting, and communication, and ends with a summary of operational requirements.

4.1 Operational Use Cases

This section discusses the events and use cases to which the Baltic Ring network operations should be able to respond. The items are described at a general level and a basic specification is given. At a later stage, the items should be elaborated in detail, to define a process for each of them. The categories follow the ISO FCAPS (Fault, Configuration, Accounting/Administration, Performance, Security) model of network management.

It is expected that the Baltic Ring network operations will be independent of procurement and planning. The role of operations is to monitor and take care of the resources allocated for common use. On the other hand, maintenance and related issues are also within the authority of operations. The actual operation – of the network elements, for example – can be delegated in a federated setup.

i. **Fault management (FM)**. Operational problems must be traceable and it must be possible to repair them. Operations must be able to monitor the status of the network and the deployed services. Monitoring should be at a level where fault isolation and localisation are possible. Responsibility for fixing faults must be clearly defined and the repair time should be predictable.

ii. **Configuration management (CM)**. the Baltic Ring network must be able to grow and shrink. This applies to the introduction of new devices, additional connectivity to the backbone, and new services. The withdrawal of the deployments must be equally possible. Operations must be able to plan and direct the necessary changes, and to operate the network elements in order to control the change. Operations must be able to plan, support and direct both planned and unplanned/emergency maintenance of the network elements.

iii. **Administration management (AM)**. Operations must produce network reporting data that is suitable for assessing the use and usability of the network. In addition, the data should support the billing models and procedures that the parties choose to deploy.

iv. **Performance management (PM)**. Operations must analyse the network management data to determine whether the network is functioning according to the specifications. The analysis can also be used for future planning and decision-making on updates and upgrades.

v. **Security management (SM)**. Operations must be able to respond to security incidents reported by the users and the anomalies they detect themselves. Operations must be able to take the necessary measures to remove the cause of the unwanted and unexpected behaviour. The network must be in a controlled, defined state and used by legitimate users.

4.2 International Federated Network Operations

This section considers the specific aspects that arise from the requirements of international network operations. Possible solutions are suggested for addressing each item.

i. **Multi-lingual issues**. Each of the proposed partners in the collaboration has a different native language. In addition, Russia uses the Cyrillic alphabet. It is therefore suggested that:

   a) The collaboration uses English as the language for operations for the time being.

   b) Operations and end-user support will be defined as a federated structure for supporting the researchers and other end users in their native language.

ii. **Responsibility and duty sharing**. The building blocks of a federated network are owned by the participants by definition. There is therefore a need to assign the operational tasks to the proper partner. It is suggested that:

   a) A joint NOC is established for coordinating the contributed resources that constitute the Baltic Ring network. This NOC can be either a traditional operations centre or a function that is distributed between the partners, who work in shifts.

   b) Operations is established as a federated structure for supporting the operational realities in different NRENs.

   c) Responsibility for reacting to, correcting and fixing the identified problems and anomalies will belong to the NREN in question.

   d) Inability to fulfil the responsibilities will be reported and escalated to the collaboration bodies.

iii. **Customer ownership and service delivery**. The Ring’s end users – its customers – will consist of various virtual organisations with unpredictable durations. It is suggested that:

   a) Customer ownership belongs to the NREN or NRENs where they originate.

   b) The NRENs involved will be responsible for negotiating the solution to the customers’ needs and for communicating it to necessary parties.

   c) The NRENs can withhold the service at their discretion.

iv. **Service level**. The performance of the federated network comes from the sum performance of the component parts. This is no different to any other network. The differences and difficulties arise from the differences between the administrative domains. It is suggested that:

   a) The NRENs decide together a target service level and communicate it to the user community.

   b) The service level should reflect the average performance of the associated networks.

v. **Workflow descriptions**. The number of partners and peer groups is large enough to create confusion about the methods used in operations. It is suggested that:

   a) Special workflow descriptions are designed, which clarify operations activities to all parties.

   b) Workflow descriptions are created for the processes listed in Section 4.1.

4.3 Network Monitoring and Reporting

Network monitoring and reporting have a special place in the federated network. The partners are dependent on the Ring services to some extent, but they may not be able to affect the systems directly. Besides the network operations and fault detection, the data can be used as input for such tasks as accounting and service negotiations. This raises the criticality of the monitoring process.

i. **Responsibility for monitoring**. The level and quality of the monitoring should be agreed, assured and clear. It is suggested that a single party is responsible for:

   a) The platform that performs the monitoring of the Baltic Ring.

   b) Ensuring that the monitoring covers the actual use and configuration of the Baltic Ring.

   c) Ensuring that all the required functions and parameters are included.

ii. **Processing and refining the data**. The network monitoring data has to be processed to be useful and informative. The processed data is required in network management, administration and in public relations. It is suggested that:

   a) A single party is responsible for the data processing and visualisation for different purposes.

iii. **Data availability**. There is no need to hide or restrict the use of the collected data. Greater availability will raise confidence, as the data is verifiable. It is suggested that the measurement data is:

   a) Available to all the partner NRENs equally.

   b) Available to the end users in an appropriate and sufficient manner.

c) Stored in a format that can be transferred to and utilised in current and future systems with reasonable confidence.

d) Saved reliably and the aspects of digital curation are taken into account in an appropriate and sufficient manner.

iv. **Guidelines for selecting the tools**. There are some special aspects that derive from the long-term nature of the operations and systems. It is suggested that:

a) The used and deployed software is selected so that it has a long life expectancy and offers the possibility to change the platforms and software.

v. **Resourcing and scoping**. Technical monitoring in a multi-vendor optical network is demanding. It is suggested that:

a) The partners provide the necessary data in a transferable format for shared use.

b) Some of the resources in the Ring are allocated for monitoring purposes, as monitoring light paths, for example.

4.4 Communication

Communication between the partner NRENs and their NOCs is central to the practical use and functioning of the network. For example, failure to communicate problems, or gaps in their communication, directly affects the availability figures. Therefore it is necessary to define the information exchange jointly.

i. **Defining the information exchange**. It is suggested that the partner NRENs jointly:

a) Define a communication model.

b) Select and agree communication formats and the documentation standards.

c) Decide the level and frequency of communication.

d) Select the tools and support structures that comply with the model above.

e) Take special care to reduce the noise and churn in the communication.

ii. **Policy for announcements**. It is suggested that:

a) Direct or urgent problems with network use will be made known without delays.

b) Notice of planned short-term operational breaks and maintenance breaks will be given not less than three working days but no more than a week in advance.

c) Long-term difficulties in sustainability will be announced without unnecessary delay and preferably not less than six months in advance.

4.5 Summary of the Requirements

The high-level operational requirements are summarised in Table 4.1 below. The number of IT systems involved is intended to be small. With efficient work definition and work sharing the overhead is kept to a minimum. Effective and well-defined procedures keep the table clean. The setup is achieved with a high level of commitment from the NREN administration teams in the establishment phase of the Baltic Ring.

Aspect	FM	CM	AM	PM	SM
Amount of infrastructure involved	Low	Low	Low	Low	Low
Amount of associated data	Medium	Low	Low	Low	Low
Activity work volume	Low	Low	Low	Low	Low
Required agility	High	Medium	Medium	Medium	High
Timetable strictness	High	High	High	Medium	High
Administrative contribution	Low	Low	Medium	Low	Medium

Table 4.1: Scope of network management functions.

