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Deliverable DS3.5.2: PERT Troubleshooting Procedures - 2nd Edition



Deliverable DS3.5.2

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Abstract

These Performance trouble Ticket Procedures are divided into two main sections. The first section is 'Operational Guidelines'. This section looks at the different types of PERT users, and gives guidance on how to conduct a PERT investigation. The second section is a detailed user guide for the PERT Ticket System (PTS). The PTS allows end users to create themselves an account on the PTS and then to request help with possible network performance problems.

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0 Executive Summary

The Performance Enhancement and Response Team (PERT) is a virtual group established within the GÉANT2 project whose purpose is to help investigate and resolve any system performance problems a user is experiencing that might be the result of a networking issue. The principal members of the PERT are Case Managers (CMs), who work in accordance with a roster and volunteer Subject Matter Experts (SMEs), who work on a purely best efforts basis. Anyone can submit a request to the PERT, but the PERT only guarantees to investigate and assist Eligible users (NRENs and other academia-related organizations) – all other users are termed Ineligible and PERT staff will only provide assistance on a goodwill basis. PERT Case Managers are responsible for receiving and investigating new PERT cases, and they should follow certain basic steps when doing so. These include determining when it is appropriate to accept a new case, how to analyse a case, when and how to seek assistance from SMEs and how to close or cancel the case.

The system used to record and manages all PERT cases is the PSNC-developed PERT Ticket System (PTS), which is accessible from any standard web-browser. The heart of the PTS is the ticket database. A PERT ticket can be in one of the following states: SUBMITTED (if the ticket has been created by PERT staff) or PENDING (if the ticket has been created by a user), ACKNOWLEDGED (when the PERT accepts the case), WAITING FOR [organization] ACTION (indicating who is the next party expected to update the case), RESOLUTION PROPOSED (when a solution has been provided to the user), CLOSED (when the user is satisfied and any lessons learned have been added to the Knowledge Base) and CANCELLED (only used if a ticket has been created in error). Depending on the chosen PTS settings, as a ticket moves from one state to another, PERT users may be sent e-mail notifications on the changes. This feature is particularly useful for volunteer Subject Matter Experts, who have an interest in certain topics but not others, and for users who wish to know when progress has been made on their case.

To simplify access to the those who use PTS on a regular basis (Case Managers, Subject Matter Experts and frequent users, such as NREN NOCs) are given certificates to install in their web browsers (instructions are given in the document on how to install this certificate). Conversely, end-users, who require only temporary access, are e-mailed a password then use that and their e-mail address as a login name.

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1 Introduction

The Performance and Enhancement Response Team (PERT) is a virtual team whose purpose is to be a centre of excellence for the investigation of network performance issues, and an authoritative source on performance-related recommended practices. The original PERT was a mailing list of interested network performance experts who offered help on a voluntary basis. Since the GÉANT2 PERT has an obligation to investigate all cases which are brought to them by their users, a more robust set of management systems and procedures were required. The result of this requirement was a set of Troubleshooting Guidelines and the PERT Ticket System (PTS). A PERT troubleshooting guide [GN2-05-108], which contained instructions on using the PTS and specified the procedure for investigating a PERT case, was published in June 2005. This second version of the PERT Troubleshooting Guide covers the use of PTSv2, and has updated troubleshooting procedures based on the lesson learned from 18 months of PERT operations.

The 'Operational Guidelines' given in section 2 of this document were created to help the PERT investigate network performance related issues in an efficient and comprehensive manner. They are particularly important for PERT Case Managers (CMs) but may also be of interest to PERT Subject Matter Experts (SMEs). The guidelines are not exhaustive, and they should not be allowed to limit the ingenuity of the PERT investigator. Nevertheless, the guidelines are derived from the PERT operations policy and should be followed as far as is possible and sensible.

Section 3 of this document gives a functional description of PTSv2. PTSv2 includes all the standard features of an issue (trouble ticket) tracker, such as a web-based front end, different user access rights, and the ability to update records (tickets) as a case develops, and has a "look and feel" based on the GÉANT2 website.

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2 PERT Operational Guidelines

These guidelines have been created to help members of the GÉANT2 PERT investigate network performance related issues in an efficient and comprehensive manner. They are particularly important for PERT CMs but may also be of interest to PERT SMEs.

2.1 Organization

For more complete information on the roles and responsibilities of the PERT staff refer to [GN2-05-018]

2.1.1 PERT Staff

There are four roles within the PERT staff: managers, Duty Case Managers, Special Case Managers and Subject Matter Experts. Duty Case Managers and Special Case Managers are sometimes together referred to as 'Case Managers' (CMs).

- PERT managers are responsible for the proper administration of the PERT
- Duty Case Managers (DCMs) make up a roster, such there is always one Full Time Equivalent (FTE) worth of DCM on duty on any given working day, split amongst 2 to 4 people. The on duty DCMs are responsible for the day to day operations of the PERT. Their primary function is to receive new PERT cases and to investigate all unresolved cases.
- Special Case Managers (SCMs) are people (normally but necessarily from the Duty Case Manager group) who have volunteered to manage a given case, on a permanent basis, such that they are responsible for the ongoing investigation and are the main point of contact for that case. Because SCMs are not normally able to dedicate their full time to the investigation of their case(s) they may and should use the Duty Case Manager(s) for assistance.
- Subject Matter Experts provide help to the DCM(s) on a best efforts basis. A DCM may specifically request help from a SME, or an SME may find out about a case them selves and choose to help.

2.1.2 PERT Users

To date people and organizations who call upon the PERT's services have been termed 'customers'. 'Customer' was originally chosen in order to distinguish between those people or organizations who requested the PERT's assistance, and those end-users who the PERT contacted as part of their investigation. However, the term 'customer' has commercial connotations, which are very misleading in the context of the PERT. As such, those requesting the PERT's assistance will no longer be referred to as customers but will instead be termed 'users' and people who operate and/or administer the end-systems involved in a PERT case will be termed 'end-users'.

A new feature of PTSv2 is that anyone can submit a request for help from the PERT, and the Duty Case Manager will assess whether that person is entitled to PERT assistance, and/or whether the PERT has the resources to help. PERT users are therefore judged on whether or not they are eligible for PERT assistance - if they are they are termed 'Eligible' and if not they are termed 'Ineligible' (capitalization is used to indicate the special meaning of these words in the context of this document). Note that even Ineligible users may get assistance from the PERT, if the PERT are not otherwise busy assisting Eligible users. However, the help provided to Ineligible users is likely to be limited.

Since the change from 'customer' to 'user' occurred after the development of PTS v2, PTS still refers to 'customers' not users (a Primary Customer is someone who has access to all of an organization's tickets, whilst an End Customer is someone who only has access to specified tickets). This terminology will be updated as and when resource and time permits.

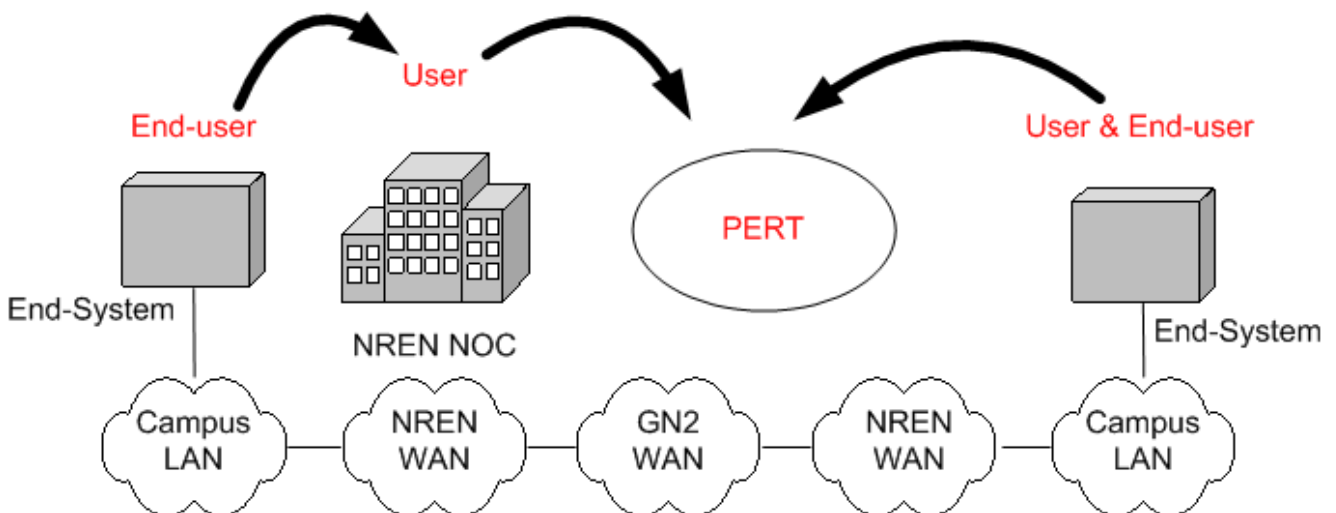


Figure 1 Relationship between End-users, Users and the PERT

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2.2 PERT Case

PERT cases should only be opened in those circumstances where:

- i) a networked system is not performing as expected
AND
- ii) the problem is suspected to be caused directly or indirectly by the network
AND
- iii) the problem is NOT believed to be the result of specific hardware failure (if this is the case the relevant NOC should be contacted)

2.3 Case Handling Procedures

The procedure below describes how a PERT Case Manager (CM) should react when they receive a new request for PERT assistance. Some steps, particularly the beginning and end steps, give detailed instructions that should be closely followed, whilst others can only offer broad advice on how to proceed. However, none of the steps are mandatory, and nothing in these procedures should prevent the Case Manager from taking whatever action, in their professional judgement, they think best. For an Eligible user a case should be opened and/or acknowledged within 2 working hours of the request being submitted (see [GN2-05-018] for more information on PERT working hours).

2.3.1 Check the eligibility of the user

A user is Eligible if they are a user of a network operated by a GEANT2 participant organization. All other users are Ineligible, however at the duty Case Manager's discretion a case may still be opened in the following circumstances:

- The PERT is not otherwise busy investigating the cases of Eligible users
- The request involves an academic network (for example in the US or Asia)
- The request is of an unusual nature and it is thought that an investigation is likely to lead to an increase in the PERT's Knowledge Base and/or experience.

2.3.2 Check the request is appropriate

A request is appropriate if it is within the scope of the PERT's business. The scope of the PERT's business is any (academic) networked system performance problem except those which are definitely caused by the non-

network components of an end system. Furthermore, if the request is related to circuit or other hardware failure the requestor should be immediately advised to contact their NREN NOC, or other direct IT support, on the grounds that such teams are better able to affect a quick repair.

Some common example issues for the PERT will be reports of a low achievable bandwidth, or unexpectedly high or varying latency.

2.3.3 Check the supplied information

Check the information against the table below:

Problem description	Description of the current system behaviour	Must have
User's expectations	User's expectations as to how the system should behave (preferably a quantitative expectation, but a qualitative description is acceptable)	Must have
Previous behaviour	Has the system ever behaved as expected	Should have
Start of problem	When was the problem discovered	Should have
Customer (user) contact	Requestor's e-mail address	Must have
A end IP address		Must have
B end IP address		Should have
A end URL		May have
B end URL		May have
Traffic type	IP Protocol, source port, destination port	Must have
A end user details	Details of the A-end technical POC	Must have
B end user details		Should have
Forward trace route	From A end to B end	Should have
Reverse trace route	From B end to A end	Ideally have
Round Trip Time	Only required if no trace-routes provided	Must have
A end topology	Local network equipment and connections	Should have

B end topology	Local network equipment and connections	Ideally have
A-end host details	Hardware, OS, application	Should have
B-end host details	Hardware, OS, application	Ideally have

Table 1 Ticket details - required/optional fields

Key:

- must have = info the user must provide before the investigation starts
- should have = info the user should provide in order to increase the chance of a quick and successful resolution. If not provided, the CM should request this info from the end users(s)
- may have = in certain cases an end user should provide this info to increase the chance of a quick and successful resolution
- ideally have = the end user may not be able to provide this info easily (or at all) but it helps if they can

2.3.4 Open a case

The sub-steps listed below should be followed precisely

2.3.4.1 Create a PERT Ticket

If the request is legitimate and all compulsory information has been provided then a new PERT case must be opened. All the users provided information should be copied across into the ticket, and relevant keywords added. If no trace-route information is available then RTT information (even if only approximate) should be put in the 'Trace route' section.

2.3.4.2 Add Case Summary

As soon as the ticket has been opened and acknowledged a 'Note' should be added. This entry should be a summary of the case. The Note should be marked as important and throughout the life of the case it should be kept up to date with important findings.

2.3.4.3 Inform PERT Community

The Duty Case Manager should then send the newly written case summary to the pert-discuss@geant2.net mailing list, so that Subject Matter Experts can determine whether or not the new case is one they are interested in following up and/or helping with.

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2.3.4.4 *Notify Involved NRENs*

Once the ticket is created, the Duty Case Manager should identify all NRENs involved in the case, which is to say all NRENs whose networks appear in the problem path. If the NRENs in question have their own PERTs established, the DCM should send them an e-mail, providing a full description of the new case. For those NRENs which do not have a PERT then the same e-mail should be sent to the appropriate NOCs. It is recommended that the PERT Ticket System's embedded mail client is used for sending mails to users, because then the mail and any replies will be attached as notes to the ticket.

