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Deliverable DS3.12.1: Description of a Decentralised PERT



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Abstract

This document provides an analysis of the requirements for a future PERT. The advantages and disadvantages of a centralized PERT (the current model) are compared with those of a decentralized PERT, along with what would be required in terms of tools for both. The concept of a Federated PERT, which combines the strengths of both models, is presented.

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0 Executive Summary

The Performance Enhancement and Response Team (PERT) is a group of engineers and scientists with knowledge and experience in one or more of those areas affecting the performance in networked systems, be it backbone router hardware architectures or end-system software application design. End-users from research and academia may request the PERT's help when they experience a poorer than expected network performance.

The GN2 PERT is a virtual team, with part-time staff provided by 10 GN2 partners. The part-time staff form a roster of on-duty Case Managers (CMs), such that there is always one person available to handle new requests for help.

Whilst the current centralized PERT (cPERT) works satisfactorily, there have been a number of issues not all of which have been resolved.

- The frequent changing of the PERT duty CM has meant that end-users have had to repeat the same information to different people as management responsibility has changed.
- The duty CMs have sometimes concentrated on diagnosing the cause of the problem, even when an adequate work-round has been identified.
- The long chain of people involved in reporting an end-user's problem to the single PERT CM has sometimes hindered communications

Nevertheless, the contributors to the current PERT were keen to see the PERT live beyond GN2, and started to explore how a future PERT would look. From an early stage it was clear that a decentralized PERT was favoured, consisting of an alliance of national PERTs. However, although it was expected that a fully decentralized PERT (dPERT) would address some of the problems currently being experienced (especially with regards to lines of communication), it was recognized that it would introduce new problems, in particular the handling of issues spanning multiple domains, and the management of the PERT Knowledgebase (PERT KB), which is a particular success story of the GN2 PERT. In order to get the benefits (and avoid the risks) associated with the centralized and decentralized PERTs, the SA3 WI12 team are recommending the establishment of a Federated PERT (fPERT), which would consist of a well-funded, central PERT and the collection of national and regional PERTs. National PERTs (nPERTs) would conduct the handling of performance issues within national boundaries. For international issues, case conduct would be broken down into 2 parts – case management and case investigation. Case management would be the responsibility of the

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central PERT, whilst case investigation may be delegated to a PERT more local to where the problem is located. A possible additional future development would be the establishment of a global PERT (gPERT), where the international element of the PERT could itself be a federation of say 3 PERTs based in the Americas, Europe and Asia. However, this would introduce more coordination issues, and is not further considered here.

Other than suitably experienced staff, the other important part of the PERT (central or national), are the tools and applications it uses for its operations. The PERT KB should remain a single point of excellence, where all important findings and recommendations should be kept, but it may prove useful to translate some of its most referenced articles in to other languages, to make it more accessible. This work would anyway be the responsibility of national PERTs. The other important tool of the PERT is the PERT Ticket System (PTS). The PTS used by the current PERT is properly called PSNC-PTS, to identify the fact it is a bespoke system developed by PSNC. Should PSNC-PTS be carried forward into the Federated PERT, and made available to national PERTs, then a comprehensive In Service Support structure should be put in place, to ensure the application's viability for the foreseeable future.

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1 Overview of the GN2 PERT

1.1 Background

The idea for a Performance Enhancement and Response Team (PERT) was originally conceived by Internet2, who as early as 2001 had realised that “[Fat pipes] are not enough” , or in other words unlimited (or effectively unlimited) bandwidth was not sufficient by itself to guarantee maximum data transfer rates from a data source to a data sink. As envisaged at the Internet2/APAN/TransPAC/NLANR Technical meeting held in Hawaii in January 2001, the PERT would be to network performance what the CERT was to network security – a group of specialists who would investigate problems experienced by end users.

A group of European research networking engineers established first a trial PERT, (as part of the GÉANT project in late 2003), and then a full scale production PERT, which followed in March 2005, as part of GN2.

1.2 PERT/NOC Relationship

Although the ‘T’ in PERT stands for ‘Team’, PERT is really a function, which may be performed by a dedicated group or may be a function of an already established NOC. Whether a PERT is part of a NOC or a completely different entity, the main difference between the NOC and the PERT is the nature of the problems they investigate: a NOC will investigate failures on their network’s equipment, which they will probably be alerted to by monitoring systems. Conversely, a PERT will receive reports (directly or indirectly) from end-users whose networked applications are not performing as well as expected, and they suspect an issue with the network connection. As such, PERT cases tend to be more difficult to diagnose but less urgent to resolve (as there is a service in place, albeit sub-optimal). Of course, the other important difference between a PERT and a NOC is that a NOC is responsible for the correct operation and maintenance of network equipment, whilst a PERT might identify and recommend changes, but would not perform these themselves.

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1.3 Structure

The GN2 PERT is a virtual organization. The Case Managers (CMs), who receive the requests for assistance and investigate performance problems, are provided by a number of NRENs (currently nine), and each works only part time in the PERT.

To ensure new reports of problems are addressed promptly there is always one Case Manager nominated to be the Duty Case Manager (DCM). The DCM (who changes on a weekly basis, and is as per a published roster) is responsible for opening new cases and making sure unresolved cases continue to be actively investigated. The actual investigation of a given case is done either by a Special Case Manager (SCM), if one has volunteered to adopt that particular case, or the DCM (if the case in question has not been adopted by an SCM).

