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Abstract:

This document details the continued efforts being carried out in order to achieve the goal of a full-scale deployment of a dynamic IPv6-enabled VPN infrastructure across the 6NET network.

Keywords:

VPN, Dynamic, IPv6, X-Bone, DVC

Executive Summary

The 6NET Activity 4.3 focuses upon the analysis of IPv6-enabled Dynamic VPN technologies and the subsequent wide-scale deployment of such a technology across 6NET. The first Deliverable submitted as part of this activity provided details of the analyses carried out on a number of such activities. This Deliverable outlines the efforts made during the second year of the project, to carry out the deployment.

Efforts have been directed on three technologies:

- USC/ISI X-Bone
- DRDC Dynamic VPN Controller (DVC)
- UMU Policy-Based Network Management (UMU-PBNM)

With each project meeting different sets of UCL requirements and further uncertainties in the status of the various projects, two workshops were held at UCL in order to bring the various parties together. These have proved to be of considerable value, leading to a number of different collaboration and integration activities taking place between the parties involved. Of particular interest to UCL and 6NET are those between UMU and DRDC, and UMU and ISI, aiming towards integration of the UMU-PBNM with the DVC and the X-Bone respectively.

The successful deployments of the IPv6-enabled versions of both the X-Bone and DVC systems have been carried out across multiple sites and initial tests involving applications (including video transmission) running over the overlays/VPNs have also been carried out.

In this report we outline the progress made during the second year of the project, as well as the various collaborations taking place between the various parties. We provide a comparison of features between the various systems and outline some of the limitations to be overcome. We describe the types of scenarios for which the IPv6-enabled VPN infrastructure is envisaged to operate. We also present a summary of the initial efforts to run applications across the VPNs. Finally we outline our further plans for wider-scale VPN infrastructure and application deployment.

Table of Contents

1. Introduction

The aim of this document is to detail the continued efforts being carried out in order to achieve the goal of a full-scale deployment of a dynamic IPv6-enabled VPN infrastructure across the 6NET network.

We show that we have successfully deployed extended IPv6-enabled X-Bone software across multiple sites, involving multi-project collaboration between 6NET, Euro6IX and ICB, and also carried out some initial tests of software running over the VPN infrastructure including a video transmission.

We provide in Section 2 a brief overview of the VPN technologies we have examined, followed by a summary of the progress made during the second year in Section 3. Section 4 provides a summary of the collaborations that are taking place between the various parties involved. Section 5 presents a comparison of the main systems under investigation. We summarise the main limitations we have faced in Section 6 and provide an outline of some of the scenarios in which we envisage the final IPv6-enabled dynamic VPN infrastructure being used. Section 8 summarises the achievements to date while Section 9 looks forward at the work that must be carried out during the final year of the project followed by mid-term conclusions in Section 10.

2. Infrastructures Examined

The previous deliverable for the 6NET VPN activity, D4.3.1 [2], summarised all investigations undertaken at UCL into the currently existing VPN technologies. These included:

- The Entrust VPN Connector
- The Netcelo VPN Management System
- The USC/ISI X-Bone
- The DRDC Dynamic VPN Controller (DVC)
- The UMU Policy Based Network Management (UMU-PBNM)

2.1. Entrust VPN Connector

The Entrust system was not, at the time, IPv6-enabled, neither was it likely to be in the immediate future. Recent IPv6-related work on portions of the system has taken place, however this is still unlikely to become available until late 2004.

2.2. Netcelo VPN Manager

The Netcelo system was enabled with IPv6 during the ANDROID project [1], however this is a proprietary system that provides little overall flexibility for the deployment of VPNs. However its availability during the final year of 6NET was problematic.

2.3. ISI X-Bone

The X-Bone [6] was found to be the most flexible and feature-filled system, however it was also not at the time IPv6-enabled, and there were various potentially limiting features that raised the question of whether it would eventually be suitable for deployment.

2.4. DRDC DVC

NRNS was developing the Dynamic VPN Controller (DVC) under contract to Defence Research and Development Canada (DRDC). The DVC system, again at the time an IPv4-only system was found to be of value in the greater degree of distribution that it provided.

2.5. UMU-PBNM

The University of Murcia (UMU) has developed a Policy-Based Network Management (UMU-PBNM) system [7]. It has been fully IPv6-enabled from its initial conception and provides fully standards-compliant mechanisms for the management and distribution of policies, incorporating also, an IPv6 Public Key Infrastructure (UMU-PKIv6) [8]. The system provided a VPN Enforcement Tool [9] for the setup of VPNs across 6WIND routers. This was provided as a proof of concept that demonstrated how the PKIv6 could be utilised.

3. Progress

Due to the lack of foreseeable IPv6 support within the Entrust system, and the proprietary and fully centralised nature of the Netcelo system, it was decided that the deployment of these two systems should not be pursued further within the context of the 6NET dynamic IPv6-enabled VPN infrastructure.