For full details on how to operate the PERT Ticket System, see section 3 'A guide to the PERT Ticket System'.

2.3.5 Troubleshooting a case

Once a case has been ticketed, the CM must begin initial troubleshooting in order to narrow down the scope of the case and translate user reported symptoms and expectations into technical descriptions of a case and performance data. There are a number of steps to this process. At each step, the CM should be aware of the information available in the PERT Knowledge Base and check to see if it is applicable or helpful.

2.3.5.1 *Gather additional information*

Contact the primary user and/or end user and ask for any missing information, which is to say any information marked as 'should have' or 'ideally have' that has not already been provided. In particular, any error messages encountered should be collected. If trace-route information has not already been provided then every effort should be made to get this. If necessary, trace-routes between other hosts on the same subnet may be used e.g. if the actual hosts block/drop ICMP for security reasons. Based on the information provided, determine which networks (domains) the end to end path traverses. At this point, if it has not already been done, the contact details of the technical POCs for each domain along the end-to-end path should be added to the ticket (as part of the first 'action').

Tech Tip: Even better than regular traceroute would be to get also a trace using 'Layer 4 Traceroute', which connects to the actual port in question and therefore helps to detect firewall filter issues

Determine what the end users' security policies are (both ends), in particular under what conditions PERT staff could be granted direct access to systems at the end-users' premises.

Tech Tip: If the transport protocol being used is TCP (which it most probably will be) then it is important to find out the send and receive socket buffers, and to calculate the path's 'Bandwidth-Delay Product'. The BDP is the product of the path RTT and the data rate of the path's minimum capacity link (the bottleneck). If the path is to be used to its maximum capacity (such that the bottleneck is full) then the TCP window must be equal to or greater than the TCP window. Therefore, the TCP advertised window must be at least equal to BDP. See the PERT KB for more information and advice on how to determine BDP.

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Use the information gathered at this stage to help make a clear problem statement in terms of a set of symptoms. E.g. a PERT report may be that an application has degraded performance. A problem statement could be that this report is a manifestation of excessive latency or sporadic packet loss and some mention of what the expected reasonable performance ought to be.

2.3.5.2 *Draw the path*

Based on the information provided, draw a diagram of the equipment and connections that make up the end-to-end path. This will require contacting the network administrators ('net admins') for each domain along the path. It will be easiest to start with the affected NRENs (and GÉANT2 if applicable) and then ask the NRENs to help contact the net admins in their region as appropriate. Once the diagram is complete it should be saved as an attachment to the ticket (ideally as a PDF) and marked as 'important'.

Tech Tip: As part of this process try to determine what cross traffic is present e.g. there may be a LAN switch in the path which has heavy local traffic i.e. traffic staying on the LAN.

Use the information gathered at this stage to help make a clear problem statement in terms of a set of symptoms. If possible, begin to consider general causes for those symptoms, e.g. a longer path or a capacity bottleneck could increase latency.

2.3.5.3 *Determine available tests and statistics*

First, contact the end-user and determine what tests have already been run. It is quite possible the end users have done one or more back-to-back tests. If these have not been successful, then clearly the problem lies in one or both of the end-systems. If no back-to-back tests have been conducted, then see if it is possible to do one, either using the actual affected system, or a spare/test system.

Tech Tip: Ideally, two back-to-back test should be run, the first involving two End-Systems directly connected via crossover and the second with the LAN switch(es) in the path.

Tech Tip: Even if back-to-back tests are successful it does not necessarily mean there is a 'problem' in the WAN – for example, the advertised TCP window might be smaller than the BDP (see above).

If the above tests have shown no problem with the End-Systems, or have proved inconclusive, or simply have not been done then the next step is to try to determine if the problem lies on the network path, including the End-System's networking hardware and software. If the performance problem in question is a low achievable data rate, then a standard test is required to test end-to-end transfer speeds. Preferably this would be done using the affected End-Systems but acceptable alternatives include other End-Systems on the same subnets, or equivalent locations. Note, if the problem end-system is an important production system then it is possible that the end-user will be reluctant to use it for any testing at all. In this case, try to get use of another system on the same subnet, from where bandwidth tests (for example) may be run from.

As well as, or instead of, the end-to-end tests, it may be possible to make use of specialist network performance Measuring Points (MPs) that are in place along the end-to-end path. If available these may also

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have statistics (from routine scheduled tests) that could show whether or not there was any deterioration in network performance at the time the end-user's problem came to light. At the very least most networks keep records (graphs) of their backbone link usage, so this information should be retrieved, either directly (if the information is public) or from the network administrators.

The PERT Knowledge Base should give some information on what tests are available, but to get the most current information will probably require contacting each domain's technical POC again.

2.3.5.4 *Localise the problem*

At this point, if no simple solution has presented itself, it is necessary to identify in what part of the end-to-end path the problem lies in order to narrow the scope of troubleshooting. The end-to-end path can generally be considered as being made up of the problematic end system (End-System A), the LAN where it is located (LAN A), the national/international WAN(s), the far-end LAN (LAN B) and the far-end End-System (End-System B).

A good troubleshooting approach is to split the troubleshooting domain into discrete areas, logically isolated from each other. In an ideal situation it would be possible to choose a point in the middle of the end-to-end path (point C), run two tests (one against End-System A, the other against End-System B), one of which would 'pass' and the other one of which would 'fail', and then reiterate the process with a new point, point C', which is itself halfway between the suspect End-System and point C. In practice it is unlikely that such test will exist and/or be available at point C. An alternative approach is to begin from End-System A and try a sequence of tests, progressing along the path to End System B. This is more time consuming but may be necessary to isolate the problem if it is not possible to directly access a mid-point C.

Choosing (and running) available and meaningful tests will be the key to localising the problem. A clear problem statement will help identify appropriate tests to run and any tests run will help to refine the problem statement further.

The tests conducted should enable the problem to be accurately categorised. Broadly, problems can be categorised as:

- End-System application
- End-System (non-application)
- LAN system
- WAN system

This classification will help to eliminate classes of problem and narrow the troubleshooting scope. If possible, the CM should try to identify a particular network element within these categories.

2.3.5.5 *Search the PERT Knowledge Base*

At this point the PERT Knowledge Base should be consulted for problems relevant to the problem category and possibilities evaluated as likely causes. If a single network element has already been identified, evaluation is quick but it is likely that causes may be more complex.

The content of the PERT Knowledge Base should grow and improve over time, as PERT cases are investigated and solved. It is to be hoped that Knowledge Base articles will either directly or indirectly solve many PERT cases.

2.3.5.6 *Request SME assistance*

It may be that one or more SMEs, alerted by the keywords in the PERT ticket have already begun working on the case. If this is not the case then, based on where the problem has been localised to, check the list of current SMEs and determine from their profile who are the best to contact. The SME will hopefully be able to suggest or eliminate possible causes of the performance issue, allowing the CM to progress towards a resolution, refine the problem definition or contact an SME in another field as appropriate.

2.3.6 Resolving a Case

2.3.6.1 *Proposing a resolution*

Based on information from troubleshooting, tests, the PERT Knowledge Base and SME feedback, it may be possible to propose a resolution. The CM should communicate to the PERT user and any intermediate contacts to co-ordinate what is required to test the proposed resolution. Any proposal should limit the possibility of invasive impact on other network users and avoid introducing security lapses. If the proposal requires multiple changes, it is advisable to manipulate only one variable at a time and observe for negative or positive impact after each step. Any changes proposed should include agreement to roll back if the impact is negative.

After a proposed resolution is implemented, the CM determines if the case has been resolved by re-running tests and reviewing for expected behaviour and contacting the reporting party to verify. If the resolution is not effective, it should still be recorded in the ticket along with any results and the prior environment reinstated. At this point, based on this new information, the SME, PERT KB or CM may propose an alternative resolution or the problem definition re-examined.

If it is not possible for any reason to implement a resolution following all appropriate efforts, the CM may still bring the case to an end.

2.3.6.2 *Finalising Resolution*

Once an issue has been solved and/or the reason for the problem understood, then the CM should contact the end-user in order to pass on investigation findings and summarise the case. It is important to ask for his or her estimates on overall satisfaction with PERT assistance to the case. Then the case should be marked as 'Resolution Proposed'. If end-user provides any other comments related to the case and/or to the PERT in general, this should be included in resolution description of the case.

In order to indicate an issue resolution two grades are introduced:

- Customer's satisfaction
- Problem understanding

The former should be used to indicate the level of user's satisfaction with PERT assistance to the case. The latter indicates how well the problem was understood.

Customer's satisfaction is defined as follows:

- Not at all Satisfied
- Not Satisfied
- Neutral
- Satisfied
- Very Satisfied

Problem understanding is defined as follows:

- Fully Understood (fix identified)
- Well Understood (no fix identified)
- Somewhat Understood
- Incomprehensible (but possible to estimate where the problem might be)
- Completely Incomprehensible (impossible to estimate where the problem might be)

2.3.6.3 *Add a Knowledge Base article*

If the issue, or any part of the investigation, is worthy of being included as a Knowledge Base article, then the CM should write an appropriate entry, cross-referencing the ticket. In general, any issue which has not previously been noted in the Knowledge Base should have a new article written upon it, and if there is an existing KB article on a given issue then the article should be checked to see if it would benefit from being updated. KB articles should always include details on any tools used, and the success had with them.

2.3.6.4 Close the case

Once a Knowledge Base article has been written (if appropriate) and once the end-user is satisfied with the PERT's results, then the ticket status should be changed to 'Closed'.

2.3.7 Special Case Managers

The PERT's experience to date is that if a case is not solved within about a week of first being opened then it is of sufficient complexity that it is difficult for subsequent DCMs, who each have only a week on duty, to have enough time to learn about the case and then lead its investigation – typically what happens is that the new DCM needs a point clarified, so e-mails the user and then waits four days for a reply, at which point it is time to handover to the next DCM! Based on this experience a new role within the PERT was identified, namely the Special Case Manager (SCM). The SCM is someone who volunteers to take over the permanent management of a given case. The SCM can be any member of PERT (even an SME, though this has not happened to date, nor is expected to) but ideally it would be the Case Manager who was on duty when the case was first raised. Such an SCM provides continuity in the investigation, and should already have built a relationship with the user (the two main purposes for having an SCM). However, another suitable candidate for being an SCM is someone of the same nationality as the user, or who knows the user, or is involved or interested in the project affected by the performance problem.

The particular responsibilities of the Special Case Manager are:

- to be a single point of contact for the case
- to coordinate the work of on-duty Case Managers (if their input is required)
- to establish and maintain a good relationship with the user and end users involved in the case
- to progress the case's investigation and keep the associated ticket up to date.

It is recognised that an SCM will have to manage their case(s) in parallel with all their other day to day work and as such there may be long periods when they can not give their time to progressing the investigation – this is the accepted disadvantage of the SCM concept (and the reason why it was not adopted from the outset). In order to mitigate this risk it is the responsibility of the DCM to monitor the progress of those cases which have been taken over by an SCM and if it appears there is no activity then they should contact the SCM to determine what is happening. If it becomes apparent the Special Case Manager does not have time to work on the case, then the DCM should themselves try to progress the case (following the SCM's advice and directions).

2.3.8 Sample Troubleshooting Methodology

PERT CMs are experienced NREN operators and has such may have their own processes for troubleshooting. The methodology outlined in this section is an example only and shows where the more detailed steps of troubleshooting a PERT case as described above fit into such a troubleshooting process.

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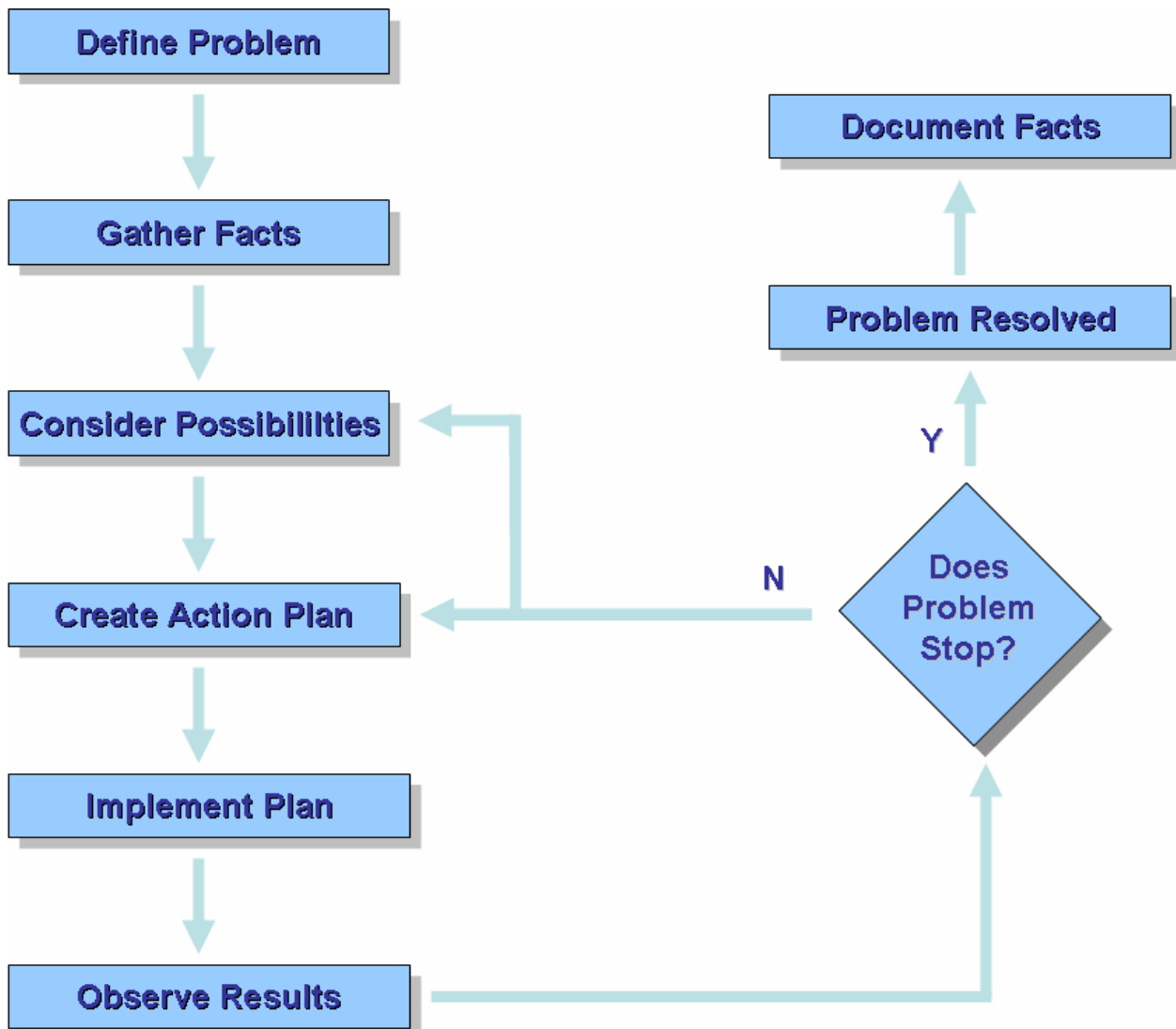


Figure 2 Troubleshooting Methodology

The following table presents the mapping between PERT troubleshooting and methodology stages.