Working alongside the Case Managers are the Subject Matter Experts (SEs⁴). SEs may be experts in one or more areas of data networking, or they may be experienced, generalist network engineers associated with a particular network e.g. an NREN's network, in which case their knowledge of that network can be of great use to the PERT. Unlike the Duty Case Managers' work, the work done by SEs for the PERT is unfunded, but conversely SEs are under no obligation to perform PERT work – they help the PERT only as and when their time allows. SEs can volunteer to be SCMs, but it is neither expected of them nor encouraged, and generally SCMs come from the Case Manager group.

1.4 Future Plans

A separate group within the PERT has been formed to study the future development of the PERT. This group perform Work Item 12 of GN2 SA3, which is called "Decentralize the PERT" since from an early stage it was decided that the future PERT should operate in a more distributed manner. Its tasks include analysing a future possible structure for the PERT (this Deliverable) and providing training to those NRENs which are interested in establishing their own local PERT.

⁴ In the current GN2 PERT the abbreviation 'SME' is used, but it has been pointed out that this may be confused with SME meaning "Small and Medium Enterprises"

2 Lessons Learned from GN2

Whilst the GN2 PERT is so far considered an overall success, this chapter focuses on some of the organizations shortcomings (past and current), and how those might be addressed in a decentralised PERT.

2.1 Focus on solving customer issues

One peculiarity of the GN2 PERT is that there was no pre-existing provider/customer relationship between the PERT and its users - in fact a large part of the cases came from countries that weren't directly involved in the GN2 PERT activity. With the decentralization of the PERT, it should be expected that the relationship between (then regional) PERTs and their users will change.

The GN2 PERT often spent large amounts of time trying to understand the problem fully, even when adequate workarounds were already identified. This was often the result of having a relatively large number of frequently changing, geographically dispersed Case Managers, each of whom took time to get to understand each problem as they took over responsibility for it. While this was useful for building collective knowledge within the PERT, this was not always ideal from the perspective of its users. The introduction of Special Case Managers has helped in this regard and it is hoped and expected that by reducing the number of times responsibility for a case is passed between different organizations the delay to case progress will be significantly reduced.

2.2 Communication with customers and intermediate networks

New cases typically reach the GN2 PERT through lengthy chains of referrals. One consequence of this is that it can take a long time for PERT case managers to get in touch with the actual users and operators close to the problem.

With the move to a more distributed PERT, it can be expected that these chains of referral will be shortened, and that will make it faster to establish communication links between case managers and users/administrators. Also, communication will be simplified by the fact that users will typically be able to communicate with their local PERT in their first language, and by having PERT contact people at an organization (typically their NREN) that they already know.

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2.3 Low usage of PERT

Following on from the above point, it must be recognised that over the first 18 months of operation the PERT investigated fewer cases than had been expected or wished for. To date there have been 21 cases logged in the PERT Ticket System (PTS), which averages out at slightly more than one new case per month, whereas early estimates (admittedly with no real evidence) expected there to be one new case a week. As a result of this the current PERT continues to operate with 1FTE of Duty Case Manager, whereas the original resource plan for the PERT allowed for approximately 2.5 FTE of Case Manager by the start of Y3. This low case throughput might partly be due to the success of the PERT KB, in that users who might otherwise have contacted the PERT may have found the answers they need on the PERT KB, but in all likelihood the most likely cause of there being fewer cases opened than expected is that central PERT is too remote and unknown to those end-users who could benefit from it.

By having a more local PERT contact (probably co-located with a NOC) it is thought that more issues will make their way in to the PERT system.

2.4 Difficulty of access to measurement data and server login

Once direct contact with remote users was established, the next significant problem was to obtain measurement data. In many cases, the only practical way to make measurements involved remote access by PERT Case Managers to a remote machine at the user's premises. Typically a PERT Case Manager would work on the case for a while, repeatedly asking the remote user to perform measurements, before requesting remote access permissions. This way, a basis of trust could be established upon which the user would grant access. Often it was helpful to be able to offer the user login access to a test workstation - typically in an NREN - in turn.

In a decentralised PERT, a local PERT can be expected to have a closer relationship to its users, so obtaining access should be easier than in the centralised GN2 PERT of today. As a caveat, NRENs often do not work with "end users" in their respective connected organisations, so "closer relationship" does not necessarily mean "personal relationship".

With decentralisation, there is the additional problem of sharing measurement results and remote access credentials between different PERTs. It is unclear how this can best be handled. Perhaps an "inter-PERT data sharing policy" would be useful. All participating PERTs would be bound to this policies, and a PERT user should be informed about the policy when they start sharing data with the(ir) PERT. If a user is uncomfortable with some of the data being shared - in particular remote access credentials - it may be necessary to provide multiple levels of privacy.

2.5 Team-building within the PERT

One aspect that works well in the GN2 PERT is the collaboration between the people from various organizations (DANTE and NRENs) that make up the "virtual organization" of the PERT case manager team. This has been helped by having weekly briefings - sometimes over videoconference, sometimes over e-mail - where the outgoing PERT Case Manager team brought the incoming team up to date with respect to developments in the current open cases.

It would be useful to find platforms for the distributed PERT teams to exchange their knowledge, possibly in the form of common workshops.

3 Conduct of Multi Domain Cases

3.1 Conduct, Management and Investigation

The conduct of PERT cases can be broken down in to two separate but related parts - case management and case investigation. Case management covers all aspects of receiving, initiating and reporting a case, whilst case investigation refers to the specific work done in diagnosing a problem. Case Management and Case Investigation very much overlap in the areas related to progressing a case, that is to say: prompting and co-ordinating third parties to take action to help progress the investigation; recording findings; and recommending (or indeed effecting) corrective action.