Notes:

- The intention is to use relatively limited amounts of resource in a well-defined manner and effectively. The attributes High, Medium and Low describe either the actual amount or the intended amount.
- The columns reflect the FCAPS categories (see Section 4.1 on page 17).

5 Operations Cost Analysis

This section introduces the three levels in the partner NRENs' evolution towards full Baltic Ring support and participation, and uses these to structure the summary of CAPEX and OPEX. It goes on to consider some of the capital investment items in more detail, including networking equipment, dark fibre and undersea connectivity, and then looks at mechanisms for optimising costs, such as agreement duration, leasing versus ownership and SLA / quality compromises. The section concludes with an analysis of initial costs

5.1 Overview of the Actual Cost

To be able to support the Baltic Ring initiative, an NREN should fulfil one of the following criteria, where a) allows limited Ring support and participation, and c) allows full support and participation:

a) IP-only transport capability: a fundamental ability, which allows the IP traffic to cross the network either routed or tunnelled. The drawback is the extra need to convert the transit optical traffic to IP packets and back to optical.
b) Dark fibre capability: the NREN has a dark fibre-based network, which supports the use of multiple wavelengths (colours).
c) Dense Wavelength-Division Multiplexing (DWDM) capability: the NREN operates a managed optical transport network.

Operating at the a) level sets several limitations on the peer NREN's use scenarios. Both the set of supported services and their quality and capacity are limited.

NRENs at the b) level can support the Ring services fully, but their own options for monitoring and administering the network are limited. Moreover, the optical capacity is limited and there's no support for long-haul optical networking.

NRENs operating at the c) level are fully compliant.

Table 5.1 and Table 5.2 below summarise the different items of capital and operational expenditure, respectively. New hardware, connectivity and software are needed. In addition, a certain amount of effort, quantifiable in cost terms as man months, is required to realise the deployment.

Item	Type	Cost Level		
		a)	b)	c)
Fibre acquisition	Connectivity	Medium	Medium	Medium
Equipment acquisition	Hardware	Medium	Medium	Low
Establishing network monitoring and operations	Man months, software, hardware	Low	Low	None
Establishing NREN internal technical support structure	Man months	Medium	Medium	None

Table 5.1: Summary of NRENs' CAPEX.

Notes:

- The NRENs are expected to try to reach level c) and interconnect with each other.
- The items are those specified in [10] Model 1. In addition, establishing the network monitoring, operations and technical support structure is taken into account.

These items are discussed in more detail in Section 5.2.

Item	Type	Cost Level
Fibre maintenance	Rent	Medium

Item	Type	Cost Level
Equipment maintenance	Service fee	Low
Equipment co-location	Rent	Low
Monitoring and provisioning	Man months, hardware, maintenance cost	Low
Technical support structure personnel	Man months	Medium

Table 5.2: Summary of NRENs' OPEX after reaching level c) and interconnection.

Notes:

- The items are those specified in [10] Model 1. In addition, the running costs of the monitoring and support structure are taken into account.

5.2 Capital Investments

5.2.1 Networking Equipment

Depending on the NREN's level of evolution (a), b) or c), as defined in Section 5.1), there may be a need to upgrade, update or increase the equipment base. This will result in a transition from one level to another. The update will be a tender for either Coarse Wavelength-Division Multiplexing (CWDM) or Dense Wavelength-Division Multiplexing (DWDM) devices.

As a minimum, the devices need to be able to relay the Ring between the neighbouring partners and enable the NREN's own access to the Ring. Relaying will involve signal regeneration in most cases. If a single-device approach is chosen, the device should be located centrally to the existing network, so that connections can be accomplished efficiently. A wider installation base would enable redundancy and extended coverage.

The equipment should have sufficient overall capacity and expansion possibilities for future development. The possibility that both national use and by-passing connections may require new interfaces should also be taken into account. Simple usage calculations reveal that the most affordable models may soon become insufficient. This has an impact on the investment budget needed.

If a green-field approach is chosen, the NREN can still adopt a strategy of having higher capacity in the central systems in the network while the leaves have more limited equipment. This leads easily to star network topologies. The Baltic Ring node would provide the first building block for the network. As it is also possible to build the national optical network independently of the Baltic Ring, the presence of the Ring can be seen as an additional option.

5.2.2 Dark Fibre Acquisitions

Because the NRENs have built their networks primarily for interconnecting domestic institutions, they may not have connections towards the national borders and other NRENs. As a result, these missing links may need to be acquired before the co-operation can start.

In addition, if the NREN wants to reach the b) level defined in Section 5.1, they may have to obtain dark fibre infrastructure. Typically these need a public call for tender process and thus they are demanding projects both in terms of man power and financially. The call for tender process needs project funding. The contractual agreement with the supplier may include an advance fee, which is a capital investment for all practical purposes.

The presence and availability of fibre infrastructure in a country are major factors affecting acquisitions. There may be areas where no fibre optic networks exist. Also, there may be links missing between certain cities on the desired path. In addition, the quality of the fibre may not be good enough for advanced use. The long fibre stretches need extra amplification, which means extra equipment purchases.

The physical construction of new optical networks means a major uncertainty concerning costs and should be investigated in the pre-study project.

5.2.3 Undersea Connectivity

The Baltic Sea can be encircled by land, except for the Danish straits. Sea cable connections are a scarce resource and they need special consideration. NORDUnet operates fibre optic connections between Denmark-Sweden and Sweden-Finland. For redundancy and shortcutting, additional undersea connections could be of benefit, which would result in a dual- or triple-ring topology.

The available alternatives are the existing undersea fibres between Estonia-Finland, Estonia-Sweden, Latvia-Sweden and Lithuania-Sweden. The fibre connections to Latvia and Lithuania go via the island of Gotland. One of the fibres between Estonia and Sweden is routed via the island of Hiiumaa.

The undersea fibre between Estonia and Finland is a special case, as the Gulf of Finland is relatively narrow. The distance is so short that no special amplification is needed between the end points. This should have a positive effect on the lease pricing, provided no other economic factor outweighs this influence. It is suggested that special attention is paid to this particular alternative.

In any event, undersea connectivity has a substantial cost compared to terrestrial links. The additional connectivity possibilities introduce more complexity to the systems. An acceptable balance should be sought, where the concrete needs of the partners are the deciding factor.

5.2.4 Establishing Network Monitoring and Operations

The NRENs involved in the Baltic Ring project have to agree on the demarcation points and the limits of responsibility for operational and administrative reasons. This process requires work time from all the parties, but it may also result in a shared information channel for operational messaging. The messaging system has both capital investment and work time components.

Depending on the choices the NRENs have made previously, they may need to perform internal changes to their current operations structures, instructions, devices and software. The task may be a small one, but it could have a significant impact. For example, the acquisition of new systems means a completely new process has to be defined, which may utilise new tools for system administration. Training may also be needed in order to reach the level required for reliable operation.

5.3 Optimising the Cost

Building the infrastructures could easily lead to parallel or overlapping systems that perform similar tasks. This may well be justified, for organisational and security reasons, for example. In addition, minimising system complexity may be best achieved with parallel, simpler autonomous structures.