PERT Troubleshooting Stage	Methodology Stage
2.3.5.1 Gather additional information	Define Problem, Gather Facts
2.3.5.2 Draw the path	Gather Facts, Consider Possibilities
2.3.5.3 Determine available tests and statistics	Gather Facts, Consider Possibilities
2.3.5.4 Localise the problem	Gather Facts, Consider Possibilities

2.3.5.5 Search the PERT	Consider Possibilities, Create Action Plan
2.3.5.6 Request SME assistance	Consider Possibilities, Create Action Plan
2.3.6.1 Proposing a resolution	Create Action Plan, Implement Plan, Observe Results
2.3.6.2 Finalising Resolution	Observe Results, Problem Resolved
2.3.6.3 Add a Knowledge Base article	Document Facts
2.3.6.4 Close the case	Problem Resolved, Document Facts

Table 2 Troubleshooting methodology

3 A guide to the PERT Ticket System

3.1 Functionality

The features available to the PTS user depend on that user's privilege level. The following types of user are defined for the PTS:

- PERT Staff (PERT Managers, Case Managers, Subject Matter Experts)
- Primary Customers (NRENs, large research projects)
- End Customers (users of the Primary Customers e.g. campus network administrators)

PERT Staff have access to all cases.

Subject Matter Experts (SMEs) come from a wide range of academic and commercial areas, and provide their help on a purely voluntary basis. Subject Matter Experts are able to read all PERT Tickets data.

'Primary Customers' are able to create PERT Tickets, and to view all tickets created by their organisation's affiliated users.

'End Customers' can create new tickets and view any tickets with which they have been affiliated. End Customers use their e-mail address and a password to login to PTS.

Hereafter, 'System Users' means all users of PTS.

3.1.1 PERT Ticket management

PERT Ticket management covers those activities and procedures related to PERT Ticket processing, e.g. ticket creation, modification or resolving.

3.1.1.1 *The Life Cycle of the Ticket*

A PERT Ticket has the following states:

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- Submitted (or Pending)
- Acknowledged
- Waiting for Customer Action
- Waiting for PERT Action
- Waiting for Third Party Action
- Resolution Proposed
- Cancelled
- Closed

The relationship between the states is illustrated below:

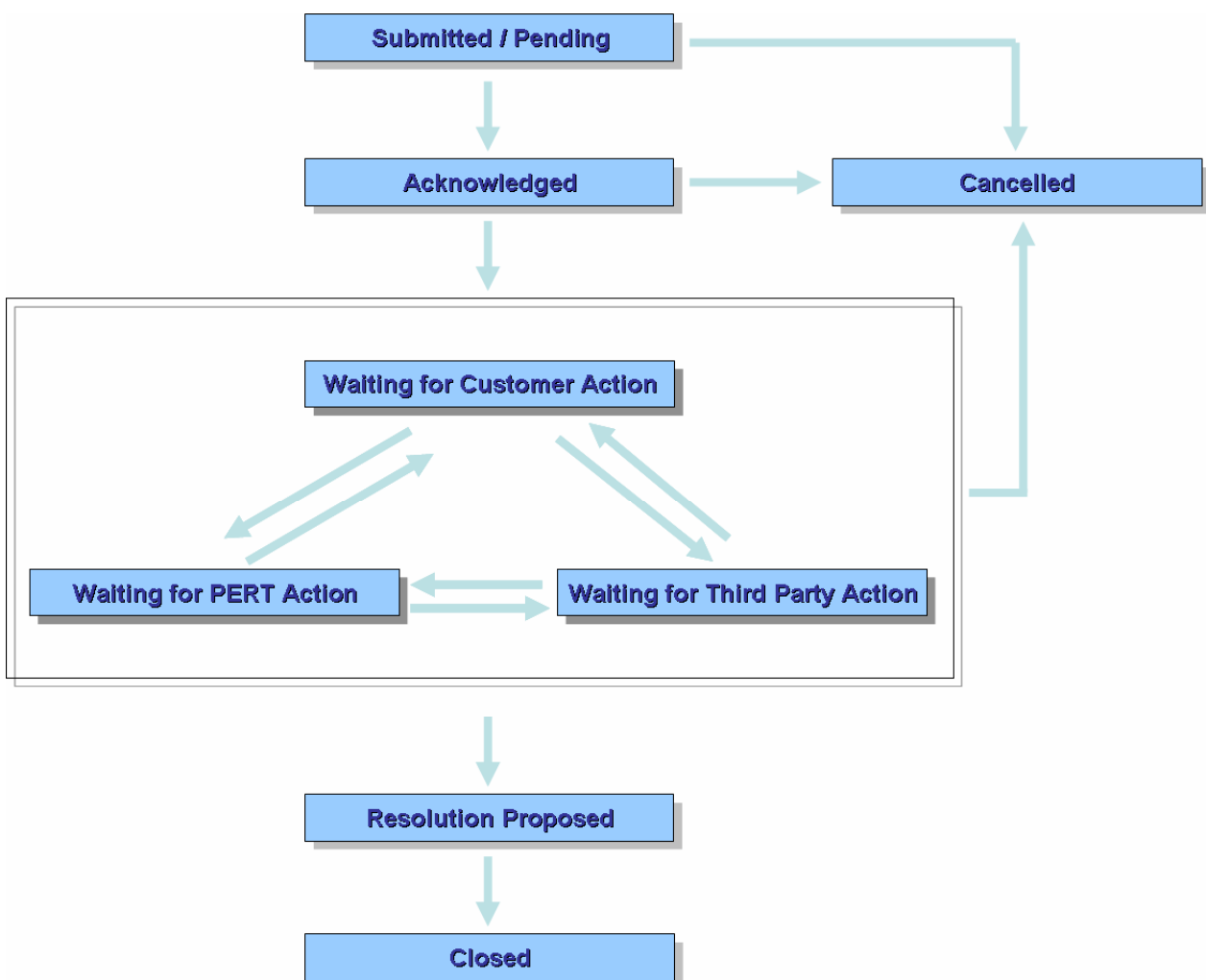


Figure 3 The life cycle of the PERT Ticket

Once the ticket is submitted to the PTS (either by the PERT staff or a user) it is either in 'Submitted' or 'Pending' state. Next it has to be either acknowledged or rejected by the Duty Case Manager (DCM) – in the

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former case the state is changed to 'Acknowledged', in the latter case the state is changed to 'Cancelled' (and no further action is required).

Once the investigation starts, the ticket's state is changed to indicate who is responsible for the completing the current stage of the investigation. There are 3 states for this: 'Waiting for PERT Action', 'Waiting for Customer Action', 'Waiting for Third Party Action'. Once an issue has been solved and/or the reason for the problem understood, the Case Manager changes the ticket state to 'Resolution Proposed'. Then, once the end-user has agreed with the Case Managers proposed resolution, the case is closed.

It is possible to cancel the ticket before the investigation starts (states: 'Submitted', 'Pending' and 'Acknowledged'). It is also possible to cancel the ticket during the process of investigation. It is not possible to re-open tickets which have been closed or cancelled.

3.1.1.2 Opening the PERT Ticket

An important new feature of PTSv2 is that a ticket can be opened by anyone who registers themselves on the system. The registration process is required in order to prevent anonymous requests and spam agents submitting junk mail.

When a ticket is created notifications will be sent out to the appropriate group of System Users (or external mailing lists), according to the Notification Policy defined for the PERT Ticket System (see 3.1.2 'Notifications System').

PERT Tickets are categorised as either private or public:

- private: the ticket can be seen by PERT Staff and the user and end-users associated with that ticket.
- public: the ticket is public and may be seen by PERT staff, all users, and those end-users associated with that ticket.

The details of public tickets only may be published in the PERT Knowledge Base web site for public use. However, lessons learned from the investigation of a private case may be included in a general KB article, as long as it does not include details, such as organisation name or IP addresses, or anything else which might identify the user in question. PERT users are encouraged to make their tickets public, so as to promote the freest exchange of information. If the PERT agrees to assist an Ineligible user then it should generally be on the condition that the ticket is made public.

A ticket is created, via the web interface, in either the 'Submitted' state (if the ticket has been created by PERT staff) or the 'Pending' state (if the ticket is created by a user), Pending tickets, if not acknowledged, may be marked as 'Spam' or 'Does not Qualify [for PERT assistance]'. For both Pending and Submitted tickets if for whatever reason a new PERT case is not justified the CM should cancel the ticket, and inform the reporting party where appropriate. A PERT Manager may review and override this action.

Once a ticket has been Acknowledged the DCM should perform any procedures that are in force. For example, as described in Section 1 above DCMs are required to add a 'Note' as soon as they have

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acknowledged a case, which should give a summary of the case. This summary should be kept up to date by the ticket owner throughout the life of the case.

If this troubleshooting shows that the case is as a result of an outage or operational issue best handled by NOC, the CM moves the case to 'Resolution Proposed'. If the CM, PM or user determine that the case was opened in error, the CM moves the ticket to 'Cancel' state.

3.1.1.3 Adding 'notes' to the PERT Ticket

Only the PERT Staff, relevant users and involved end-users are allowed to add notes to a ticket. The note can be added to the ticket in 'Acknowledged', 'Waiting for ... action' or 'Resolution Proposed' states only. If the PERT Ticket was in the 'Acknowledged' state, the state is changed to 'Waiting for PERT action' state. If the PERT Ticket was in the 'Resolution Proposed' state, the state is changed to one of the following:

- Waiting for End Customer Action
- Waiting for PERT Action
- Waiting for Third Party Action

PERT staff can and should change ticket states manually if so required.

When a new note is added notifications are sent to the appropriate group of the System Users, as per the Notification Policy defined for the PERT Ticket System (see 3.1.2 'Notifications System').

Ticket notes are automatically marked with the date and time of their creation and the author's name, the first line of the Note is the Note's title and the author should also assign a priority to the note. The priority describes the importance or significance of the note. The options are:

- Important – Significant actions contributing to the reasons/solutions for the case, or other important information related to the case.
- Normal – Regular actions moving the case forward.
- Low – Ancillary information such as software output, or e-mail exchanges.

If the detailed troubleshooting determines that the issue cannot be fixed or if it shows it is as a result of an outage or an operational issue better handled by NOC, the CM changes the ticket state to RESOLVED and informs the user and appropriate NOC. If at any stage the CM, PM or user determines that the case was opened in error, the CM moves the ticket to CANCELLED. The PM may review this decision and override it. If it is determined an issue was caused by equipment failure then the case should be marked as RESOLVED (not CANCELLED).

3.1.1.4 Resolving the PERT Ticket

Only Case Managers are allowed to resolve a ticket, but they should normally only do so once they have the agreement of the end user (if the end user is not reachable then the CM is permitted to resolve the ticket anyway). When a ticket is resolved an explanatory e-mail is sent to the end user(s) associated with the case and notifications will be sent out to appropriate group of the System Users, as per the Notification Policy defined for the PERT Ticket System (see 3.1.2 'Notifications System').

To resolve a ticket the CM will change the ticket state to 'Resolution Proposed' state and add appropriate details to the ticket resolution field, which should include the following information:

- Time and date of resolution
- Problem duration
- Description of resolution
- Resolution rating

The CM should examine the resolved case with a view to creating a new article for the PERT Knowledge Base, or expanding an existing article.

If later the CM and/or end user decide the ticket resolution was premature then the CM can (and should) change the ticket back to one of 'Waiting for ... Action' states. The PMs may also review a resolved case and re-classify it if they think necessary.

3.1.1.5 Closing the ticket

Once a ticket has been resolved, and all conditions are met (see paragraph 2.3.6.4 'Close the case') the ticket should be closed by Case Manager.