The conduct of future PERT cases will largely depend on two specific factors. First, the nature (and in particular the geography) of the problematic path; and second, the size and scope of the centrally-run European PERT. The simplest scenario to consider is when a performance problem is reported on a path that is fully contained within one domain (say one specific NREN) and that domain operates a PERT. In this case, full responsibility for all aspects the case related to both management and investigation will reside with that domain's PERT. Conversely, a much more complicated scenario would exist if there were little or no centralized PERT, and the problem was found on a path which began and/or ended in a domain where there was no local PERT. In such a case it is not at all certain the case could be successfully managed and this by itself is probably reason enough for a well-staffed central PERT with an international mandate.

3.2 PERT Models

Listed below are the three basic options for the future European PERT, namely the fully centralized PERT, the fully distributed PERT, and the Federated PERT. For each option there is a description of how a multi-domain case might be conducted, along with the strengths and weaknesses of each model. A fourth option, the so-called Global PERT, which is a variation of the Federated PERT, is also considered.

3.2.1 Fully centralized PERT

A single, fully centralized PERT would be a single organization responsible for conducting the management and investigation of any network performance problem reported by an appropriate end-user. Exactly which end-users would be allowed to contact the PERT could in time become an issue. Note that this is the same issue that faces the current GN2 PERT (which to a large degree is a fully centralized PERT) however at this relatively early stage of the PERT's existence any and all requests for help are investigated as the PERT seeks to raise its profile. The single PERT would at least offer simplicity in terms of responsibilities, since all responsibility for case management and investigation, including communicating with the end-user, would stay within this simple organization. However, whilst most end-users who are sufficiently knowledgeable as to recognise and report a network performance problem are also likely to be competent English speakers, this is not an assumption that should always be made and so the direct communication between the central PERT and the end-user may not always be beneficial, or indeed possible.

Once a case has been opened it would be investigated in the same way as is currently done for the GN2, which is to say a nominated engineer would establish points of contact in each involved organization (end-sites, transit domains) and then actively investigate the causes of the problem.

3.2.2 Fully Decentralized PERT

A fully decentralized, or distributed, PERT would have no full-time central co-ordinating body. Rather, each PERT would operate independently, communicating only with their own users and neighbouring PERTs, in much the way that NOCs have traditionally operated. In fact, the only significant difference between the distributed PERT and no PERT at all is that the independent PERTs would establish guidelines and/or requirements that prospective new PERTs should adhere to in order to be properly considered PERTs. For such an organization to be an improvement on the existing GN2 PERT there would have to be a sufficient number of active PERTs in Europe so as to make the PERT accessible to the majority of (if not all) end-users.

To open a new case, regardless of the geography of the problem, an end-user would contact their local PERT. The local PERT might be local to the user's campus, or their regional network, or the NREN. The local PERT would establish the user's eligibility to use the PERT (probably an easier task for a local PERT than a centralized PERT) then create a new PERT case. Assuming the network path experiencing problems spans more than the local domain, the local PERT would then contact the appropriate neighbouring PERTs (or if PERTs do not exist in the neighbouring networks, the appropriate NOCs). In this way, the existence of the problem would be promulgated in a cascading fashion. This kind of communication is very scalable (since each PERT only needs to maintain links with its immediate neighbours), but its sequential nature means it would probably be slower than an equivalent parallel alert.

Once the case is opened, investigation would most likely proceed in an ad hoc manner. There may be separate tickets in one or more PERT ticket systems (depending on the preferences of the involved PERTs), and likewise each ticket may or may not be accessible to the staff of other PERTs (depending on the policies of the PERTs in question). Of course, it may be a requirement of becoming a recognised PERT that it grants access

to its PERT ticket system (PTS), but the initial feeling of the Future PERT study group is that the barrier to entry to becoming a PERT should be kept low, and therefore such a strict requirement is unlikely.

3.2.3 Federated PERT

The Federated PERT is a model that seeks to combine the strengths (and minimize the weaknesses) of the fully centralised and fully decentralised PERTs. Concentrating for now on Europe, the Federated PERT would consist of a well-funded, well-resourced central PERT, and the collection of all European PERTs (national and (if they exist) regional and campus).

Put simply, the central PERT would take responsibility for the management and, if appropriate, investigation of multi-domain issues, whilst the national PERTs would be responsible for all aspects of case conduct for those problems contained within national borders. Although there will be this clear distinction between national and international PERT cases it is nevertheless vital that overall the PERT stays intact as far as being a knowledge community is concerned, and so an important part of the PERT processes will be that the lessons learned by one PERT are made available to all, and likewise experts in one PERT are able to offer advice or even active assistance on a case being managed by a different PERT.

Both the Federated PERT and the fully decentralized PERT rely on the willingness of NRENs to share knowledge and offer advice freely. Whilst this has been true of all the NRENs that currently participate in the PERT it is perhaps not an assumption that can be made for all NRENs. It will be necessary to make clear to NRENs what they stand to gain by playing an active role in the PERT.

3.2.4 Global PERT

The Global PERT is really an extension to the Federated PERT model. The Global PERT implies that PERTs are established in other areas of the world. Ideally these non-European PERTs would also be federated, so that for example there might be a pan-American PERT which would be the central PERT for a federation of PERTs from North and South America, or sub-divisions thereof. The main benefit of such an extended federation is that it might help address the problems experienced to date with problems spanning multiple time zones. With, say, 3 international PERTs based in respectively Europe, America and the Far East, there could be a more intensive approach to investigating long distance performance, with the international PERTs handing over management of such cases as they reach the end of their working day. Of course, whilst this would increase the intensity of the investigation it does introduce complexity in the management of the case, and specifically with the logging and reporting of case history – in which of the international PERTs ticket systems should the case be recorded and updated? Probably the easiest way to handle this would be for the case to be recorded in both (or even all three) ticket systems, and to have pointers in each ticket to the tickets in the other systems so that new information could be quickly and easily found (in much the same way that national PERTs in Europe might refer to one another's PERT tickets).