The Baltic Ring strives to optimise costs at the international level. This is an important matter not only for the countries supporting the information networks but also for the multi-national research projects. The large distributed e-Science projects are dependent on networks for their function and collaboration. Cost is a major limiting factor in building the research platforms. So far, the implementation of large-scale research infrastructures has been restricted to the most prominent initiatives only. The advent of DWDM and dark fibre has enabled NRENs to commit to extend the infrastructure to the wider community.

i. **Agreement life span**. The agreement duration is the easiest way to add flexibility to the financing. For most organisations' cost structures, longer durations are better as they allow the owner of the contributed resource to assume a constant reliable income.

ii. **Leasing versus ownership**. When a tender is carried out, it is possible to choose between leasing and ownership. In an uncertain case, both alternatives can be covered. This principle applies both to the hardware and to connectivity. Leasing spreads the financing over a longer period of time. Ownership is a special case of upfront payment. If the upfront payment doesn't cover the whole purchase amount, the remaining part can be paid in instalments, with a loan, for example. An upfront payment can be associated with a leasing agreement as well.

iii. **Harmonising hardware**. Using similar equipment means savings in the technical implementation, as the devices interoperate well. In addition, the spare parts could be compatible, which helps with repairs and may introduce savings in maintenance fees. Also, expertise is accumulated as the technical personnel can exchange information and give peer support in the event of difficult problems.

iv. **Co-operation in building the fibre routes**. The construction of completely new fibre routes for long-haul connections is very expensive. Co-operation and co-financing, either with other consortium members or with third parties, are recommended approaches in order to reduce costs. A fibre cable contains multiple fibre pairs and the excess pairs could well be shared, as there is no requirement for complete long-haul cables in the foreseeable future.

v. **Using and sharing existing infrastructure**. All of the existing infrastructure that is owned by the partners can, in principle, be shared under certain terms. This includes computer rooms, cross-connects, fibre ducts and routes. Under the proposed consortium guidelines, the shared resources should be competitive compared to the market offerings.

vi. **SLA and quality compromises**. If a lower maintenance service level is acceptable to the Baltic Ring Consortium, one can prefer lower charges to higher quality and approve operational risks. This approach accepts longer service breaks during cable cuts, for example, in return for reduced payments. Another way is to negotiate over the quality of the equipment and connectivity. However, this is a rather dangerous way to achieve savings, as the operation of the whole Ring is endangered. If these kinds of methods have to be applied, the degraded level should be accepted by the whole consortium.

5.4 Initial Analysis: Cost Summary

This section provides summaries of the estimated minimum cost. The estimates indicate the additional resourcing that is needed on top of the current operational level. The calculations correspond to the yellow bar "C" in Figure 5.1.

5.4.1 The Case for Basic RING1

The authors estimate that in order to achieve a RING1-type network (Section 3.1, Figure 3.1 on page 6), the total amount of capital expenditure would be around 1.7M euro (±20%) and the total operational expenditure around 6.0M euro (±20%) over a five-year period (Table 5.3). This is based on a rough calculation of two level a) NRENs and four level b) / c) NRENs. On top of this, the cost of work time should be taken into account (Table 5.4). The work time expenses differ greatly, so they have not been converted into a monetary value.

The figures in Table 5.3 are based on a refined estimate. The costs were discussed during the NREN visits. The figures should be used as a rough tool for evaluating the cost level.

It should be noted that fibre lease prices in the Baltic countries are up to five times higher than in the Nordic countries. The operational costs are therefore more dependent on actual fibre pricing than is typically the case, and the margin of error in the cost estimates is greater. Operational costs may decrease substantially if an inexpensive dark fibre option is available. The indicative pricing for the undersea dark fibre pricing between Finland and Estonia was obtained during the project.

The most critical factor is the availability and pricing of fibre optic connections between the sites. The calculations are based on reasonable fibre pricing which can be obtained from the healthy commercial market.

The expenditure will apply to an NREN that is either missing some critical devices and infrastructure (levels a) and b)) or is adjacent to a level a) or b) NREN. In some cases, missing connectivity between two level c) NRENs may result in type C expenses to them both. If an NREN is already well interconnected with others it may not incur any substantial expenses except the provisioning of new connections.

5.4.2 The Case for Optimized RING1

If the RING1-type network is wanted to be optimized closer to the RING2-type network (Section 3.1, Figure 3.2 on page 7), the associated cost has been calculated in [2, Section 7]. Reference [2] introduces the entity of Carrier X, which would facilitate the link between NORDUnet PoP in Helsinki and PSNC PoP in Bialystok. The idea is based on the coordination of the DWDM network development according to the principles of the Baltic Ring.

The optimized RING1 would introduce savings by simplifying the domain structure (Section 3.2.4), but there may still be some redundant infrastructure present. This suggestion takes into consideration the fact that NRENs may be cautious for changing their DWDM current equipment and suggest resource sharing in the region of the Baltic countries. The compromise approaches the RING2 model as close as it is feasible.

The optimized RING1 gives opportunities for savings in the work time budget. The savings result from the limited deployment needed for the Carrier X. The NRENs do not need to carry out a complete transformation to DWDM capability (level c)), but they can adopt a stepwise strategy. This reduces need e.g. for the personnel training, installation work force and operational capabilities, but it doesn't remove them completely.

However, the optimized RING1 depends deeply on the support and contributions from the Baltic Ring consortium NRENs. The NRENs, who already operate large-scale DWDM networks, may wish to support the establishment of the Carrier X. Their knowledge and expertise can speed up the development and deployment. The work time need estimate is given in Table 5.5. The need for labour in level a) and b) NRENs is considerably smaller compared to the case of basic RING1. The peer support is assessed to double the amount of work in NRENs in level c).

5.4.3 The Case for RING2

The building of the RING2 would mean building a technically completely interoperable network around the Baltic Sea. Using today's technology this would mean building a parallel network either for the PSNC PIONIER or NORDUnet parts of the Ring. In addition, a new network, the Carrier X [2, Section 7] needs to be established.

The possibilities and economics related to the establishment of Carrier X are discussed in 5.4.3. The extent of both the PIONIER and NORDUnet is wider than Carrier X in the Baltic Ring. If a parallel network would be built to replace either of them, the price would be higher as well, not just a double. It is hard to justify such extra financing, as in the current situation the parallel network wouldn't provide significant cost savings in the maintenance phase, which would justify the additional CAPEX. If the use of the Baltic Ring would grow very extensive, the administration and optical regeneration costs might give the reason, but this situation is years away.

The possibilities of the RING2 should therefore be put aside until the planned life cycle of the current DWDM networks is reached. Practically, this will be due between 2020-2025. Greater integration may be possible then due to more tight co-operation during the years and advances in technology.