3.1. D4.3.1 Stage

Our opinion at the time of the previous deliverable D4.3.1 [2] was that the initially stated goal in the Description of Work (DoW), of deploying the X-Bone as the 6NET dynamic VPN infrastructure, was unlikely to be the suitable path to take. Hence the proposal was made for efforts during the second year of work to be redirected to a different technology from that envisaged in the DoW.

3.2. 52nd ICB Meeting – 25/26 April 2003

Shortly after the submission of D4.3.1, Peter Kirstein chaired a meeting of the International Collaboration Board (ICB), to which Joe Touch, X-Bone project leader, was invited. UCL's plans for VPN deployment were presented at the meeting. It emerged that the X-Bone software was in the middle of undergoing a major re-write and had evolved significantly. Moreover in the light of the UCL/6NET interest, Joe Touch volunteered to give the IPv6-enabling a higher priority.

3.3. 1st VPN Workshop – 10/11 July 2003

In view of the uncertainty in requirements and status of projects, a VPN Workshop [5] was organised in July 2003. The main aim was to bring the various parties together in order to discuss and resolve some of the issues of confusion and also to encourage collaboration.

The overall goals of the workshop were achieved and all parties were brought up-to-date on the status of each of the projects. Consensus was reached over specific points of confusion and there was a general agreement that collaboration between the parties would benefit all. It was agreed also that a further workshop four months later would be beneficial. In addition, DRDC/NRNS agreed to port DVC to IPv6.

3.4. Further Investigations

Further investigations of both the X-Bone and DVC systems were carried out at UCL.

A specially packaged alpha-version of the future X-Bone version 3, with IPv6 functionality, was installed on four machines locally, but the creation of some initial test overlays was successful only with IPv4. The official X-Bone 3.0-Beta release was installed subsequently on the same four machines. During testing, UCL helped to identify number of bugs some in configuration and others specifically in the IPv6 portions of functionality.

It was clear that the X-Bone would soon be again in a position to provide the greatest number of features (meeting a greater number of UCL's VPN requirements), the greatest degree of flexibility in configuration and deployment, and was already IPv6-enabled (albeit problematic at the time) whereas the IPv6-enabled DVC was not due to become available until the beginning of 2004.

However the X-Bone still lacked certain features present within DVC, such as the dynamism of being able to add nodes during run-time, and the distributed nature of management, which it was felt would be very beneficial for the deployment.

3.5. 2nd VPN Workshop

The second VPN Workshop [5] was organised as a one-day meeting in order to provide an opportunity to follow up on progress of collaboratons that had been taking place and further discuss the issues involved.

The workshop showed a degree of collaboration that has made a difference to all partners involved in the activities; it is intended that subsequent workshop meetings will be organised during 2004. A summary of the collaborations is provided in Section 4.

3.6. Milestone 4.3.2

An official X-Bone 3.0-Beta2 version was released shortly after the 2nd VPN Workshop. This has been tested successfully and used to deploy IPv6-enabled overlays across multiple sites (currently UCL, UMU and ISI), partially meeting milestone 4.3.2 for extended VPNs. Subsequently the final X-Bone version 3.0 has been released; this has also successfully been used to deploy IPv6-enabled overlays across the three sites.

The overlays deployed have been of star, ring and linear topologies and make use of combinations of SHA1/MD5 and DES/3DES authentication and encryption algorithms.

4. Collaborations

As mentioned earlier, various collaborations between the various parties have been taking place since the first VPN Workshop. It should be noted that all collaboration with UMU is part of a strong 6NET-Euro6IX collaboration. Of particular interest to UCL and 6NET are the following:

4.1. UMU/DRDC

Investigations between UMU and DRDC into whether it would be possible to integrate parts of the UMU-PBNM into the DVC system. Much analysis has been carried out into providing solutions for this, focussing mainly on:

- The definition of path validation schemas to be used by the DVC nodes and supported by the UMU-PKIv6
- The integration of security and certification modules in Perl (DVC) and in Java (UMU-PBNM and UMU-PKIv6)
- The integration of DVC policies with the UMU-PBNM management system
- The integration of the UMU COPS implementation within the DVC nodes, which would act as Policy Enforcement points (PEPs)
- The definition of the certificate lifecycle management protocol to be used (CMC or CMP)
- The definition of the role of DNSsec within DVC environments

4.2. UMU/ISI

Investigations were made between UMU and ISI into whether it would be possible to integrate parts of the UMU-PBNM into the X-Bone system. This has made much less progress on the overall UMU-PBNM parts, with efforts mainly focussing on the UMU-PKIv6 integration into the X-Bone. This includes a separate web page as part of the UMU-PKIv6 system for certification. Various interoperability problems have been examined and resolved, or are in the process of being resolved.