4 Constitution of a Federated PERT

This chapter describes how a Federated PERT might be constituted, taking into account the experience gained to date with the GN2 PERT

4.1 Introduction

When assessing the cost/benefits of implementing a PERT, it is important that NRENs appreciate that investigating network performance is something that NOCs typically already do. In essence, a performance issue is one that is difficult to diagnose, (perhaps even difficult to quantify) and tends to affect only a small number of specific users. The difference between a performance issue and a more traditional NOC case is that because the former are normally (almost by definition) not as serious as circuit outages and other hardware failures, their investigation is not prioritised. Furthermore, as and when the performance problem is solved (perhaps by a work round, perhaps by some transient condition passing) a NOC may not take the time to analyse and record the root causes of the problem, so this information is not then available for future reference.

A decentralised PERT should simplify the work of the NOCs in this regards, since when they are investigating performance network problems spanning multiple domains, there will be agreed channels of communications, and a common way of working.

Taking the above in to account, it can be seen that an NREN (or indeed any other network provider) should not need to commit any additional resource or time in order to put in place a basic PERT function. Rather, in order to provide a basic PERT function all that should be necessary is for some simple procedures and tools to be put in place, examples of which are described below. It is very important that NRENs realise that the PERT need not be a significant additional commitment, so as not to be deterred from taking part in this international community.

Despite what has been written above, it may be that some NRENs are reluctant to make even the small effort that will be required of them to establish a basic PERT. It may be that additional encouragement is required, in the form of additional funding, or alternatively an additional charge if the central PERT has to cover for the lack of a national PERT. A more detailed discussion on this point lies outside the scope of this document.

In the case where a PERT is a sub-function of a NOC it is a matter of debate as to whether or not end-users should be made aware of the PERT. On the one hand by distinguishing the PERT from the NOC, end-users will come to learn the difference between these two functions and will come to have a realistic expectation of the service they can expect when reporting a network performance problem. An alternative view is that end-users should see the NOC as a single service, and as such the PERT should not be promoted as a different service. To avoid confusion there should be a consistent approach across the Federated PERT, and the decision as to which to take should be made at the highest level of the NREN community.

4.2 Constitution of a Federated PERT

To date GN2 has operated a central PERT, drawing on engineers from different NRENs, who take it in turns to act as the first point of contact for end-users submitting new requests. From even before the beginning of the GN2 project it had been hoped that the PERT would evolve along similar lines to the CERT (the choice of 'PERT' as a moniker was no coincidence), and as such the next stage in the PERT's development is to move to be a more distributed organization, with a local PERT function operating at each level of a the European research network hierarchy. For the reasons described in Chapter 3, the Federated model is currently preferred to the fully decentralised model.

A local PERT would confer the following advantages.

- Formalization and recognition of work that is in fact already being done by most NOCs
- Greater effectiveness in solving performance related problems, through the use of tried and tested procedures and tools
- A better service to the end-user, as their individual concerns are given greater attention, backed up with the assurances of specific response times related to the handling of these performance cases.
- Greater efficiency in investigating complex performance problems, as the local PERT would be able to quickly and easily call upon assistance from other PERTs (and in particular the European central PERT) using well established and regulated lines of communication.
- Access to valuable and important knowledge related to performance in hosts, servers and networks, in the form of the PERT Knowledge Base.

As implied above, the "barrier to entry" for establishing a PERT should be set as low as possible in order to encourage all NRENs to take part. At this relatively early stage of researching the requirements for, and a specification of, a future PERT, the list below represents the current best prediction as to what will be required of any NREN wishing to take part in a federated European PERT.

- The nomination of an individual (by name) to be the head of the PERT function within the organization (plus a deputy to handle PERT matters in his or her absence).

- The creation of an e-mail address in the form `pert@{nren}`. Ideally this mail would be directed to all members of the PERT team plus (if the PERT team are not full time) the NOC's standard Service Desk, so that the mail will always be seen in good time, even if it is not possible for a PERT engineer to start an immediate investigation. Although the PERT will in all likelihood be made up of staff from the NOC it is important that there is a clear distinction made between the work of the PERT and the work of the NOC.
- A statement as to the response times that will be honoured by the PERT, both in replying to end-users and to other PERTs (these times could well be the same). Most probably a PERT will begin with a long response time (perhaps 1 working day) and then as experience grows this could be progressively reduced.
- A commitment to adopt the agreed channels of communications and common working practices

Further to the above, expected pre-requisites, it is noted that the PERT Knowledge Base has proved a most useful tool for the GN2 PERT, and new PERTs will most likely be encouraged (but not required) to put some kind of local PERT KB in place. The concept of a local PERT KB is described fully in Chapter 5

Once the NREN has created its own PERT, it should make every effort to ensure the PERT methodology is replicated at all levels of its national networking, creating a federation of PERTs amongst its regional and campus networks.

One more aspect of the Federated PERT remains to be considered, and that is the policy of sharing data. It will probably be the case that in order to be a full member of the Federated PERT then an NREN will have to commit to making available certain basic data (such as network topology, link capacities and utilizations) to the other PERTs. Exactly what data should be included is a subject for further investigation, but it is noted that the actual mechanics of making this data available will most likely be done by the perfSONAR applications currently under development.