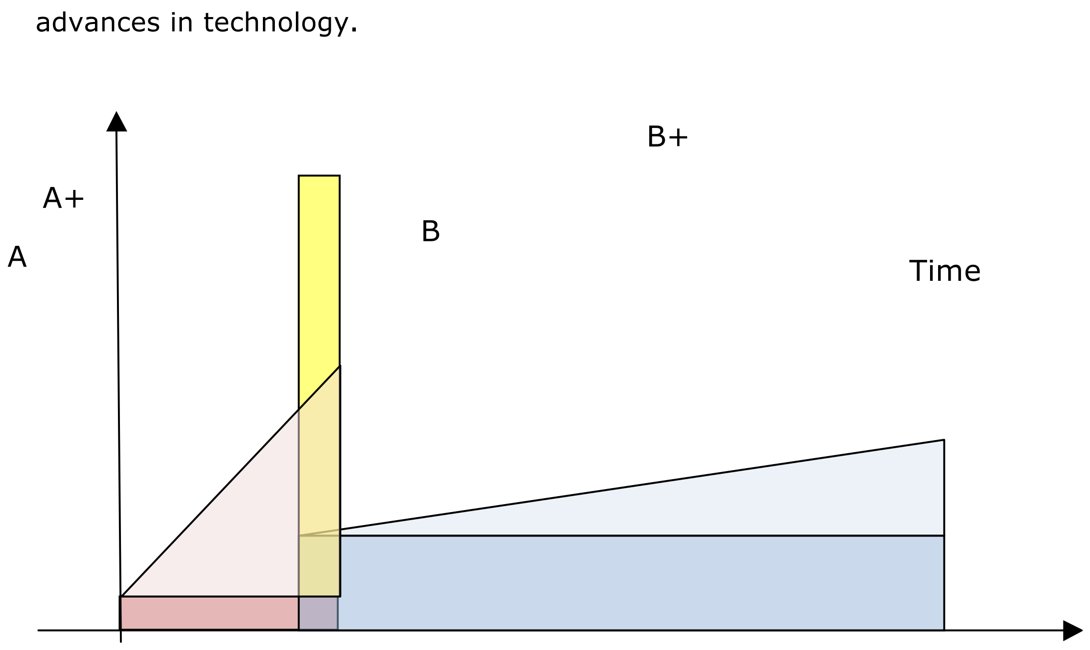

Figure 5.1: Schematic diagram of the structure of associated cost.

Notes:

- The NREN activity is being changed from red (A) to blue (B).
- The red system has a lower base cost (A), but the price of operations grows quickly as the use increases (A+).
- The blue system has a higher base cost (B), but the price of operations (B+) grows more slowly. This leads to cost optimisation and makes extended use possible.
- The yellow bar (C) represents the transition cost.
- In economic terms the most knotty point is the transition period, where both the red and blue systems exist and contribute to the financing needs.
- The DWDM transition is expected to follow this diagram approximately.
- The pricing of the leased capacity is a major factor contributing to A+.
- In reality the transition from A to B may happen before the cost reaches the indicated level.

NREN Level	Capital Expenses (Euro)	Operational Expenses (5 Years) (Euro) (Fibre Lease and Equipment Service Fees)
a) LITNET	330000±20%	1000000±20%
b) EENet [1)]	390000±20%	1200000±20%
b) EENet [2)]	190000±20%	740000±20%

NREN Level	Capital Expenses (Euro)	Operational Expenses (5 Years) (Euro) (Fibre Lease and Equipment Service Fees)
b) SigmaNet	330000±20%	1600000±20%
c) RUNNet (e-Arena) 3)	190000±20%	620000±20%
c) DFN 4)	10000±20%	60000±20%
c) NORDUnet 5)	90000±20%	110000±20%
c) PSNC	190000±20%	620000±20%

Table 5.3: Estimated capital investments for network equipment and connections for RING1. Forskningsnettet, SUNET and Funet are planned to connect the Baltic Ring via NORDUnet. These NRENs are already present in the planned Baltic Ring PoPs.

Notes:

- 1. This portion includes the expenses for the spans between FI-EE and EE-LV.
- 2. This portion includes the expenses for the span between EE-RU.
- 3. RUNNet is expected to meet EENet by the RU-EE border. RUNNet has already a connection between St. Petersburg and Espoo.
- 4. DFN is assumed to join the Ring in Hamburg with a local loop.
- 5. NORDUnet is assumed to operate the Helsinki end of the EE-FI submarine connection.

NREN Level	Capital Expenses (Work Time)	Operational Expenses (5 years) (Work Time)
a)	2 MY±0.5MY	2.5 MY±0.5MY
b)	1,7 MY±0.2MY	2 MY±0.4MY
c)	0.3MY±0.1MY	0.5MY±0.1MY

Table 5.4: Estimated work time consumption for RING1.

Notes:

- Setting up the DWDM capability is labour intensive. The estimated error margin decreases as the existing NREN capabilities increase.

NREN Level	Capital Expenses (Work Time)	Operational Expenses (5 years) (Work Time)
a)	0.8 MY±0.2MY	0.7MY±0.2MY
b)	0.8 MY±0.2MY	0.7MY±0.2MY
c)	0.6MY±0.1MY	0.5MY±0.1MY

Table 5.5: Estimated work time consumption for optimized RING1.

6 Cost-Sharing Model

This section introduces the basic principles of proposed Baltic Ring cost-sharing model (cost pricing, cost coverage and agreeing on the costs); suggests how different items might be financed; makes the case for tariffs; discusses the partners' contributions and commitments; and gives deployment and usage examples.

6.1 Basic Principles

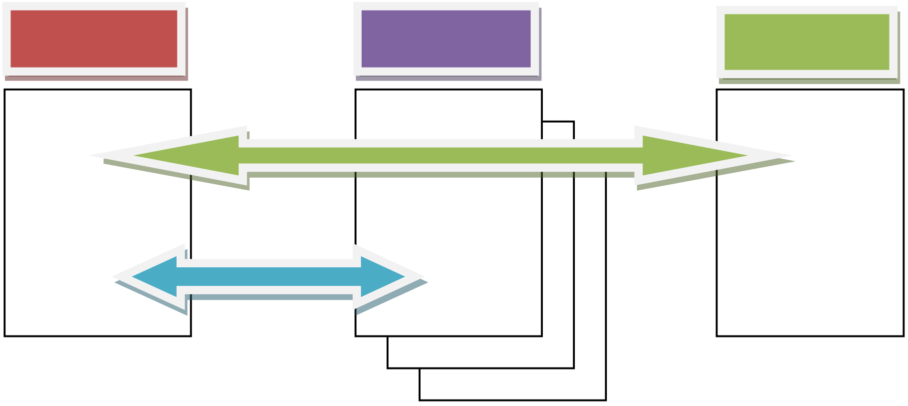

Figure 6.1: Bilateral connections between NRENs.

Notes:

- The arrows represent a dedicated communications channel or light path. (The green arrow deployment is discussed in Section 6.7 on page 38.)
- Co-operation between the nearest neighbours is the simplest case (blue arrow).
- The intermediary NRENs will be involved parties and support the physical construction process.
- In a ring topology, NREN1 and NREN3 are also neighbours (compare with Figure 3.1 and Figure 3.2).

The basic principles underpinning the cost-sharing model are as follows:

i. **Cost pricing**. The NRENs are publicly funded organisations. They may receive their financing directly from the state budget, indirectly from the users, or from a combination of the two. Their mission is to provide services and to cover their costs through their billing. The NRENs apply the principle of cost pricing. It is suggested that this principle is widened to cover the partner NRENs. This means that the NRENs will not impose any additional costs on each other, but will follow their usual billing models.

ii. **Cost coverage.** The main principle of cost coverage is that the cause pays the costs. In communications there are always at least two parties that want to communicate with each other. In an international case, there are parties in different countries who want to establish a shared communication channel – a light path or paths – between them. In addition, there may be countries in between which are crossed but are not a member of the particular research project. The parties are expected to cover the expenses to their national NRENs and the expenses of the cross-border NRENs for the duration of the deployment.

iii. **Agreeing on the costs**. The NRENs around the Baltic Sea are operating in different circumstances, which is reflected in their operational costs. In addition, the technological and operational choices they have made may have practical implications; for example, they may mean that the price of the same operation varies from case to case. In order to establish a full path through the Ring, negotiations with multiple parties are needed, with the end-point NRENs occupying a special position. The costs are agreed between the end-point NRENs and the end-user institutions. The end users negotiate with their own NREN. The NRENs involved will negotiate with each other.