3.1.2 Notifications System

E-mails are used to notify System Users of new events. The type and frequency of notifications are defined in the Notifications Policy, which is a collection of rules describing when and to whom e-mail alerts should be sent. The e-mails will contain a brief event description and a link to the web page with the PERT Ticket data.

3.1.2.1 Sending the e-mail based notifications to the End Customers

When the PERT Ticket is acknowledged, an e-mail is sent to the end user informing them that the case has been forwarded to PERT.

When the PERT Ticket is resolved, an e-mail is sent to the end user informing them the case has been resolved.

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3.1.2.2 *Providing the automatic notification for Subject Matter Experts*

The SME is allowed to enter the rules that specify their area(s) of expertise. Any opened or updated ticket is checked against these rules, and if a match is found, the SME is notified about the ticket changes. By default the Subject Matter Experts database is searched in order to find SMEs interested in the ticket subject and a notification with the problem description is sent to those SMEs.

3.1.3 **Authorization & Authentication module**

The PERT Ticket System provides for a simple authentication and authorization service. System Users are authenticated by AA service using either X.509 certificates or login and passwords, whilst end-users are authenticated using their login names (their e-mail addresses) and passwords. In the future it is expected that PTS will be upgraded so that it may use the AAA service provided by the GN2 JRA5 working group.

3.2 **Graphical User Interface**

3.2.1 **Authorization and Authentication**

The principal method for the authorization and authentication of PERT staff is by X.509 certificates which are installed in the users' web browser. Certificates are created and given to PERT Staff by the PTS administrators (PSNC staff) as directed by PERT Managers. The text below describes, step-by-step, how to install PERT certificates, using Mozilla Firefox version 1.0 as an example. Note, the PERT certificate has to be saved to disk before it can be installed. PERT staff can also have a login name (their e-mail address) and password – a useful way of accessing PTS if they are not using their usual computer.

3.2.1.1 *X.509 Certificate Installation*

Go to "Edit -> Preferences" (see Figure 4) and then to "Advanced -> Manage Certificates" (see Figure 5)

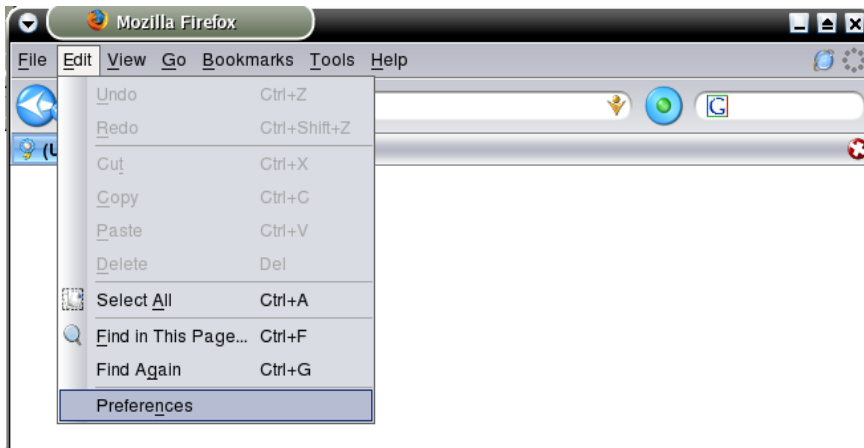


Figure 4 Firefox browser - Edit/Preferences menu



Figure 5 Firefox browser - Preferences window

Next click “Manage Certificates” – a new window will open (Figure 6). Choose “Import”. Find and select the certificate file you were sent (and had saved to disk). You will be asked for the certificate’s password (which you will be sent along with the certificate). If you enter the correct password, your certificate will be successfully imported.

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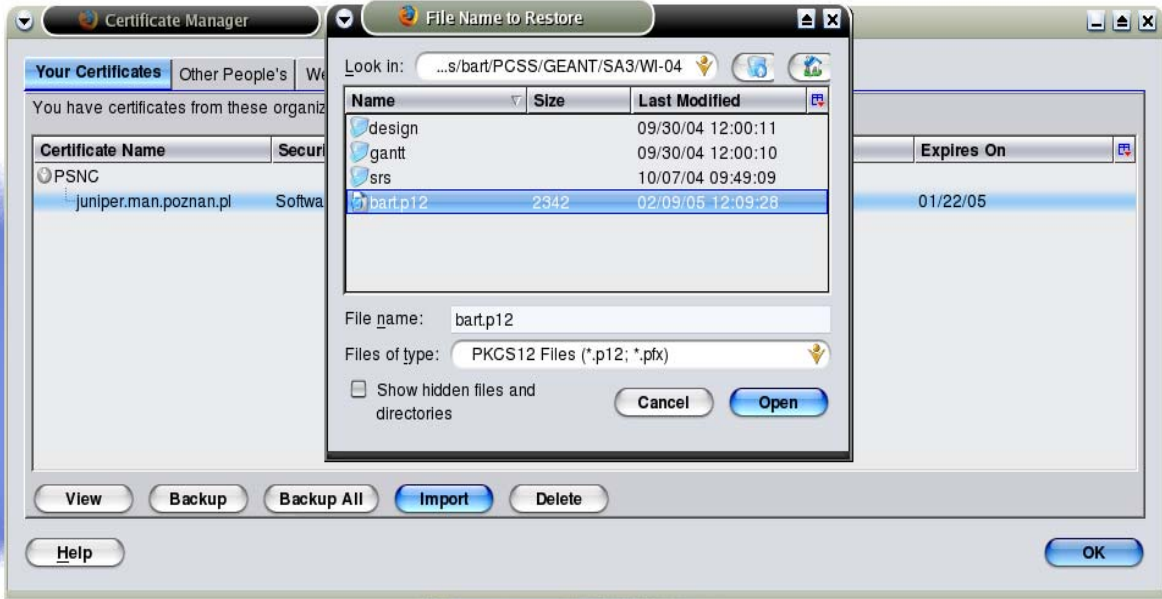


Figure 6 Firefox browser - Certificate Manager/Your Certificates

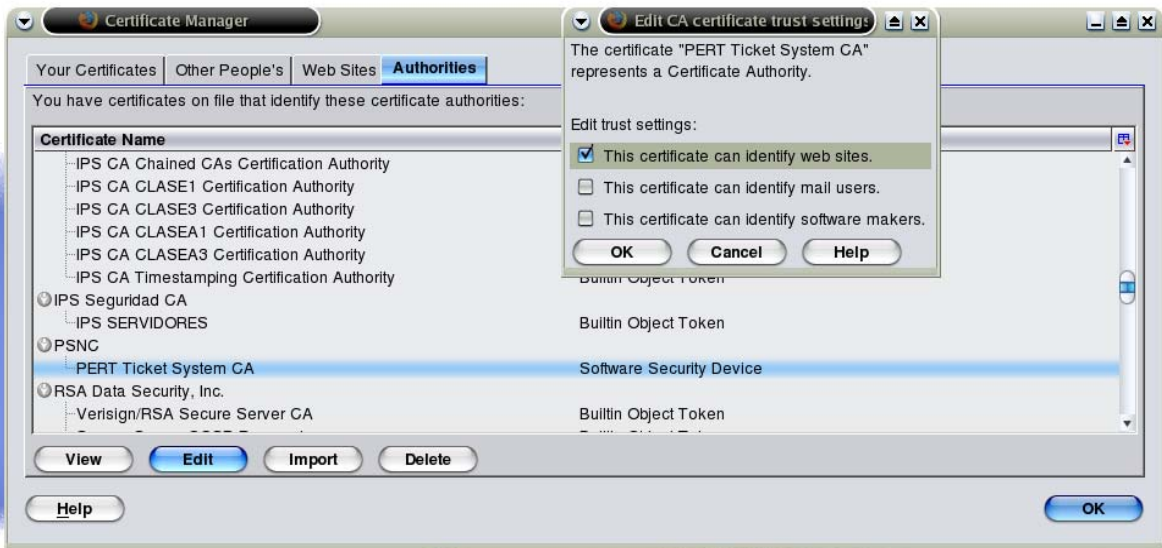


Figure 7 Firefox browser - Certificates Manager/Authorities

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Activate the checkbox “This certificate can identify web sites”. Then click on “OK”. This completes the installation of the certificate is finished and you will now be able to access PTS simply by clicking on the hyper-linked text “Login as certified user” on the PTS log in screen.

3.2.2 Login form

All PTS users must login to use the system. There are two alternative methods used for user identification:

- certificate
- e-mail and password

Most users who have valid certificates will use the “Login as certified user” option. If a user gets an ‘Invalid Certificate’ error they should contact the PTS administrators (PSNC <ge2-sa3@ngn.man.poznan.pl> or if in doubt check the steps for adding the certificate to their web browser (section 3.2.1).

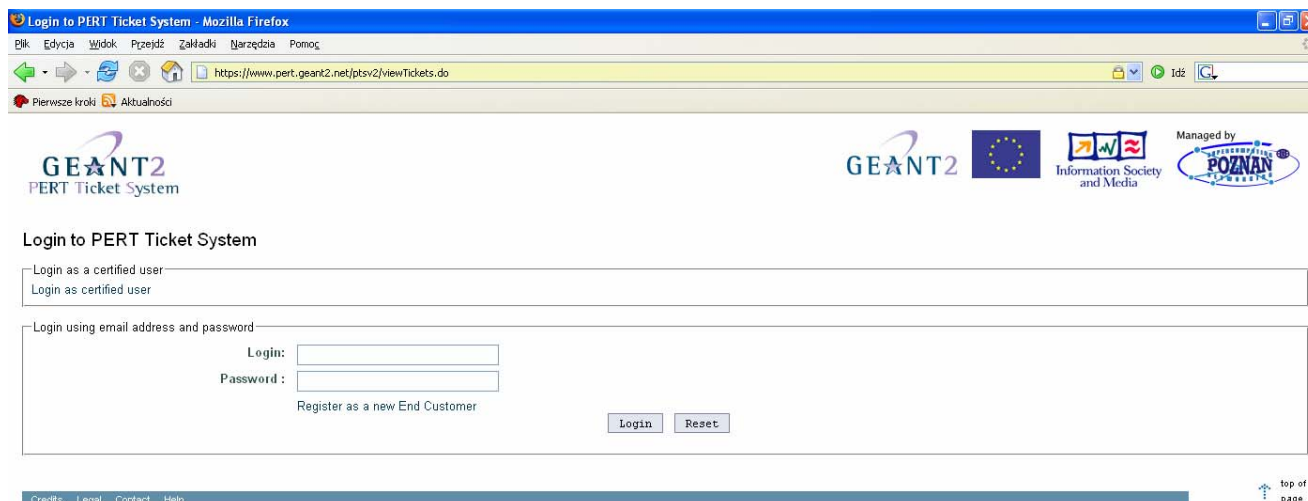


Figure 8 Login screen

3.2.3 Privileges

The following table presents the set of privileges for each PERT Ticket System role.

	<i>PERT Manager</i>	<i>Case Manager</i>	<i>Subject Expert Matter</i>	<i>Primary user</i>	<i>End user</i>
PERT Cases					
Create a Ticket	✓	✓	✓	✓	✓
View Tickets	✓	✓	✓	✓	✓

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	<i>PERT Manager</i>	<i>Case Manager</i>	<i>Subject Expert Matter</i>	<i>Primary user</i>	<i>End user</i>
Assigned Tickets	✓	✓			
Active Tickets	✓	✓	✓	✓	✓
Updated Tickets	✓	✓	✓	✓	✓
Favourite Tickets	✓	✓	✓	✓	✓
Pending Tickets	✓	✓			
Keywords	✓	✓	✓	✓	✓
Advanced Search	✓	✓	✓	✓	✓
PERT Diary					
Add Diary Entry	✓	✓			
View Diary Entries	✓	✓			
PERT Schedule					
PERT Schedule	✓	✓			
PERT Users					
PERT Staff	✓	✓			
Users	✓	✓			
End-users	✓	✓			
Organizations	✓	✓			
Settings					
Mail Settings	✓	✓			
Notification Settings	✓	✓			
Change Password	✓	✓	✓	✓	✓

Table 3 User privileges for each PERT Ticket System role

3.2.4 PERT Cases

3.2.4.1 Menu

The menu has the following entries:

- Create a Ticket
Creates a new PERT Ticket

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- View Tickets
Displays all PERT tickets
- Assigned Tickets
Displays all tickets directly assigned to the user and if the user is the Duty Case Manager as per the PTS schedule, all unassigned ones, if the user is the Duty Case Manager as per the PTS schedule, all unassigned ones too.
- Active Tickets
Displays all tickets which are not resolved, closed or cancelled
- Favourites
Users can mark a ticket as a favourite. This option filters all tickets so that just favourites are displayed
- Pending Tickets
Displays all pending tickets which are awaiting Case Manager's approval.
- Keywords
Filter tickets to display based on the keywords associated with them
- Advanced Search
Displays tickets filtered by one or more of the following user specified criteria:
 - Ticket ID
 - Open data
 - Close date
 - Report date
 - State
 - Author
 - Resolution rating
 - Keywords

3.2.4.2 Create a ticket

To create a new ticket the PTS user should select "Create a Ticket" from the left-hand menu and then fill in the form, the first part of which is shown below:

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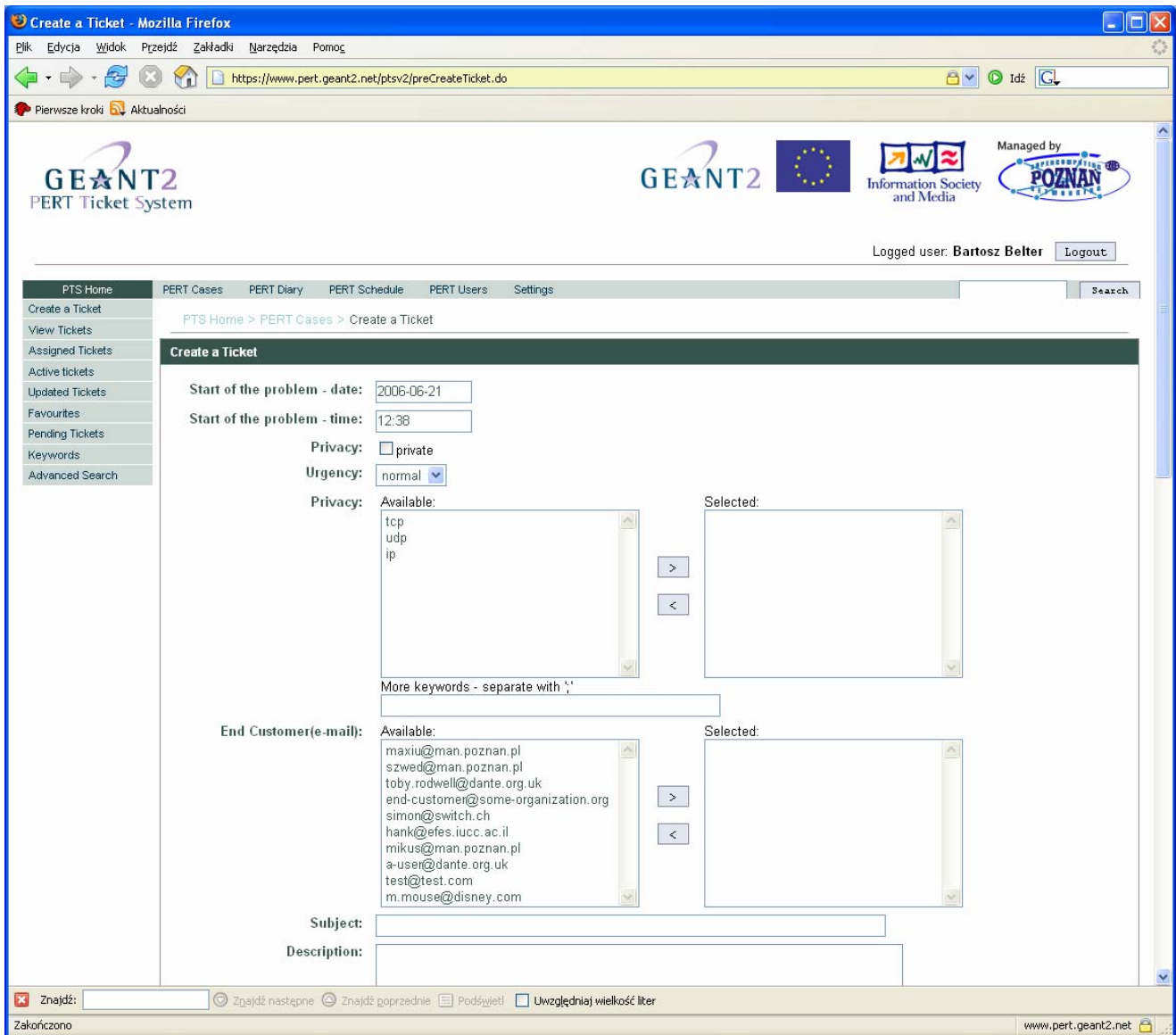


Figure 9 Create a new ticket

Field description:

- Subject – title of problem
- Description – detailed information on the problem
- Start of problem date – date when problem occurred
- Privacy
 - “public”: ticket will be visible to all PTS users,

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- “private”: ticket will be visible only to Case Managers, Subject Matter Experts and users from the specific organization to which the author belongs
- Urgency – How quickly the problem needs to be investigated
- Keywords – Keywords are selected from a list of predefined phrases or input by author
- End Customers – e-mail address(es) of the people or organizations who reported the problem. They will be notified (by e-mail) of any changes to the ticket.

The above are all required fields and are marked with asterisk (*). There are other optional fields for more detailed information (e.g. End System Software, Error Messages).

Initially the ticket state is set to either ‘Submitted’ or ‘Pending’ state and only PERT Managers or Case Managers are able to change the ticket state (to ‘Acknowledged’ or ‘Cancelled’). A ticket must be ‘Acknowledged’ before any notes can be added.

3.2.4.3 PERT Ticket details

The ticket view is divided into two sections: “Overview” and “Full Description”. In Overview mode user can see the most significant ticket details plus the list of case notes. The notes are presented in the table with the following information included:

- <unnamed> - The colour of field indicates the priority of the action (red for important, dark grey for normal, light grey for low priority)
- date – When the action was added
- author – Who created the note
- description – The first line of the note’s content, which will be shown in full if “more” is clicked on

The list of possible actions to be performed on the ticket includes the following:

- Cancelling the ticket
- Acknowledging the ticket
- Resolving the ticket
- Closing the ticket
- Editing the ticket
- Writing e-mails
- Adding notes
- View ticket attachments

The picture below shows the Ticket details screen in Overview mode.

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The screenshot shows the 'Ticket Details' page in the PERT Ticket System. The browser address bar shows the URL: https://www.pert.geant2.net/ptsv2/ticketDetails.do?ticketId=1. The page header includes the GEANT2 logo, the European Union flag, and logos for Information Society and Media, and POZNAN. The user is logged in as 'Bartosz Belter'. The navigation menu includes: PTS Home, PERT Cases, PERT Diary, PERT Schedule, PERT Users, Settings, and Search. The main content area shows the following ticket details:

- Ticket ID: 1
- Subject: Ticket no 1
- Description: Description
- Current Status: UPDATED
- Author: Jan Kowalski (PM) someone2@somewhere.org
- Assigned Ownership: not assigned explicitly by any Case Manager

Buttons for actions include: Resolve, Cancel, Edit, Write e-mail, Add note, Assign ownership, Mark all notes read, and View attachments list. A 'Show:' dropdown is set to 'all'. A legend indicates priority levels: important (red square), normal (grey square), and low (light grey square). The ticket history table is as follows:

Date	Author	Description	[More]	[Edit]
2006-06-21 09:26	Bartosz Belter	sdfsd	[More]	[Edit]
2006-06-10 10:39	Bartosz Belter	attachement test	[More]	[Edit]
2006-02-03 11:16	Mail Daemon	Subject : Re: [PTS:24] testtest	[More]	[Edit]
2006-02-03 11:07	Bartosz Belter	to: bart@man.poznan.pl	[More]	[Edit]
2006-02-03 11:02	Bartosz Belter	to: bart@man.poznan.pl	[More]	[Edit]
2006-02-03 11:01	Bartosz Belter	to: bart@man.poznan.pl	[More]	[Edit]
2006-02-03 11:00	Bartosz Belter	to: bart@man.poznan.pl	[More]	[Edit]
2006-02-03 11:00	Bartosz Belter	to: bart@man.poznan.pl	[More]	[Edit]
2006-02-02 20:29	Toby Rodwell	Bracket test!	[More]	[Edit]
2006-01-06 13:17	Jan Kowalski (PM)	aaaa2 aa	[More]	[Edit]
2006-01-06 13:11	Jan Kowalski (PM)	Important action no 1	[More]	[Edit]

Figure 10 PERT Ticket details

cancelling the ticket

In most cases there is the opportunity to cancel the ticket by clicking the “Cancel” button available on the top of Ticket Details page.

Resolving the ticket

Only Case Managers and PERT Managers have this option. In order to resolve the case, the user has to select two resolution ratings: the level of user’s satisfaction and the level of problem comprehension. For more details refer to section 2.3.6.2 ‘Finalising Resolution’.

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3.2.5 Add or remove tickets from Favourites

Users may select any ticket to be added to their personal 'Favourites' list. To mark a ticket as a Favourite the user clicks on the appropriate "fav" link (see Figure 11). Tickets may be removed from the "Favourites" list by clicking on appropriate "remove" link (see Figure 12).



Figure 11 Add tickets to favourites

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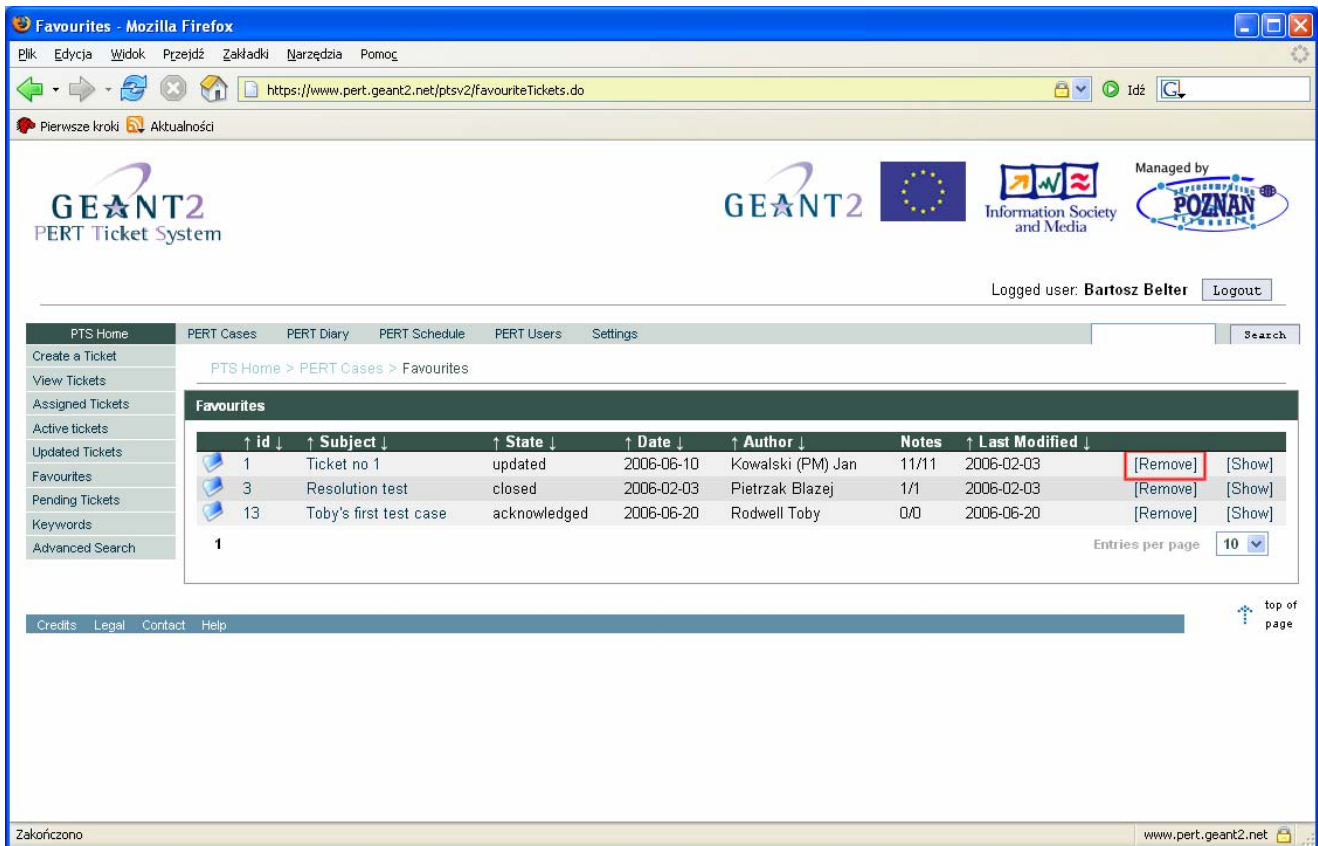


Figure 12 Remove tickets from favourites

3.2.5.1 View tickets

The picture below shows the View Tickets screen. The format is the same for Assigned Tickets, Active Tickets, Updates Tickets, Favourites and Pending Tickets (the only difference being what tickets are listed).