Exactly how to assess an NREN's compliance with its responsibilities as a participant of the Federated PERT is a matter for further discussion and general agreement by the GN2 members. Whilst a form of certification may be appropriate, it should be borne in mind that some NRENS will only be able to put in place a very basic PERT, and any certification process should take this into account.

5 PERT Knowledge Base (KB)

The current GN2 PERT maintains a "PERT Knowledge Base" in the form of a Wiki - i.e. user-editable Web pages. The Knowledge Base contains information about many aspects of network performance, and is one of the key benefits of the PERT, and crucial to its ongoing success. This section looks at possible evolutionary paths for the knowledge base in a decentralized PERT, as well as some general suggestions for improvement.

5.1 Localized Knowledge Bases

Regional PERTs may want to adapt (parts of) the knowledge base for their local user communities. This could involve translating its contents to a local language, but also adapting the contents so that they are more relevant to specific networking approaches used in the respective community.

The current - "central" - Knowledge Base should evolve to support the derivation of such localized versions. At the very least, this involves publishing under a license that permits the creation of such derivative works. See below for further discussion of this issue of licensing.

5.2 Translations

A large part of the PERT Knowledge Base is made up of detailed technical information that is mostly useful for technically sophisticated users. At least in Europe, most of those users can be assumed to be able to read technical English.

It would be helpful to identify those sections of the PERT Knowledge Base that are good candidates for translation, such as introductory topics on network performance, and "how-to" documents containing generally useful performance tips for specific systems.

5.3 Other Adaptations

A localized PERT knowledge base could include information that is specific to the community at hand. For example, it could document the performance implications of available access types available in an NREN. Some case histories may also be more suitable for localized knowledge bases.

5.4 Risks of Fragmentation

An almost unavoidable consequence of having localized knowledge bases will be that knowledge will become fragmented over time: Content will be taken from one knowledge base and localized for a community, and then members of that community will quite naturally focus their effort of maintenance and enhancement on their localized version. There are several possible approaches to mitigating this natural tendency towards fragmentation.

One approach would be to offer hosting localized versions of the knowledge base on the same (central) infrastructure as the central knowledge base. This would have the advantage that localized and non- (or not-yet-) localized parts could remain closely integrated. On the other hand, it would make it harder for localized versions to be "branded" for the regional community, i.e. by an NREN. Also, it would require all maintainers from regional communities to obtain access credentials on the central system, although this is not so much of an issue if a Wiki continues to be used.

In the general case, we have to expect that regional communities will host their localized knowledge bases on their own systems, and maintain them using the tools they are familiar with, and apply their respective Look and Feel.

5.5 Licensing

As mentioned above, the PERT Knowledge Base should be licensed in a way that permits the creation of derivative works such as localized knowledge bases. Conversely, it would be desirable if such derivative works would themselves be under a similar license, so that local improvements can be re-integrated into the central (or another localized) knowledge base.

Approaches such as the Creative Commons [\[Attribution-ShareAlike\]](#) license should be evaluated for their suitability to govern the distribution, localization, and integration of the PERT Knowledge Base. An interesting question is whether such licenses can usefully support restricting access to localized versions, if that possibility is considered by some PERT sub-communities.

5.6 Flow of Information Between Decentralized Knowledge Bases

If and when localized versions of (subsets of) the PERT Knowledge Base emerge, there are some active steps that can help integrate enhancements done both centrally and locally. Maintainers of specific knowledge base instances could monitor changes to other knowledge base instances through mechanisms such as RSS/ATOM (Really Simple Syndication), and integrate relevant enhancements into their local versions.

There is a trade-off between strong coordination and openness to local enhancements. Currently, active participation in the maintenance of the central PERT Knowledge Base is relatively low, and local enhancements would be interesting as an opportunity to broaden this effort. Provided that suitable licensing is in effect, it seems appropriate to encourage such activities and then try to collect the most important local enhancements for integration into the central knowledge base.

5.7 General Issues

Besides the issues concerning decentralization in particular, described below are some general issues with the current PERT Knowledge Base.

5.7.1 Ease of searching

Given the wealth of information in the knowledge base, most users will only be interested in small parts of it. The natural way to find these relevant topics would be to use search engines. The "TWiki" software supporting the current PERT Knowledge Base has limited search possibilities: A keyword search feature exists, but it does not provide any "ranking" of the results. Ranking has long been a focus of public search engines such as Google, and consequently, users have become used to receiving search results in meaningful order.

The current approach at improving the ease with which to search the PERT Knowledge Base involves making it easier for public search engines to index its contents. To this end, a script was written to turn the set of topics in the Knowledge Base wiki into an XML sitemap. These sitemaps have been initially introduced by Google, but recently their support has been announced by Yahoo! and Microsoft, two other big search engine operators. They can be used to "prime" a search engine with a list of documents, and include a desired "weight" for each page. Our script derives the weight from the number of revisions and the number of authors, based on the assumptions that topics with a high degree of review should be weighted more highly. Also, we have improved the robots.txt file that governs traversal of the site by search engine indexing robots, in order to exclude many types of pages that used to make the search index unwieldy.

5.7.2 Navigation

The PERT Knowledge Base contains many cross-references between topics, so that it is already quite natural to pass from one article to another and obtain a deeper understanding of certain subject areas in the process. This kind of exploratory usage could be supported by providing explicit hints about the relationship of the current topic to referenced ones, but not at the cost of overwhelming the user with forests of remotely-related pointers.

5.7.3 Entry Points

The current entry point of the Knowledge Base is a long list of varied topics, in the spirit of a Table of Contents. This is useful for the returning visitor, but probably somewhat off-putting to a curious person who comes across the site. It may be possible to lure such users into the depths of the Knowledge Base by providing more "narrative" introductory text.