6.2 Calculating the Cost

The cost of a complex deployment can be divided to individual segments or connections. The cost of a single connection between two research groups can be calculated using e.g. the topology in Figure 6.2. The research groups involved may want to share e.g. a distributed database. There exists eight (8) different cost elements in the chosen topology. The elements may include several specific costs, which are CAPEX or OPEX. For example, the cost C_1, which is the cost for connecting research group α (alpha) to NREN1 may include besides the obvious fiber fees, the customer premise equipment (CPE), corresponding equipment in the NREN DWDM systems and installation work fees.

The cost for a single light path between the two research groups doesn't naturally include the full cost of the NREN long-haul backbone fiber connection, e.g. C_2. Neither does single research light path pay the full cost of an inter-NREN cross-connection, e.g. C_3. The cost C_2 is more like the NREN1 tariff for the connections in home country. The cost C_3 is negotiated and divided between the NREN1 and NREN3. The single light path in question will use only a part of shared resources and thus get only a part of the total cost. The direct costs for connecting the research groups (C_1 and C_6) will be covered in full.

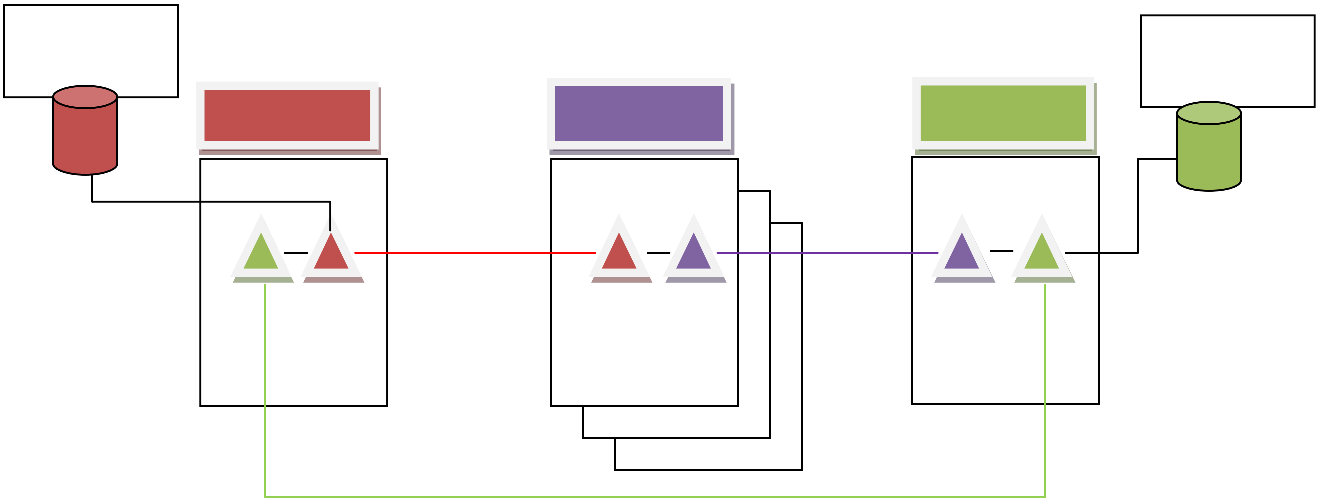

Figure 6.2: Identifying cost of a light path connection between two research groups. The groups are located in the NREN1 (α/alpha, red) and NREN3 (β/beta, green). There are two alternative routes of establishing the connection either the direct NREN1-NREN3 connection or via NREN2. The various costs "C" are numbered and explained in Table 6.1. The costs "C" can be either the CAPEX or OPEX. The total cost for both connections is the sum over C_i.

The cost is summarized in Tables 6.2 and 6.3 from the NREN and the research group perspective. In the cross-NREN case the NREN2 will get rebate for using their infrastructure. The cost is divided equally, so that the NREN1 and NREN3 can tender the price to their own customer research group.

The division of the NREN cross-connection (C_3, C_5, C_7) price is expressed in fractions to illustrate the division. The fractions sum up to one (1). The fractions are paired using letters (k,l) for C_7, (m,n) for C_3 and (o,p) for C_5. For example, the division of cost C_3 could be m=3/2 and n=3, if NREN1 would finance more of the connectivity. The calculation will sum to one: 1/(3/2) + 1/3 = 2/3+1/3=1.

Item	Description	Remark
C_1	Research group α connection (black)	NREN1 internal
C_2	Part of the ring administered by NREN1 (red)	NREN1-NREN2 interconnection
C_3	Connection between NREN1 and NREN2 (black)	Demarcation point between two DWDM networks (regeneration)
C_4	Part of the ring administered by NREN2 (purple)	NREN2-NREN3 interconnection
C_5	Connection between NREN2 and NREN3 (black)	Demarcation point between two DWDM

Item	Description	Remark
		networks (regeneration)
C_6	Research group β connection (black)	NREN3 internal
C_7	Connection between NREN1 and NREN3 (black)	Demarcation point between two DWDM networks (regeneration)
C_8	Part of the ring administered by NREN3 (green)	NREN1-NREN3 interconnection

Table 6.1: Cost elements for the Figure 6.2.

Route	Type	Cost		
		NREN1	NREN2	NREN3
NREN1- NREN3	Nearest neighbour	C_1+C_7/k	0	$C_6+C_7/l+C_8$
NREN1-NREN2-NREN3	Cross-NREN	$C_1+C_2+C_3/m$	$C_3/n+C_4+C_5/o$	$C_5/p+C_6$

Table 6.2: Cost for different light path routes in Figure 6.2 for NRENs. The Cost C_7 is shared between NREN1 and NREN3 so that $1/k+1/l=1$. The Cost C_3 is shared between NREN1 and NREN2 so that $1/m+1/n=1$ and the Cost C_5 between NREN2 and NREN3 so that $1/o+1/p=1$. The NREN crossing cost is coloured purple. Adding more NRENs to the Ring would introduce more cost terms similar to the crossing cost.

Route	Type	Cost	
		α (alpha)	β (beta)
NREN1- NREN3	Nearest neighbour	C_1+C_7/k	$C_6+C_7/l+C_8$
NREN1-NREN2-NREN3	Cross-NREN	$C_1+C_2+C_3/m+$ $(C_3/n+C_4+C_5/o)/2$	$C_5/p+C_6+$ $(C_3/n+C_4+C_5/o)/2$

Table 6.3: Cost for different light path routes in Figure 6.2 for research groups. The notation of k, l, m, n, o and p is as in Table 6.2. The crossing cost (purple) is divided to the research groups equally.

6.3 Co-Financed Cross-Border Fibres

When building inter-NREN cross-border fibers it is technically feasible to co-locate the DWDM nodes made by different vendors near each other [see Section 3.2.2]. This results in a more reliable signal transport and makes the technical installation work easier, which results in savings. In some cases, the NRENs may already operate networks, which have PoPs rather near each other. As one can't assume this is always the case, the connection between the NRENs using cross-border fibre is a special case in the cost analysis.