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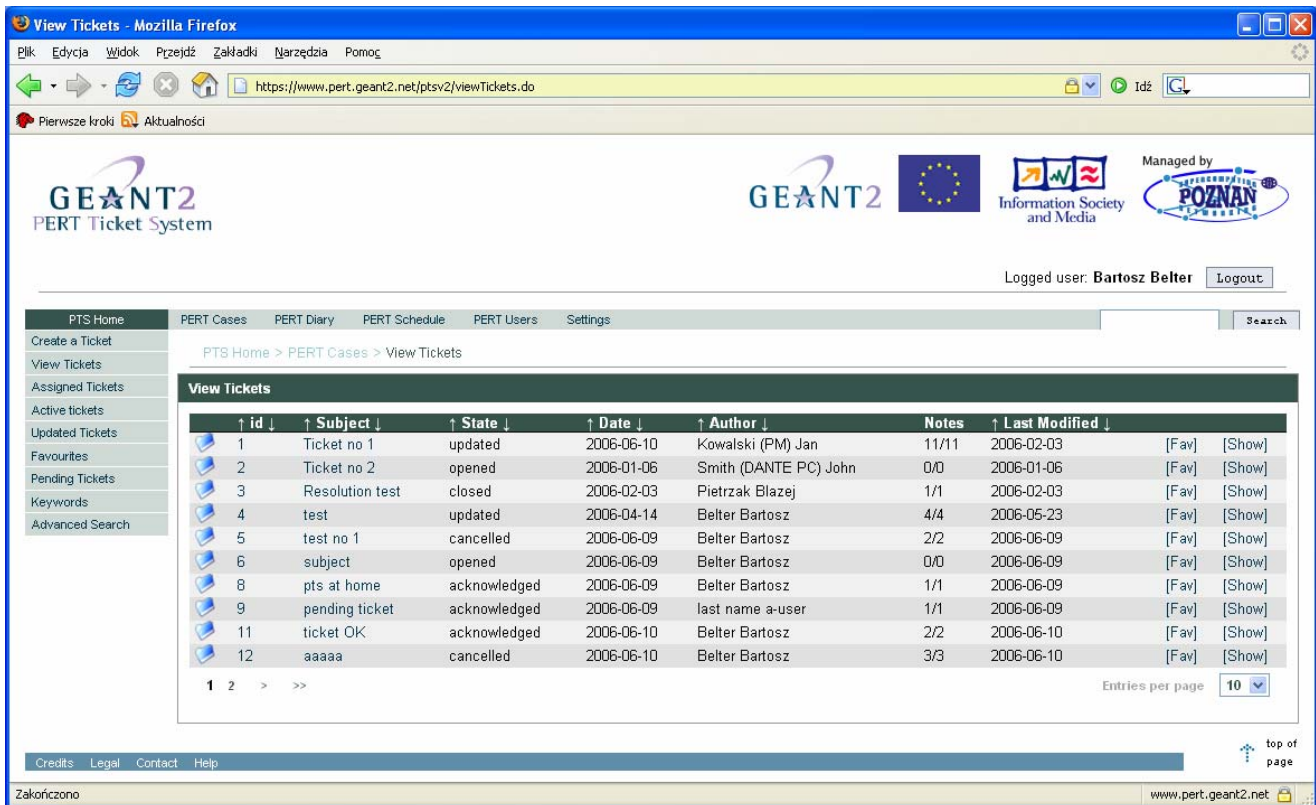


Figure 13 View Tickets page

The table has the following columns:

- # – ticket id (unique to each ticket in the database)
- Subject – title of the ticket
- State – current ticket state
- Date – open date of ticket (date when ticket was created)
- Author – author of the ticket
- Notes – number of unread notes
- Last Modified – date when ticket was modified last time
- <fav> - if there is “fav” link available it means the ticket can be added to “Favourites”; if this field is empty it means the ticket has already been added to “Favourites”

By clicking the arrows in the table header, the tickets can be put into ascending or descending numerical/alphabetical order.

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3.2.5.2 Keywords

Keywords in tickets may be used for advanced searching and to notify users (particularly Subject Matter Experts) about new tickets which may interest them. User may select keywords from a predefined list or provide their own words.

The picture below shows the Keywords page.

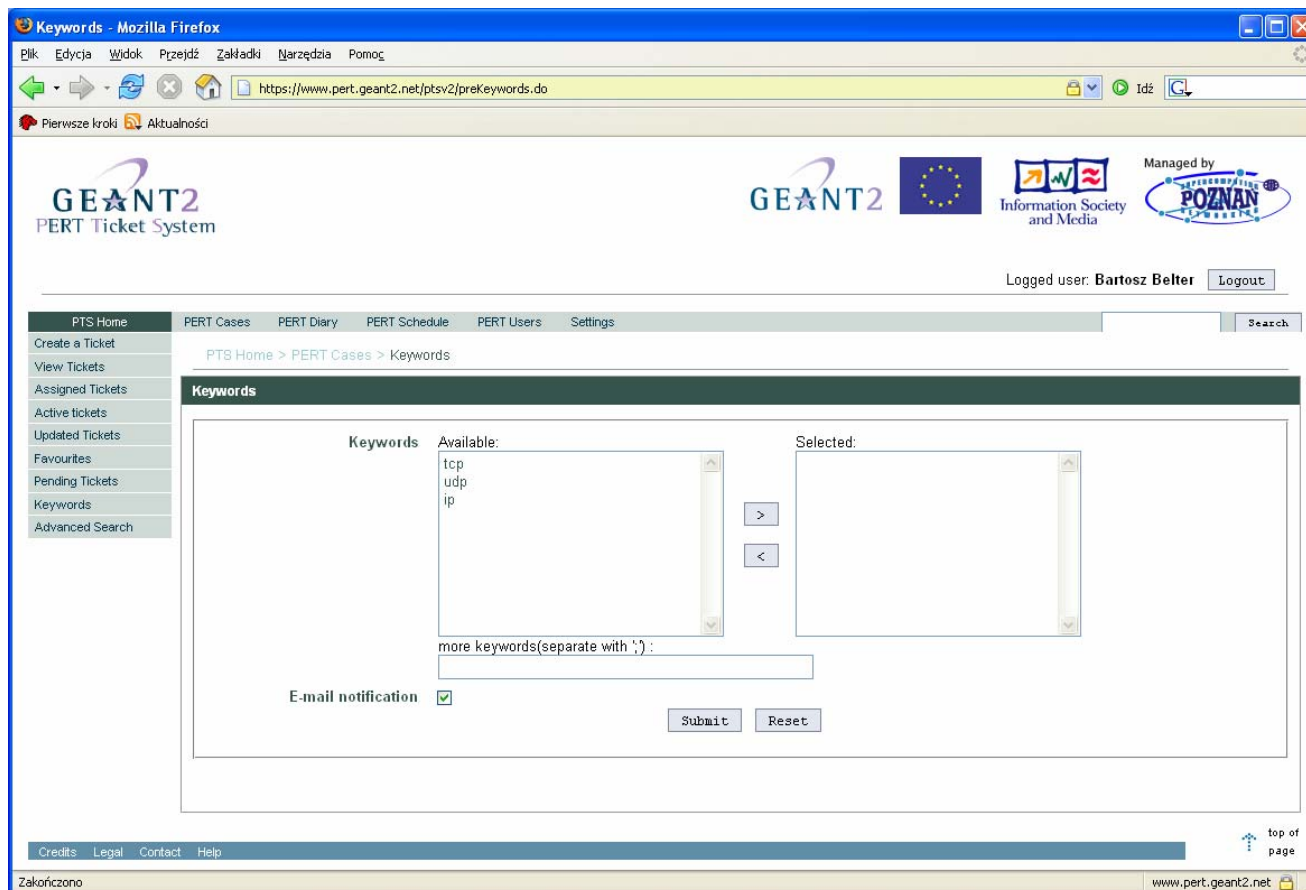


Figure 14 Keywords page

If a user is interested in receiving notifications about changes in tickets which contain chosen keywords they need to check the option “Notify me ...” and save the settings by selecting ‘Submit’. They also need to make sure that the global notifications option allows their user groups to receive notifications.

3.2.5.3 Advanced Search

Users are able to search for tickets which meet specified conditions. The following picture presents the Advanced Search page.

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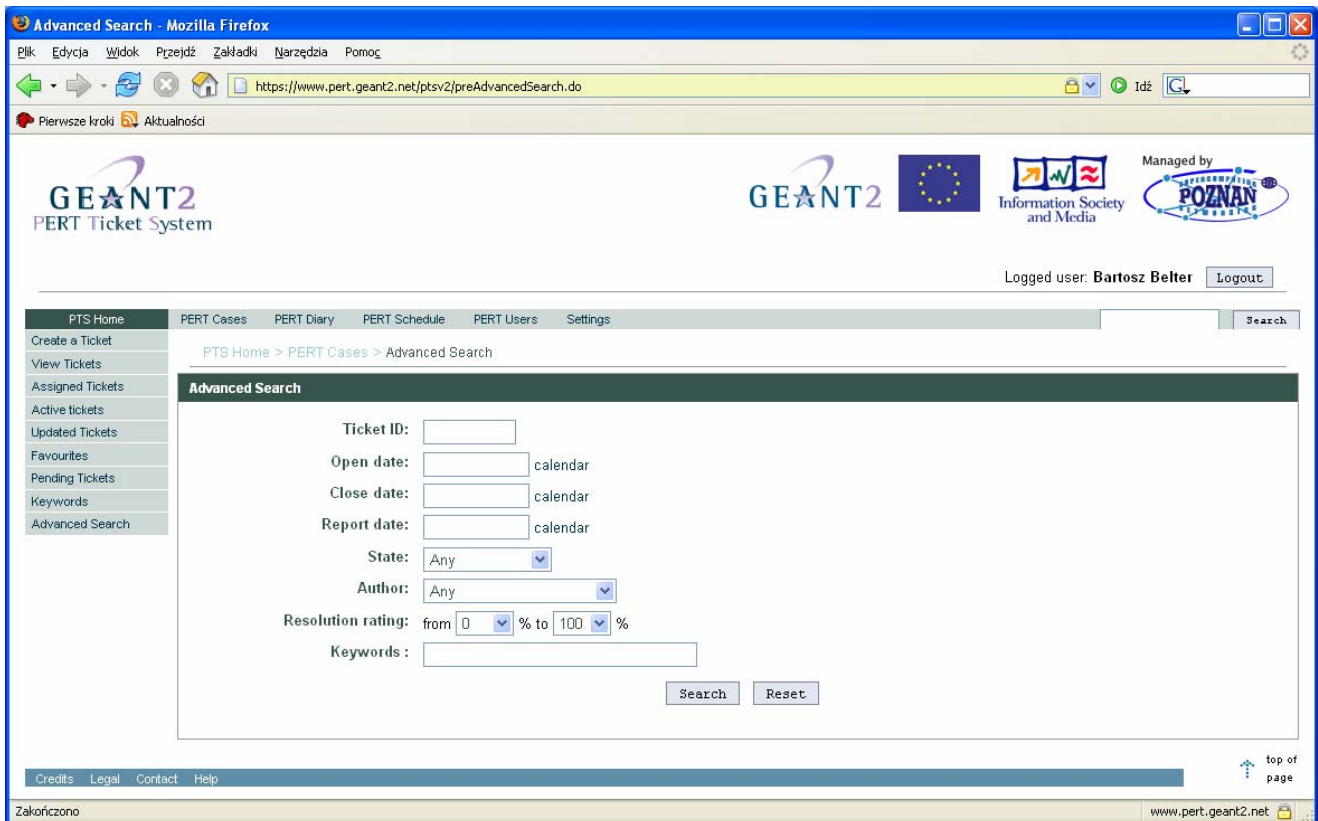


Figure 15 Advanced search form

In the search form there are several fields corresponding to the fields in tickets:

- Ticket id – unique value for each ticket
- Open date – date when tickets were added to PERT
- Close date – date when tickets were closed (resolved)
- Report date – date which was input in “Add ticket” form
- State – list of states which ticket are in
- Author – select name from list of all tickets' authors
- Resolution rating – range of values indicating “quality” of resolution
- Keywords – short phrases added in “Keywords” field in “Add ticket” form

User can use one or more criteria from the list presented above to search tickets database.

3.2.6 PERT Diary

The PERT Diary should be used by Duty Case Managers to record what happened during the period of their duty. Entries should be made on a daily basis and they will typically be short since the actual results of an

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investigation are stored in the associated ticket case notes. Rather, the PERT diary keeps track of who worked on what and when. This can be helpful for future Duty Case Managers, and also the PERT Managers

The following picture presents the View Diary Entries page. It shows one line per diary entry – to see the whole diary entry, click on the ‘more’ link. Each entry is shown by date, author and the first line of the content. Any Case Manger may add a new entry but only the author is able to edit the content of an entry. Dates are added automatically to new entries and cannot be edited. Diary entries may be filtered by date period.

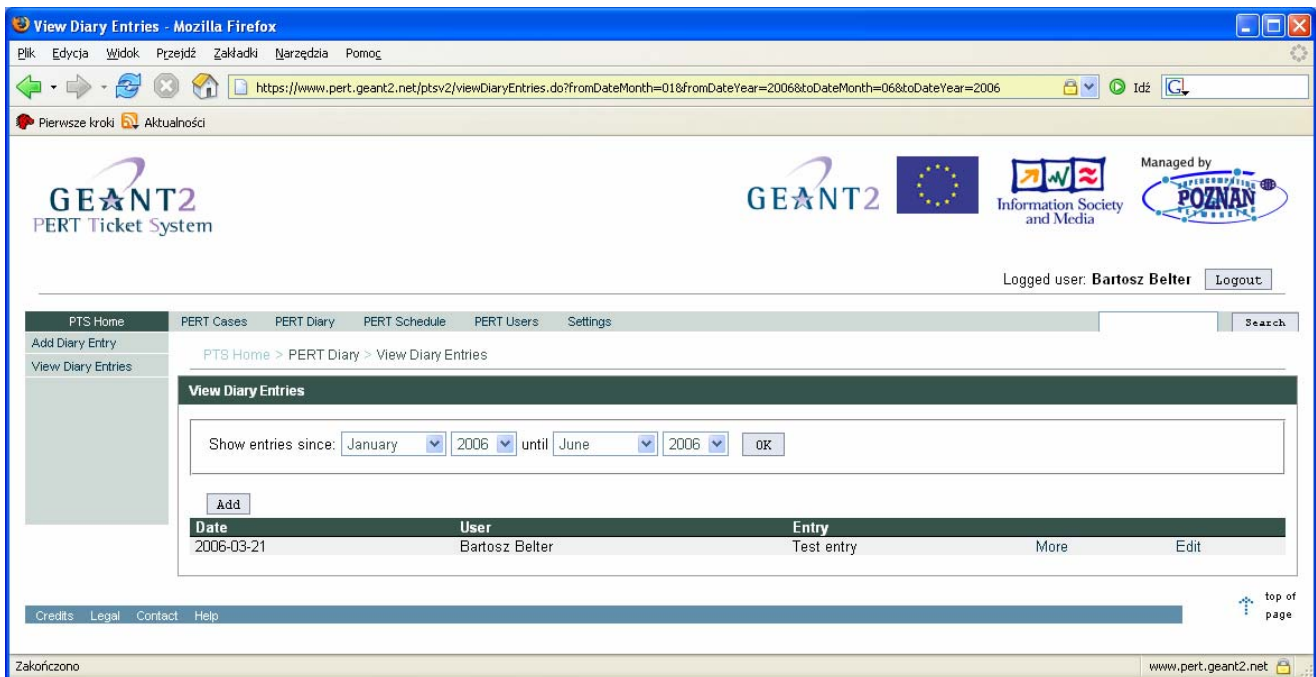


Figure 16 PERT Diary page

3.2.7 PERT Schedule

The PERT schedule shows the roster of Case Manager duties. A Case Manager may add themselves (or even others) to days for which there is currently no assigned Case Managers, but once an Case Manager has been assigned to a given day only a PERT Manager can change the entry (that is, change the duty of Case Manager).