6 PERT Tools

This section covers an issue of privacy and security of PERT Tools, including:

- PERT Ticket System (PTS)
- PERT Knowledge Base (PERT KB)
- Performance Measurement Points (MPs) and Measurement Archives (MAs), collectively called Measurement Sources (MSs).
- PERT Home website

The sections below describe how the current PERT Tools would be used and/or developed for each scenario depicted in the chapter “Multi-domain Case Conduct”.

6.1 PERT Tools in fully centralized PERT

This of course would be a continuation of the current format of the PERT. Once an issue is identified, it would be reported to the centralized PERT. The on-duty Case Manager would be responsible for storing it in the central PTS repository and case investigation (and management) would proceed as usual.

6.1.1 PERT Ticket System

A fully centralized PERT has the advantage that there is only one ticket system in use and so no possible confusion as to where tickets should be kept. However, there is an issue about the privacy of data, as all data can be read by all Case Managers who (currently) come from a wide variety of organizations. PSNC-PTS (assuming it continues to be used) may need to be enhanced to better protect sensitive data, and of course any credentials stored in the database should be encrypted.

6.1.2 PERT Knowledge Base

A single central PERT KB has the advantage that all information is kept in one place. Using English as the PERT KB language should not pose any serious problem since it is the common technical language well understood by data network professionals around the world.

6.1.3 PERT web site

Content management of a central PERT website is straightforward, as again there is just a simple website to keep up to date, and there are no synchronization issues.

6.1.4 Measurement Sources

As a single organization is responsible for all the PERT's work, it should be relatively easy to arrange read-only access to all relevant measurement sources (e.g. to deployed perfSONAR MAs), as the organization takes responsibility for securing its communication channels to private data archives.

6.2 PERT Tools in a Fully Decentralized PERT

6.2.1 PERT Ticket System

In a fully decentralized PERT each constituent PERT would be responsible for its own PTS. Ideally (perhaps even necessarily) each PERT would allow access to its PTS to staff from other PERTs, though the access might be limited in some way, so that not all tickets, or not all ticket details would be visible (of course, much information is likely to be in the local language and therefore inaccessible to other PERTs anyway). If PERTs were interested in deploying their own instances of PSNC-PTS then that application would benefit from two specific new features: first, the development of a web services interface (which was anyway in the original development plan); second, the creation of additional privilege levels, so that local PERT engineers could have full access, whilst foreign PERT engineers would have more restricted access. Furthermore, authentication should ideally be done by eduGAIN compatible AA system, as per [eduGAIN Architecture].

Some NRENs may choose to use an existing ticket system for tracking performance issues, and it might be difficult to interface such software with other PTSs (e.g. to exchange tickets data via the defined web services interface). Furthermore, as existing ticket systems might be used to keep tracks of non-PERT related tickets, there may be a reluctance to grant access to such a system to the wider PERT community

6.2.2 PERT Knowledge Base

A fully decentralised PERT would have the disadvantage that there would be no single centre of excellence for keeping articles on network performance issues. On a positive note, any local PERT KB would be in the preferred language of local users.

6.2.3 PERT Web Site

Like a decentralised PERT KB, PERT web-pages would benefit from being in the local user's language, but each site is unlikely to be as content-rich as a single, central website.

6.2.4 Measurement Sources

GN2-JRA1 is working on interfacing MSs with eduGAIN infrastructure. This should make the process of integrating JRA1 infrastructure with a decentralized PERT straightforward.

6.3 PERT Tools in PERT Federation

The PERT Federation would be the union of national European PERTs and a central PERT. The goal of the central organization would be to investigate and coordinate international performance issues.

6.3.1 PERT web site

A central PERT web-site, administered by the central PERT, would be a good first point of contact for end-users. The web-site would list all the PERTs in the federation, the level of service each offers, and contact details. There would of course also be a general description of the PERT's work, and information on how to obtain the PERT's assistance (local or otherwise).

6.3.2 PERT Knowledge Base

The use of the PERT KB in a federated environment is described fully in Chapter 5

6.4 PERT Bulletin Board

Bulletin boards, also known simply as ‘forums’⁵, are often used by IT professionals to share knowledge and experience and to discuss topical subjects. The original GN2 PERT plan called for a PERT forum, which would be accessible to all and would allow members of the public to enjoy the spin-off benefits of the PERT, including assistance from Case Managers when they were not otherwise engaged. As it transpired, to date there has not been a large demand for the PERT’s assistance and so there has been no need to set up a ‘best efforts’ service alongside the standard PERT service.

Looking to the future, and revisiting the potential benefits of a forum, it is noted that a PERT forum could be a useful alternative to the traditional mail-list, such as pert-discuss@geant2.net. A typical forum application allows users to choose whether or not to receive e-mails when new posts are made to the forum, and whether this is for all posts or just posts on a specific topic. This gives users greater control on the amount of PERT-generated e-mails they receive. Another, perhaps greater, advantage is that such forums are accessible to Internet search engines, and so articles and threads can be more quickly found.

The main disadvantage of a bulletin board is that its management is likely to be more complicated than that of a mailing list.

In case of a Federated PERT it is expected that the central PERT would take responsibility for any PERT Bulletin Board, including moderation of all the forums and its maintenance. However it is possible that regular contributors to the forum could take part in moderating the forum, and in so doing become so called PERT Associate Members.

It is expected that a PERT Bulletin Board would include at least two constituent forums:

- a restricted forum
- a private forum

A restricted forum would require a potential user to register themselves in the forum. The registration process would require a confirmation from the user (e.g. by replying to an email). The private forum would be limited to invited PERT engineers, and would allow the discussion of potentially sensitive topics. Current implementations of on-line bulletins (like phpBB or YaBBForum) support the categorization of forums as restricted or private, in the manner required.