The situation is illustrated in Figure 6.3. The upper Type I case applies to the situation, where the NREN PoPs are situated near each other. The actual meeting site may actually exist slightly inside one of the countries. The costs of the different fibre segments are indicated and numbered with C_{ij}, which can be compared with the Figure 6.2.

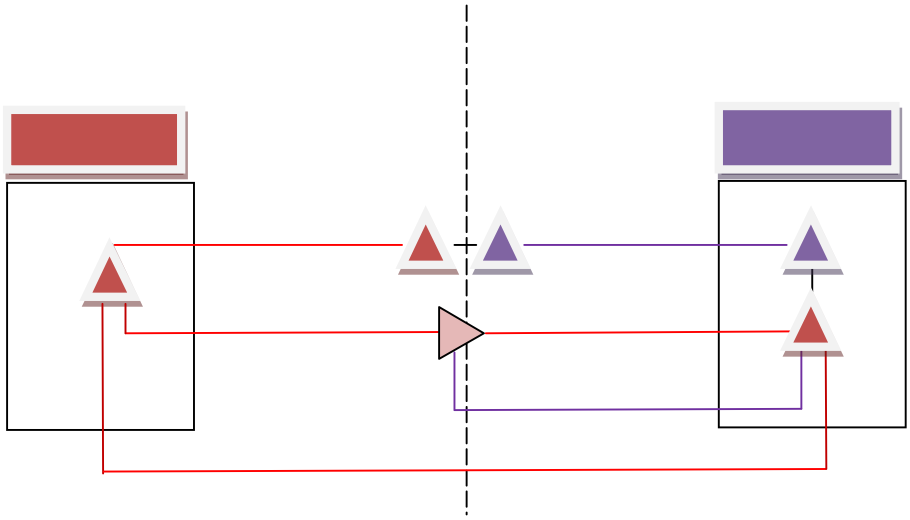

Figure 6.3: Four alternative ways to build cross-border connection between NRENs. The solutions differ by the location of the meeting or peering site. Type I peering is conducted near the national border while type II and III peering is done inside NREN2. The colors represent the ownership of the fibres: the red fibres belong to the NREN1 and purple fibres to NREN2. Types II and III differ by the fibre ownership. The black lines represent local loops. The pink triangle stands for optical amplification. In the Type IV peering no optical amplification is needed. The various costs "C" are numbered and explained in Table 6.4. The costs "C" can be either the CAPEX or OPEX.

The Type II/III cases (Figure 6.3) corresponds to the situation, where NREN1 doesn't have a PoP near NREN2, but a great distance needs to be crossed. The NREN1 and NREN2 have to consider, whether they choose the Type I approach or alternatively select either Type II or III, where NREN1 establishes a new PoP near NREN2's current PoP. The more controlled co-location may be considered more secure. If the meeting point would exist near the national border it may be in a remote location, which makes the maintenance and deployments harder.

Item	Description	Remark
C_{21}	Connection to the national border (red)	NREN1 internal

Item	Description	Remark
C_{22}	Optical amplifier(s)	Needed for long fibre distance
C_{23}	From the national border to NREN2 (red)	Provided by NREN1
C_{31}	Connection to the national border (red)	NREN1 internal
C_{32}	Connection between NREN1 and NREN2 (black)	Demarcation point between two DWDM networks (regeneration)
C_{33}	Connection to the national border (purple)	NREN2 internal
C_{93}	Connection to the national border (purple)	NREN2 internal
C_{10}	Unbroken connection between NREN1 and NREN2 (red)	Provided by NREN1
C_{11}	Connection between NREN1 and NREN2 (black)	Demarcation point between two DWDM networks (regeneration)
H_1	Hosting costs for NREN1	NREN1 PoP in NREN2

Table 6.4: Explanation of the cost elements in Figure 6.3.

In the Type II case one can essentially presume, that the costs $C_{21}=C_{31}$ and $C_{23}=C_{33}=C_{93}$. The remaining question for NREN1 is, if $H_1+C_{22}+C_{23}+C_{10}<C_{32}$, which is most certainly not the case: it is remarkably more costly to establish a PoP inside another country compared to peering near the border.

The special case where $C_{22}=0$ is named the Type IV. It corresponds to a situation, where no optical amplification is needed in the connection. The fiber distance between the NRENs can be rather long, if long-haul optics is used in the transmission. The Type IV is technically the simplest deployment, which introduces additional savings in the service and repairs.

6.3.1 Establishing a Ring

In the bilateral Type II situation it is clear, that NREN2 saves the cost of building a PoP near the border area. The saved PoP is not a good argument, however, because NREN2 may not have such plans anyway, which makes it an unnecessary and needless cost. NREN1 faces the cost of building the amplification infrastructure and a new PoP.

It doesn't help either, if there would be savings in the (possible) amplifying budget associated to C_{33} and other transmission improvements, which would optimize the total cost. The situation changes in a ring topology, where NREN1 and NREN2 would have two connections with each other for redundancy. The similar situation exists in a ring with more participants (see Figure 6.2).

In a symmetrical geographical scenario the costs $C_{31}=C_{33}$ and $C_{21}=C_{23}$. The symmetry makes it theoretically possible to swap the fibers so, that NREN1 pays the fibres on it's side of the border and NREN2 pays it's own fibres respectively. The technical responsibilities for the connections would be shared so, that each NREN would account for one entire connection to the neighbor NREN. Some of the imbalance in the geographical symmetry may be compensated by savings in the amplifying budget. The cost for hosting a neighbor NREN PoP could cancel each other.

For each of the participating NRENs the added cost would be comparable $C=C_{21}+C_{22}+C_{23}+H_1$, where the hosting cost would be realized in the home country. When using barter trade with the partner NRENs this amount would equal a roughly double connectivity compared to the outcome the NREN would reach alone.

6.3.2 Provider-User Model

If a ring topology is not feasible, the cost imbalance in the Type II situation (Figure 6.3) can be solved by contractual methods. The bilateral economical balance could be reached with a combination of different tools. These methods are very case-by-case dependent, as the topical needs for NRENs vary.

If the NREN1 provides the connectivity to NREN2, it is naturally eligible to use fees. The research community in NREN1 and NREN2 may share joint projects, which would exploit and finance the connectivity. It may also be, that NREN2 can provide access to resources, which would contribute to the NREN1 decision-making. In addition, NREN2 may provide services, which NREN1 would like to use. The services for bartering can include e.g. cloud services or light path connectivity to distant locations.

6.3.3 Sharing Fibers with Joint DWDM Equipment

The Type III (Figure 6.3) is an important special case, where NREN2 provides the fibre connectivity until the border and NREN1 provides the transmission for both. This particular alternative can be very remarkable, if NREN2 is able to use same DWDM hardware with NREN1, because then only one, shared piece of equipment is needed in the joint federated PoPs (see Section 5.3 item iii).

The use of joint equipment would introduce savings in the DWDM hardware and PoP internal connections (C_{10}). The NREN1 could, in principle, carry some NREN2's customer connections on the leg from the border to the PoP, which would introduce additional synergy (C_{93}). The physical setup would approach gradually the optimal federated RING2 (Figure 3.2) (see Section 5.3 item v).

In the Type III (Figure 6.3) cross-border connection the costs would be divided by NREN1 and NREN2 by $C_{21}+C_{22}+H_1>C_{93}$. If symmetrical distances to the national border line are presumed, $C_{21}=C_{93}$, and NREN2 stays in debt to NREN1 with $C_{22}+H_1>0$. The economical imbalance can be leveled using tools and means described in previous sections 6.3.1 and 6.3.2.