The picture below shows the PERT Schedule.

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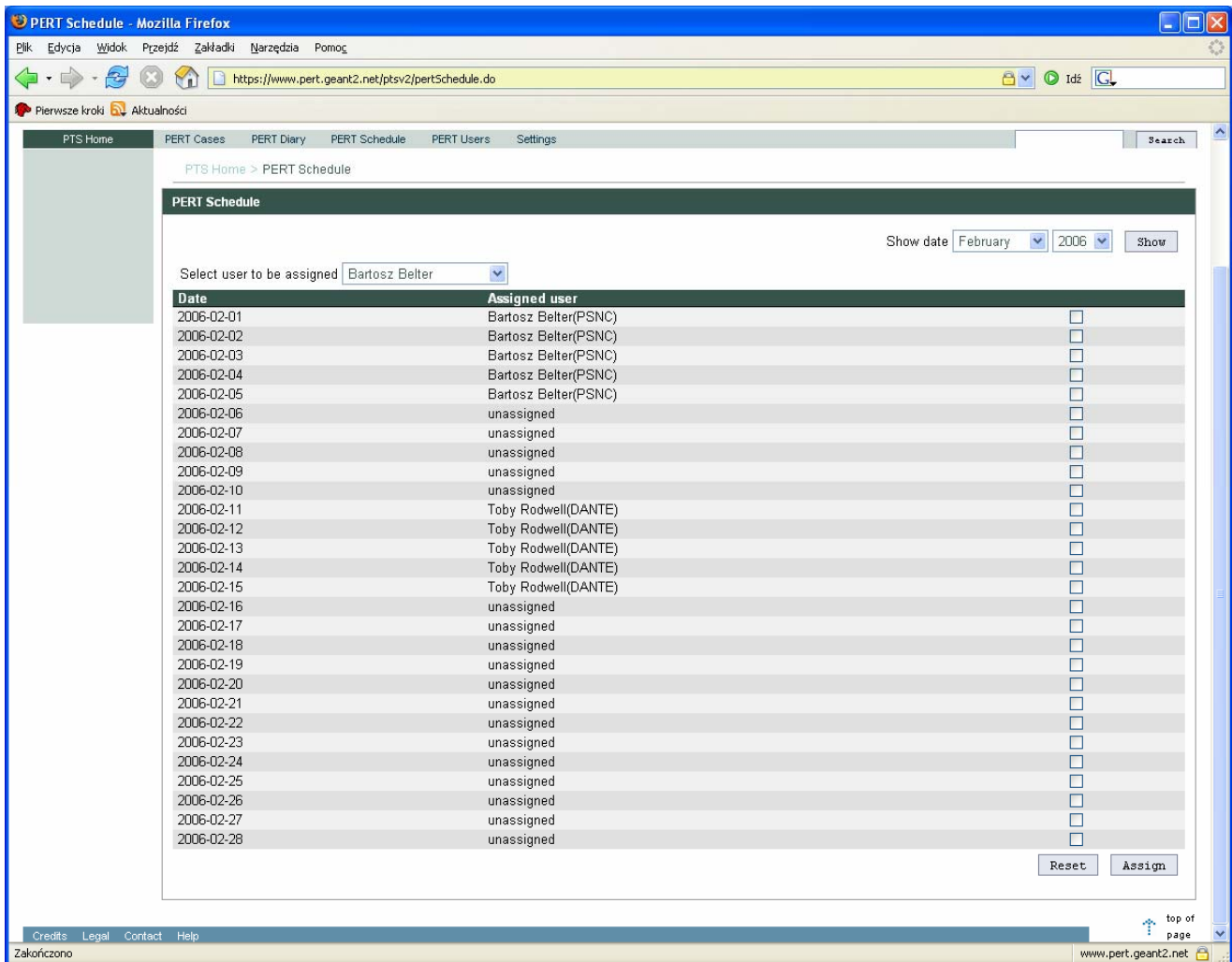


Figure 17 PERT Schedule

If the user wants to add themselves to the schedule, they first select the appropriate month. Then they select (tick) the check box against each date for which they are assigning a given Case Manager to be on duty. Next they have to select a Case Manager (one only) from the drop down list. Finally, they have to click the 'Assign' button at the bottom of the page.

3.2.8 PERT Users

'PERT Users' allows Pert Managers and Case Managers to add, delete or modify the details of System Users. Users are divided into three main sections:

- PTS Staff – The list of privileged users - Pert Managers, Case Managers and Subject Matter Experts
- Primary Customers – The list of users who represent the PERT's pre-approved Eligible users (mainly people coming from NRENS)

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- End Customers – A list of end users

The picture below shows the page with the list of users belonging to the PERT Staff group.

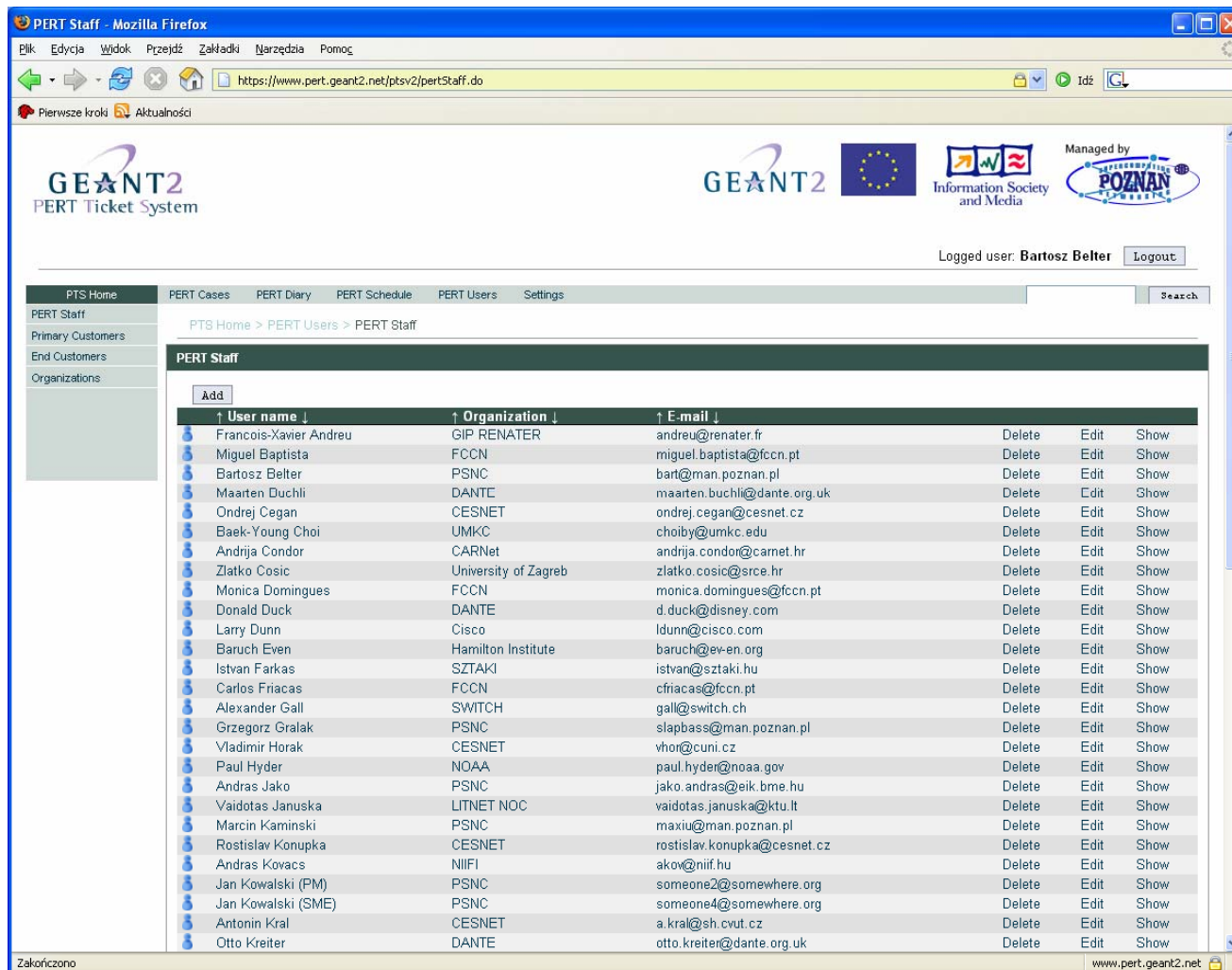


Figure 18 Users Management – PERT Staff panel

The left-hand menu also has an option ‘Organizations’, which shows the list of organizations recognized by the PTS.

Please note that once a new PERT Staff or ‘Primary Customer’ user has been created, they should request and install an X.509 certificate.

Certified users are described by the following attributes:

- First and last names
- E-mail address
- Distinguished name – the same text string as in “Subject” field in their user certificate

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- Organization – the organization to which this user belongs
- User group – the user's privilege level and role in PTS

End users are represented by the same attributes, but only their e-mail address and password are obligatory.

Organizations

This screen allows the creation editing and displaying of organization information. Each organization's entry holds full information about the, location, contact details and users associated with that organization. It is possible to add, delete or modify any of these details, except for the list of associated users – in order to change this, the individual user's details have to be updated.

Organization's attributes:

- Name – short name of the organization (it may be acronym)
- Full name
- E-mail – for contact
- Locality: street, city, country, etc.
- AS list – all the AS's administrated by organization
- Users – list of users belonging to the organization

The picture below shows an example of View Organization Details page.

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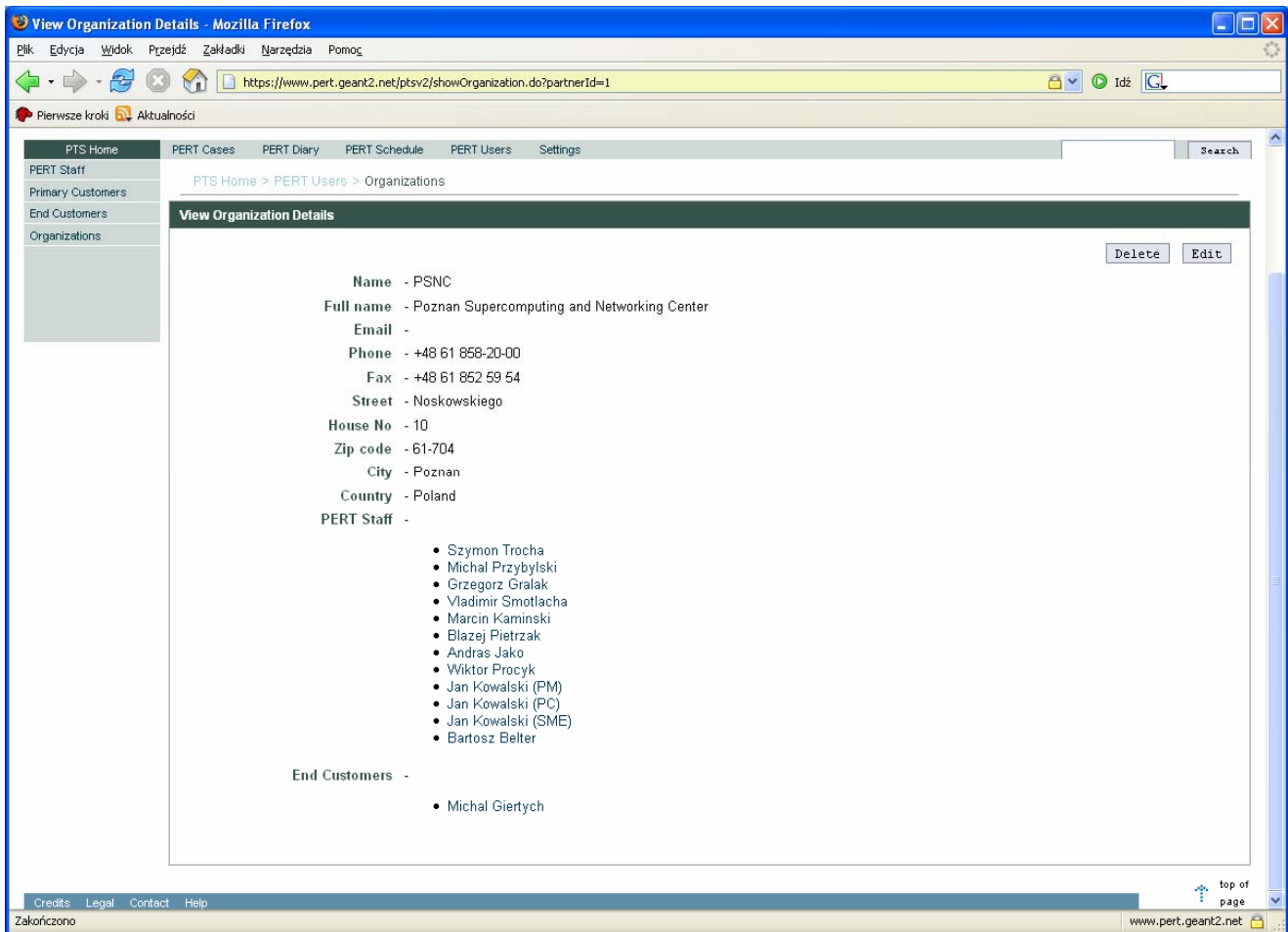


Figure 19 Organization details page

3.2.9 Settings

For easier management settings are divided into a few categories:

- Mail Settings
- Notification Settings

Mail Settings

The picture below shows the Mail Settings administration panel.