6.5 PERT Ticket System - In-Service Support

Since the PSNC PTS could become the recommended tool for tracking the performance issues, it is very important to make sure the software is properly supported and maintained. Put another way, a pre-requisite of

⁵ Strictly speaking bulletin boards and forums are related but not synonymous – one bulletin board can include one or more forums.

the PSNC-PTS becoming the preferred PTS is for a satisfactory level of support to be put in place. Since PSNC-PTS has been developed under GN2, it is likely that its support would be aligned with, indeed most likely part of, the In Service Support (ISS) activity that has begun under GN2 (Work Item 15 of SA3), and will continue in to GN2's successor project. As such, the PSNC-PTS IIS will include the functions described briefly below.

6.5.1 Service Desk

This function will most probably be provided by a common Service Desk for all applications developed under GN2 and related projects. The Service Desk is the single point of contact with the software user, and its principle tasks are to receive user requests, categorise them, forward them to the appropriate specialist team, and keep the user updated with respect to the progress of their request.

6.5.2 Documentation

Good quality documentation is vital to the success of an application, and too often it is overlooked in the rush to develop a working product. PSNC-PTS already has some related documentation, namely a user guide that forms part of [Troubleshooting Guide] The ISS documentation team should work closely with the original developers in order to produce accurate and up to date instruction manuals for both application administrators (the NREN staff who install and configure the software) and the end-users. Ideally the documentation should be created in some form of mark up language, for example [DocBook]. Documentation also covers on-line information, such as Frequently Asked Questions (FAQ), which pre-empt those questions most commonly asked by PTS customers.

6.5.3 Enhancements and Maintenance

It is likely (but not certain) that PSNC-PTS will continue to be developed. If this is the case then enhancement requests must be prioritised, planned and implemented. Whether or not an enhancement function is offered, any bugs discovered in the production application must certainly be fixed. Again, the fixes must be prioritised, planned and implemented. Aside from bug fixing there will also need to be general so called source maintenance, such as ensuring the application continues to work with new releases of supporting software (specifically Java), and (if the base code becomes open source) incorporating changes made by external developers.

All this work will be done by the PSNC-PTS development team, which may or may not be a continuation of the current PSNC development team. If PSNC do not retain development responsibility for the application then there will be need to be a very carefully controlled handover between the PSNC team and their successors.

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6.5.4 Functional Testing

When a new version of the application or patch, becomes available, it must be fully tested to make sure that it works properly and that the changes made have not introduced new bugs. This is the responsibility of the functional testing team.

6.5.5 Release Management

A new version can only be released once it is ready in all respects, which means to say it has been properly tested, and new documentation available. The Release Management team are responsible for this, along with the distribution, and in some cases even installation, of the software.

7 Conclusion and Future Work

Although the GN2 project is only half way through its 4 year life, the decision process for the future of the PERT is already well underway. The initial recommendation of the current PERT participants, formed at the June 06 GN2 Tech Workshop, was for a (fully) decentralized PERT, but this recommendation was made before it became apparent that there was likely to be funding available for a central, European-wide PERT function. A comparison made between a fully decentralized and a fully centralized PERT suggested that each had advantages and disadvantages, and that these be combined in a Federated PERT, which would consist of a central team, responsible for solving international performance problems, and national (or local) PERTs, which would be fully responsible for issues which lie entirely within their national borders, but would also assist the central PERT in investigating problems where traffic originates, terminates or transits their domain. Ideally this hierarchy of central/local PERT would be repeated on a national basis, so that the national PERT acts as a central PERT for regional or campus PERTs.

Clearly the success of a Federated PERT will depend to a large extent to the number and quality of national and regional PERTs. Exactly what incentives to give for the establishment of national PERTs is a matter for future study, but it is anyway intended to run a workshop on 'How to set up a PERT' at the summer 2007 GN2 Technical Workshop. In those cases where a country is delayed in setting up its PERT, the central PERT should be able to provide a temporary service similar to that provided by today's fully centralized PERT.

This document has studied the various options for a post-GN2 PERT, and explains why the recommended replacement to the current central PERT would be a Federated PERT. If the federated model is accepted as the model for the future PERT, then the next step will be (as part of GN2 Year 4) to produce a detailed policy, covering the roles and responsibilities of the constituent groups of the PERT.

8 References

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- [Troubleshooting Guide]** http://www.geant2.net/upload/pdf/GN2-06-094v6-Deliverable_DS3-5-2_PERT_Troubleshooting_Procedures-Second_Edition.pdf

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9 Acronyms

BIND	Berkeley Internet Name Domain
CERT	Computer Emergency Response Team
CM	Case Manager
cPERT	Centralised PERT
DCM	Duty Case Manager
DMZ	Data Management Zone
DNS	Domain Name Service
dPERT	(fully) Decentralised PERT
FAQ	Frequently Asked Questions
fPERT	Federated PERT
FTE	Full Time Equivalent
GE	Giga Ethernet
gPERT	Global PERT
HPC	High Performance Computing
ISS	In Service Support
JRA	Joint Research Activity
MA	Measurement Archive
MP	Measurement Point
MS	Measurement Source
MTU	Maximum Transmission Unit
NDT	Network Diagnostic Tester
NFS	Network File System
NOC	Network Operations Centre
nPERT	National PERT
NREN	National Research and Education Network
OTRS	Open Source Ticket Request System
PERT	Performance Enhancement and Response Team
PERT KB	PERT Knowledge Base
PTS	PERT Ticket System
RSS	Really Simple Syndication
RTT	Round Trip Time
SA	Service Activity
SCM	Special Case Manager
SME	Subject Matter Expert

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Description of a Decentralised PERT

Acronyms



SSH	Secure Shell (Protocol)
TCP	Transmission Control Protocol
VNC	Virtual Network Connection
WI	Work Item
XML	Extended Mark up Language

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Appendix A **Review of Existing PERTs**

As part of the research for this report, those NRENs which currently provide a PERT were canvassed for their experiences. The following responses were provided.