6.4 Financing of the Costs

The NRENs around the Baltic Sea operate on a solid economic basis. The funding models for operations and development projects differ from country to country. All the countries are expected to take care of their expenses sovereignly and thus the Baltic Ring co-operation currently has no planned funding element. This does not exclude financial planning and cost-awareness. The research and education needs are the key factors driving the usage and provisioning of the shared resources.

Item	Coverage Method	Expected Cost Level	Remark
Initial development	Consortium members, grants	Medium	Man months dominate
Fibre paths and supporting hardware	Consortium members, grants	Medium	Availability has strong influence on financing need
DWDM equipment and supporting software	Consortium members, grants	Medium	Co-tendering may introduce savings
Internal light paths	Projects and parties using service	Low	Users benefit
Collaboration bodies	Consortium members	Low	Defined by scoping
Operations financing	Consortium members	Low	Defined by scoping

Table 6.4: Suggested cost coverage methods and levels.

Notes:

- The consortium partners use their budget and other financing tools for establishing the infrastructure.
- The users are billed for the service.
- The consortium administration and operations financing is expected to be restricted.

6.5 The Case for Tariffs

There is a need for price lists (tariffs). The lists would support planning the use of the network. If a pricing level is known, it improves the ability to respond to tenders from the community. Even if the exact price is subject to some uncertainty, the information would still be useful for budgetary purposes and similar economic planning.

Saving and making available the history of the tariffs would enable long-term tracking of the general Ring economics. An increase in cost in some areas may identify potential development targets. In addition, a decrease in price may indicate service innovations and improvements, which could be applicable to other partners as well. The economic figures can be used as a basis and reference material for decisions.

A proposal for a tariff table template is given in Appendix A on page 43. For clarity and ease of application, it is suggested that all partners use the same tariff table format. If this is not feasible, the alternative tables should include as similar information and descriptions as possible. It is suggested that the tariff tables remain valid for a reasonably long time, with the same period for all partners. This would remove the uncertainty about the effective date and enable a coherent update cycle for all the partners at the same time.

The number of services (rows) in the tariff table may vary as the NREN wishes. All partners should have similar services available, but the number of services is not a measured success factor (see discussion on portfolios in "D3: Organisational and Operational Model" [3, Section 4.3]). The rate for connectivity – light path – services can be tied to distances, as the approximate distances, between cities, for example, are easily available using commodity services. The square brackets "[]" are used to indicate alternative content. The suggested alternatives are separated by a pipe "|".

The tariff table should not be seen as an automatic obligation to provide the services listed. Instead, it should be seen as a sign of will to provide the services. A negotiation is necessary in each actual deployment, but it can be built on the information provided in the table.

6.6 Contributions and Commitments

The contributions and commitments from the partners can be fitted to the consortium framework and to the work done in its bodies. The allocation of people to various roles and the infrastructure contributions, together with the means and tools for changing them, are discussed in D3 [3] Section 6.

Contributions from third parties constitute a different challenge, because, for example, the consortium may not have a bank account. In other words, the consortium may not be able to receive direct economic support. The consortium may accept contributions related to development projects, where third parties may participate in certain tasks as experts or provide support, such as for investments. In other situations, it may be feasible to channel support to the consortium through some of the partners.

If the volume of third-party activity increases, it may be possible to establish a peer group. The reverse case is the contribution of the Baltic Ring consortium to other research and education initiatives. The further development of these needs has been left for subsequent work and can be followed up later.

6.7 Deployment and Usage Examples

6.7.1 Green Arrow – Example of a Simple Deployment

Let's assume that in the topology illustrated in Figure 6.1 on page 30, NREN3 wants to initiate a connection to NREN1 via NREN2. The connection is to meet the needs of a research group in NREN3, which wants a dedicated communications channel to another research group, which is located in NREN1. NREN3 contacts NREN1 and they negotiate the case in question. If sufficient agreement is reached, NREN3 contacts NREN2 and orders connectivity between itself and NREN1. The order is based on the capacity and tariff information that NREN2 has provided to the Baltic Ring consortium.

NREN2 processes the order. If it is accepted, NREN2 starts the implementation and interacts with NREN3 and NREN1, respectively. If the Supervisor function has been implemented (see [3] Section 6), it is notified and kept aware of the development. NREN2 may outsource some of the necessary work to it. The connection is tested and taken into operation and monitoring. NREN2 sends an invoice to NREN3 and NREN1. They pay the bill, which is shared as agreed in the initial negotiations. The research group in NREN1 will get an invoice from NREN1 and the research group in NREN3 from NREN3, respectively.

6.7.2 Usage Scenarios

When the Ring is operational and the actual use period starts, the use patterns may be varied. As the usage cannot be accurately predicted, an economic scenario analysis will have to suffice. Let’s assume a Ring with three interconnecting parties after some years of operation. The parties are expected to have a roughly equal share of the Ring infrastructure under their respective administration. In principle, one can assume either a symmetric or an asymmetric case to exist. The asymmetric scenario (the right-hand chart in Figure 6.4 below) also covers also the case of a single dominating NREN out of the three.

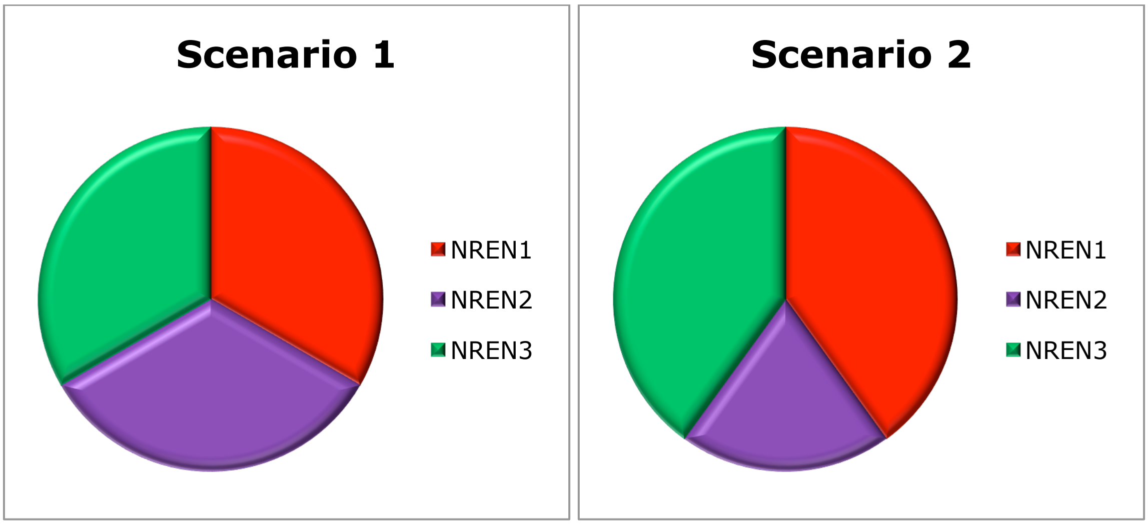

Figure 6.4: Two example Ring usage scenarios.

Notes:

- The different sections in the pie diagram represent the relative volume of Ring use by the NRENs.
- Scenario 1 is the balanced case, where the volume of use is roughly even.
- In Scenario 2, NREN3 is using the Ring less than the others.