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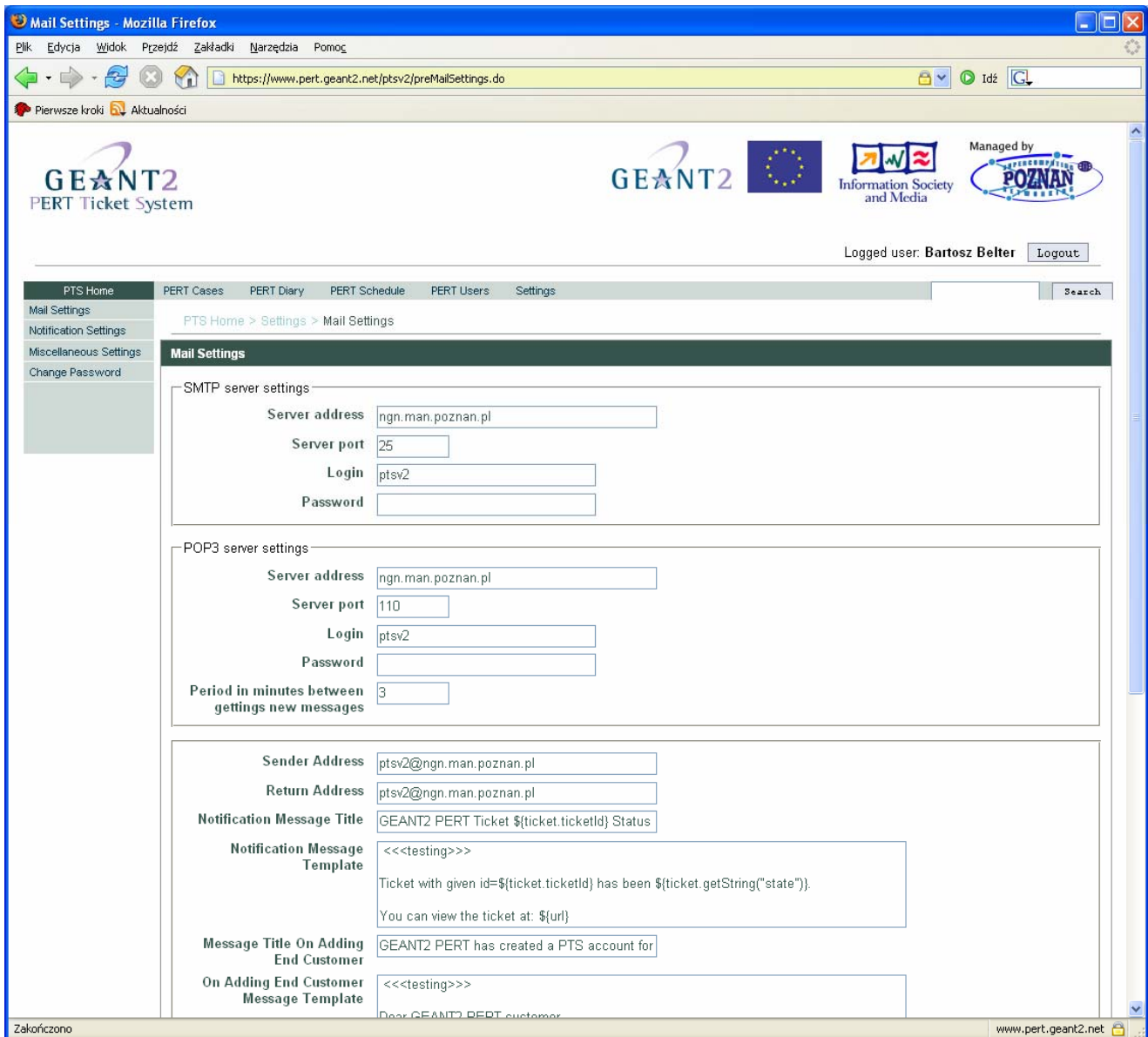


Figure 20 Settings - Mail Settings panel

The Mail Settings panel is divided into three sub-sections:

- SMTP Server – for the automatic sending of notification e-mails
 - Server address – address of the SMTP server
 - Server port – port the SMTP server is listening on (the default value is set to 25)
 - Login name and password
- POP3 Server – for automatic collection of e-mails sent to the PTS, which will be included as a note to the appropriate ticket (that is, the ticket included in the e-mail subject line).
 - Server address – POP3 server; Server port – standard port is 110
 - login and password

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- Period in minutes between checking of new messages – how often PTS has to check mailbox
- Templates for notification messages
 - Sender and Return address – the ‘Sender’ and ‘Reply To’ addresses to be used.
 - Notification Message Template – standard template used to create the content of each message sent
 - On Adding End Customer Message Template – template used in notification sent to an end-user when an account is created for them.

SMTP server has to be configured in order to enable the functionality of automatic e-mail notifications. The behaviour of this service is configured in the Notifications Settings panel (for more information please refer to the section Notification Settings below)

POP3 server has to be configured in order to properly collect e-mails sent to the PTS.

The Templates section has to be configured in order to customize messages sent to PTS users.

Notification Settings

These settings define the notification policy - under what circumstances the system will notify a given set of users of new events. The picture below shows the Notifications Settings panel.

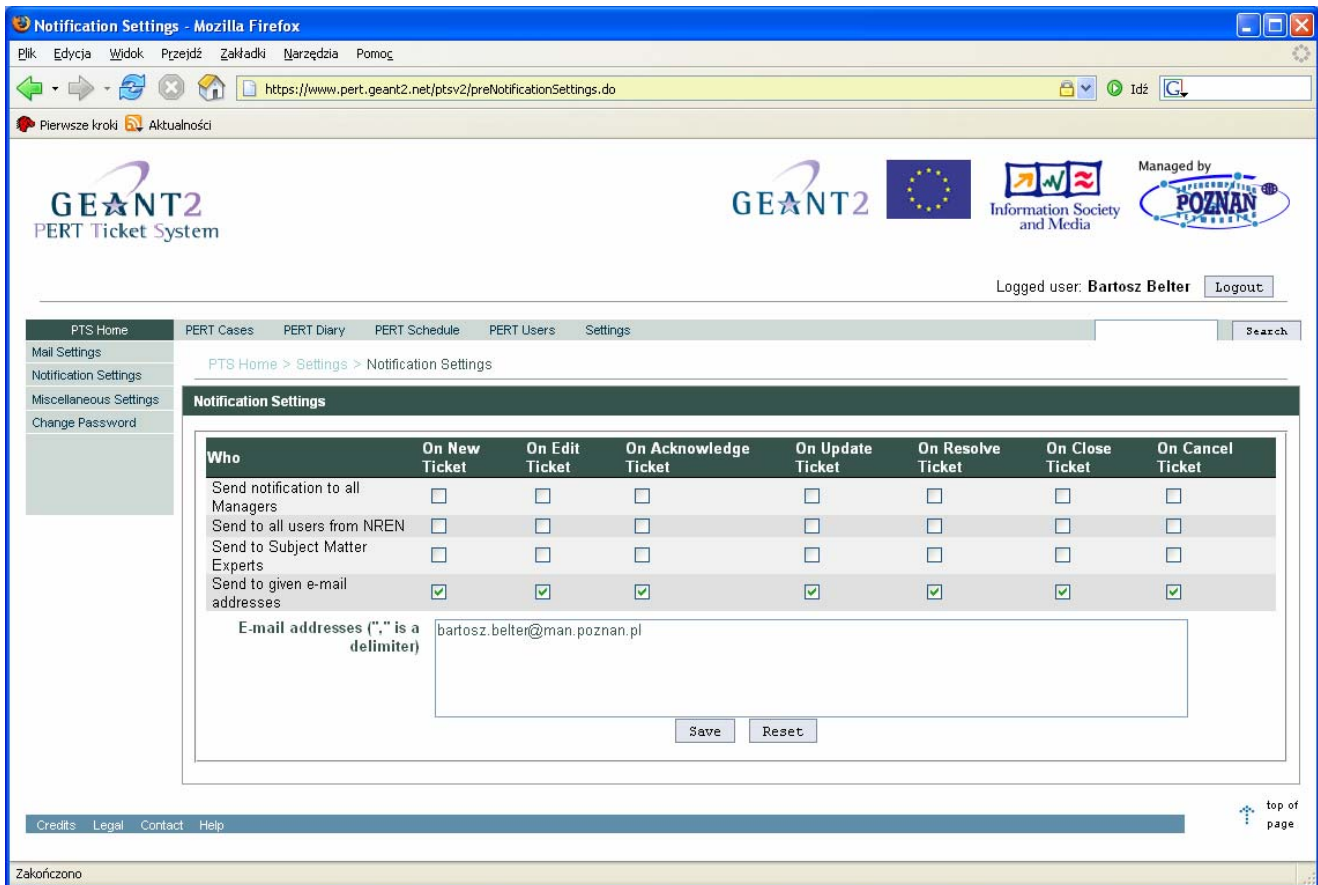


Figure 21 Settings - Notification Settings panel

The global notification policy depends mainly upon:

- types of users who will receive notifications :
 - Case Managers
 - Users who belong to a specific organization
 - Subject Matter Experts who have selected keywords and set “Notify me by e-mail” in Keywords panel
 - others that e-mail addresses are included in separate text field (“E-mail addresses”) and delimited with commas
- tickets' states that have been changed

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PTS Home > Settings > Notification Settings

Who	On New Ticket
Send notification to all Managers	<input checked="" type="checkbox"/>
Send to all users from NREN	<input type="checkbox"/>
Send to Subject Matter Experts	<input type="checkbox"/>
Send to given e-mail addresses	<input checked="" type="checkbox"/>

E-mail addresses ("," is a delimiter)

Figure 22 Notification Settings - On New Ticket example

Based on the selections in the example presented above, when a new ticket is created and is in open state notifications will be sent to:

- all Case Managers
- all e-mail addresses defined in bottom text area

Notice that in the example no Subject Matter Experts will get any notification, even those that set “Notify me by e-mail” in Keywords.

4 Conclusions and Next Steps

By following the troubleshooting guidelines laid down in section 2 of this document, and by having a good understanding of the workings of the PTS (as explained in section 3 of this document) a PERT Case Manager will be able to effectively and efficiently investigate PERT cases. Experiences gained in dealing with real PERT cases resulted in suggestions for PERT Ticket System improvement and the soon to be released, updated version of PTS is the result of the discussions between the users (PERT community) and PTS developers. PTSv2 addresses several important changes in the operation of the PERT (e.g. the introduction of Special Case Managers), but there are other areas of interest which may be of interest to explore, such as integration with other Trouble Ticket Systems (TTS) via a web services interface. Such integration would mean that a Trouble Ticket created in a network operator's TTS could be automatically (or perhaps semi-automatically) used to create a ticket in the PTS and subsequent updates to the ticket on one system could then be used to automatically update the ticket on the other. This functionality may be addressed in GÉANT Y4, once the future structure of the PERT (post GÉANT2) is better understood. However it is recognised that language is likely to be an issue (as tickets raised in an NREN TTS will almost certainly be written in the national language, not English).

5 Abbreviations

AAA	Authentication, Authorization, and Accounting
AS	Autonomous System
BDP	Bandwidth Delay Product
CM	Case Manager
DCM	Duty Case Manager
ICMP	Internet Control Message Protocol
IP	Internet Protocol
LAN	Local Area Network
NOC	Network Operations Centre
NREN	National Research and Education Network
PERT	Performance Enhancement and Response Team
PM	PERT Manager
POP[3]	Post Office Protocol [version 3]
PTS	PERT Ticket System
RTT	Round Trip Time
SCM	Special Case Manager
SME	Subject Matter Expert
SMTP	Simple Message Transfer Protocol
TCP	Transmission Control Protocol
WAN	Wide Area Network

6 References

[GN2-05-018] T Rodwell, "PERT Operating Policy", 2005

[GN2-05-108] B Belter et al, "[Performance Trouble Ticket Procedures](#)", 2005

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