A.1 **FUNET (Finland)**

PERT-service in FUNET has been running since the beginning of 2006. Currently about six people are involved in PERT work. FUNET-PERT does not have standard procedures for performance investigation.

Tools in use: iperf, tcpdump and traceroute.

There is no dedicated ticketing system in FUNET for tracking performance issues. They are handled by their NOC in the same way as other network-related issues.

There is a small amount of performance cases handled by FUNET so far (three cases, all internal to FUNET). Each of them took several weeks to close. Two of them were solved with routing changes and TCP-tuning and one needed a change in a firewall configuration. Lessons learned show that the most important problem with PERT investigation in FUNET is related to gathering information from the customers.

A.2 **GARR (Italy)**

At the moment GARR PERT work is conducted by one person (with some contribution from other people, and occasionally some senior NOC staff). There is no formal GARR PERT as such, and there is a possibility they might not have enough manpower to do implement one in the future. Usually PERT matters are considered as a network issue and addressed and solved by the NOC.

A.3 **NIIF/HUNGARNET (Hungary)**

The PERT has been running in Hungarnet for about 2 years. It is staffed with three network engineers.

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The only PERT case handled by Hungarnet so far was the Budapest-Trieste case, which is well known to the GN2-PERT community. Hungarnet PERT has experienced many problems whilst investigating that issue, especially they noticed the following: - it was hard to get information about the "customer" network - they couldn't get access to customer's end system - the lack of time they could spend on the investigation - the lack of time the customer could spend on the case.

There are no standard procedures in Hungarnet for performance investigation.

Tools in use: iperf, bwctl, tcpdump, traceroute, ping, mtr, looking glasses, etc.

A.4 RESTENA NOC (Luxembourg)

PERT is not used as a production service in RESTENA yet. Currently it serves only as a point of contact for requests coming from outside of RESTENA network. The members of RESTENA PERT pointed out that the development and evolution of this service will strongly depend on how much it is being triggered by GN2-PERT. The performance issues in RESTENA PERT are being handled by NOC staff (up to 7 people). They handle no more than 4 performance cases per year. The investigation is usually based on their network experience, there are no formal procedures for performance investigation. It normally takes weeks to close a performance problem.

Tools in use: ping, tcpdump, traceroute, i.e. "standard" networking CLI tools, network monitoring data like: traffic count, server load, router cpu/memfree, interface errors, packet loss, etc.

RESTENA NOC does not use a dedicated issue tracker for tracking performance issues, they use the NOC ticketing system, i.e. OTRS. They expressed interest in deploying PTS for future use in RESTENA PERT.

Most performance problems handled by RESTENA NOC are related to operator or access line provider issues, i.e. temporary connection loss, packet loss. They have not experienced real line capacity problems, because most access lines and backbone connections are over-provisioned.

If it is a user related issue (application response time, network slow), the biggest problem is getting measurements from the user side (users are rarely technically skilled). If dealing with line problems involving commercial providers, feedback is difficult to get, and not always guaranteed. But there are case were communication is good and feasible.

Because of its aggregation algorithm, measurements (mrtg data) are not always detailed enough over a long period of time (in the past) to track problems at a specific time.

A.5 SANET NOC (Slovakia)

PERT functions are carried out by the NMC in cooperation with local administrators (two persons in NMC responsible for PERT investigation).

Currently SANET PERT has about 10 PERT cases completely solved, however, because the number is still insignificant, it has no ticketing system, dedicated to track performance issues. SANET expressed no interest in deploying PTS to handle performance cases in local PERT.

Typical PERT issue handled by SANET NOC is caused by errors on links interconnecting end-points, wrong duplex settings on particular end host (e.g. manually configured full-duplex instead of auto-negotiation) or vendor specific problem (e.g. drivers for GE cards).

SANET NOC has no clear PERT procedures for performance investigation, issues are handled on per-case basis.

Tools in use: iperf, tcpdump, traceroute, nttcp, ping, ngrep. A special case is a multicast environment, where they typically use a set of RTP streams ranging from 256 kbps up to 20 Mbps.

A.6 SWITCH (Switzerland)

The PERT in SWITCH has been running since October 2004 (creation of the alias). It is staffed with four network engineers. There are no formal PERT procedures, however, SWITCH has succeeded in solving many performance issues during its two year history. Although the number of cases submitted to PERT is very impressive (in comparison to other NRENS), SWITCH has not been running any ticketing system. They have expressed no interest in deploying PTS to track local performance issues.

Typical tools in use in SWITCH: traceroute, NDT, tcpdump, wireshark.

Lessons learned show that most significant problems experienced whilst investigating performance issues are related to the communication channel between PERT and customer. Sometimes it is very difficult to get contact to the actual technical people at the customer. Once those people were involved, PERT usually made quick process. Additionally, there is a lack of feedback from customers, often making it unclear whether the problem has solved itself or whether the customer lost interest.

A.7 UNI-C (Denmark)

There is no actual PERT in Denmark. Performance issues are being solved within a given provider's network or completely ignored. In case of very urgent performance issues UNI-C uses its professional networks to contact network managers at the relevant providers.