If we assume that the provisioning costs are roughly equal, the costs of deployment compensate each other and each country seems to pay only for their own use (Scenario 1). In the imbalanced scenario (Scenario 2), the situation is tilted so that NREN2 will receive more rebate due to their 1/3 share of the infrastructure. In other words, Scenario 1 will minimise the flow of the funds, while Scenario 2 will include more transactions the more imbalanced it is. The transactions are due to the cost coverage principle discussed in Section 6.1 ii on page 31.

The imbalance is not a problem, as the users of NREN1 and NREN3 are receiving the service, which they have evaluated and assessed to be necessary and affordable. It is probable that NREN2's rebate will be used to increase its level of evolution (as defined in Section 5.1), which will help reduce the imbalance.

7 Summary

The Baltic Ring project suggests, that the prospective Baltic Ring consortium should adapt a well-known network management model as a target for the operations. The ISO FCAPS categorization seems to fit well for the need, but there are also other alternatives.

The international network operations include several aspects, which suggests a common supervisor or NOC process to be established. The common supervisor cannot perform the task alone, but it needs support from the NRENs. The operations seem to naturally become federated as well. The quality of the monitoring and reporting data will be important. The communications will be decisive for success.

The cost analysis indicates that the cost for establishing and maintaining the Baltic Ring is substantial, but it is the more justified the more Ring is used. The most cost efficient way to implement international connectivity for the research and education community are the NRENs. If a NREN needs to undergo the DWDM deployment, the transition period will require a lot of funding.

The Baltic Ring project suggests, that the prospective Baltic Ring consortium would exercise the principle of cost pricing towards the consortium members. As well, it is suggested that the cause will pay the cost. Each of the cases may have own special characteristic, for which the importance of negotiations is stressed.

For easing the negotiations the Baltic Ring project suggests, that the NRENs would share tariff information about their resources contributed to the Ring. The tariff information would permit budgetary calculations for tenders.

8 References

[1] E. Elmroth, "Knowledge Infrastructure for the Fifth Freedom in the Baltic Sea Area", TemaNord 2010:516 www.norden.org/en/publications/publications/2010-516 (2010).

[2] T. Breach, J. Myyry, B. Mortensen and J. Miettinen, "Baltic Ring D2: Network Design" (2011).

[3] J. Miettinen, "Baltic Ring D3: Organisational and Operational Model" (2011).

[4] http://www.terena.org/ (2011).

[5] http://www.terena.org/activities/tf-msp/ (2011).

[6] http://www.terena.org/activities/tf-noc/ (2011).

[7] https://portal.nordu.net/display/NORDUwiki/NORDUnet+inter-NREN+Forum (2011).

[8] https://portal.nordu.net/display/opsforum/Home (2011).

[9] http://www.seefire.org/ (August 2011).

[10] D. Davies, SEEFIRE project deliverable "D3.2: Economic Model for the Acquisition and Operation of Dark Fibre Networks in SE Europe" (2006) http://www.seefire.org/content/modules/downloads/SEEFIRE-WP3-Economic-study-d-20060223x.pdf

[11] http://www.porta-optica.org/ (August 2011).

[12] S. Sima (ed.) et al., Porta Optica deliverable "D3.2.3v3: Economic analysis, dark fibre usage cost and model of operations" (2007) http://www.porta-optica.org/publications/POS-D3.2_Economical_analysis.pdf

[13] http://www.itil-officialsite.com/

[14] http://lhcopn.web.cern.ch/lhcopn/ (2011).

[15] E-J. Bos, E. Martelli, P. Moroni, "LHC Tier-0 to Tier-1 High-Level Network Architecture", v. 2.0 (2005) https://twiki.cern.ch/twiki/pub/LHCOPN/LHCopnArchitecture/LHCnetworkingv2.dgf.doc

[16] G. Cessieux, "Proposed LHCOPN operational model", r. 23 (2010) https://twiki.cern.ch/twiki/bin/view/LHCOPN/OperationalModel

[17] http://www.ndgf.org/ (2011).

[18] O. Smirnova, "OGF-Europe Tutorial: How new communities can get access to a Grid infrastructure", NorduGrid/NDGF, OGF25 Catania (2009). https://portal.nordu.net/download/attachments/7832024/20090302-oxana.pptx?version=1

[19] Interview with Vera Hansper (NDGF operations coordinator) and Ulf Tigersted, 7.3.2011 (CSC).

[20] http://technical.eu-egee.org/ (2011).

[21] http://www.egi.eu/ (2011).

[22] http://www.egi.eu/infrastructure/Figures_and_utilisation/ (June 2011).

[23] https://ggus.eu/pages/docu.php

[24] http://edupert.geant.net/ (2011).

[25] Interview with Pekka Savola (CSC/Funet PERT contact), 2.8.2011 (CSC).

[26] http://edupert.geant.net/PERTs/index.html (2011).

9 Glossary

AM	Administration Management
ARC	Advanced Resource Connector
CAPEX	Capital expenses
CM	Configuration Management
CPE	Customer Premise Equipment
CWDM	Coarse Wavelength-Division Multiplexing
DWDM	Dense Wavelength-Division Multiplexing

EGEE	Enabling Grids for E-Science
EGI	European Grid Infrastructure
EU	European Union
FM	Fault Management
FP*n*	*n*th Framework Programme for Research and Technological Development
FCAPS	Fault, Configuration, Accounting/Administration, Performance, Security
FRAND	Fair, reasonable and non-discriminatory
GGUS	Global Grid User Support
GRID	Global Resource Information Database
ISO	International Organisation for Standardisation
IST	Information Society Technologies
NDGF	Nordic DataGrid Facility
NOC	Network Operations Centre
NREN	National Research and Education Network
OLA	Operational Level Agreement
OPEX	Operational expenses
PERT	Performance Enhancement and Response Team
PM	Performance Management
PoP	Point of Presence
PTS	PERT Ticket System
QoS	Quality of Service
RAND	Reasonable and non-discriminatory
ROC	Regional Operations Centre
SEEFIRE	South-East Europe Fibre Infrastructure for Research and Education
SLA	Service Level Agreement
SM	Security Management
SME	Subject Matter Expert
TERENA	Trans-European Research and Education Networking Association
TPM	Ticket Process Management
TF-MSP	TERENA Task Force – Management of Service Portfolios
TF-NOC	TERENA Task Force – Network Operation Centres
VO	Virtual Organisation
WLCG	Worldwide LHC Computing Grid
QoS	Quality of Service

10 Appendices

Appendix A Baltic Ring Tariff Table Template

Appendix A. Tariff Table Template

Baltic Ring Tariff table for [NREN]

The following table covers the tariffs concerning the use of the Baltic Ring. The list is valid for a period of twelve (12) months starting from the date of signature.

Tariff Name	Technology	Scale	Rate	Duration (Months)
Light path [carry through | terminating home country| geographical limitation]	[MPLS | Ethernet | DWDM]	[BE | 1 Gbps | 10 Gbps]	[fill rate] euro/km	12
Hosting [site | features]	N/A	[Rack unit | Rack]	[fill rate] euro/month	12
[copy and add rows]				

Agreed upon and signed by:

Organisation name: ______________________

Signature: ______________________

Name: ______________________

Title: ______________________

Date and place: ______________________