The longer-term goals include points that were discussed during the 2nd VPN Workshop:

- Integration of DNSsec support of the UMU-PKIv6 with the X-Bone nodes
- Analysis into the use of attribute certificates within the X-Bone

The outcome of these collaborations will be important for UCL's 6NET VPN infrastructure deployment activity, as it will influence the level of focus that will be directed on each of the technologies to be deployed within 6NET on the larger scale.

5. Comparison

5.1. Usage Comparison

5.1.1. VPN System Installation & Configuration

5.1.1.1 DVC

The DVC is required to act as a dedicated system running on the boundary between the public Internet and the private internal network. The set-up procedure for this is very simple, with the provision of an ISO CD image based on FreeBSD, a command-line-run configuration script requesting correct host name and address details, and the configuration of coalitions being carried out through a simple Java-based policy configuration tool. The local DVC Operator is responsible for creating and maintaining the policies.

5.1.1.2 X-Bone

The X-Bone configuration procedure (specifically for an Overlay Manager) is somewhat more involved than the above. The X-Bone is distributed either as a FreeBSD Port or as a Linux rpm. Before X-Bone can be installed, the base operating system must be installed and correctly configured. In addition to this, (depending upon the set of features required) a number of external software dependencies must also be installed and properly configured (e.g. Apache for the provision of the X-Bone GUI). This does require a certain amount of knowledge about configuration of the external dependencies, which the DVC system operator does not need. However the nature of the X-Bone distribution allows easily for a multi-functioning node, unlike the dedicated nature of the DVC system. Following the X-Bone software installation, a command-line-run configuration script populates the node daemon configuration file. The node daemon must be run on all machines.

With the help of the DVC system developers, UCL has packaged successfully a working X-Bone Resource Daemon installation onto an ISO CD image [3] similar to the DVC distribution. This should aid the deployment process and potentially avoid some of the more common problems encountered.

5.1.2. VPN System External Dependencies

It should be noted again, that until very recently, the X-Bone releases that UCL had experimented and deployed with were not final releases of the software. The software was not stable when the specially packaged alpha release was provided for UCL, and a number of bugs and oddities were encountered during the beta release phase. The second beta release was subsequently made available and deployed successfully, as is now the case with the final version 3.0 release.

In particular, the fact that experimental releases were used until very recently meant that software dependencies (such as essential Perl modules and components such as Apache) had to be installed and configured manually. Although the final release is packaged such that dependencies are installed by default, there is still the question of configuring the external dependencies. The DVC system appears to have an advantage in this area, since the pre-packaged Operating System/DVC system installs and configures all software as needed. The X-Bone may be able to overcome this issue through the provision of a packed CD image as described above, and/or the extension of the command-line-run script to configure relevant external dependencies. Recent inclusion of the X-Bone into the FreeBSD ports collection should make installation on FreeBSD a simpler process.

5.1.3. VPN System GUI Comparison

5.1.3.1 X-Bone

The X-Bone system provides a web-based interface for node discovery and overlay deployment/tear-down operations. This consists of web forms in which overlay configuration data is entered and submitted for overlay creation or node discovery. The interface is fairly simple and straightforward with a good level of help available on the various input fields.

5.1.3.2 DVC

The DVC provides a substantially more visually intuitive interface of a point-and-click nature, allowing the viewing of coalitions and the establishment of VPNs with either all or selected coalition members.

Although the visually intuitive GUI design would be beneficial for adoption as part of the X-Bone GUI, this may not be fully possible due to the nature of the X-Bone design. The Overlay Manager requires certain information, which it uses to then automatically deploy relevant overlays. The current X-Bone web interface deals with the gathering of relevant data appropriately, and effectively, in order to deploy the standard overlays. However, the feature for defining custom overlays (new to version 3.0) would very likely benefit from such a graphical interface as provided by the DVC.

5.1.4. Policy Definition Comparison

5.1.4.1 X-Bone ACL

Access policies within the X-Bone are defined via a set of administrator-configured Access Control Lists (ACLs) inserted into the X-Bone configuration file. The command-line configuration tool requests the ACL rules to be provided upon initial installation, and further rules must be added by directly editing the configuration file. Both cases require a certain amount of knowledge about the format of ACL rules.

Both the UMU and the DVC systems on the other hand provide fairly intuitive Java-based policy configuration tools. They both create standards-based XML formatted policy files.

5.1.4.2 UMU Policy Tool

The UMU tool provides a web-based (Java applet) interface in a form structure, asking specific questions that map onto relevant policy rules. The set of questions is open to change and the tool provides a generic method for the creation of XML-based policies.

5.1.4.3 DVC Policy Tool

The DVC tool is a Java application, more specifically designed for the DVC system itself, providing configuration options only relevant for installation onto the DVC node. These include options for creating coalitions and adding sites, selecting resources for sharing and defining expected remote resources. The tool also has the ability to push the policy directly to the DVC node.

5.2. Feature Comparison

5.2.1. IPv6 Capability

IPv6 capability is an essential requirement for UCL. Version 3.0 of the X-Bone fulfils this deployment requirement.

The UMU-PBNM system has been fully designed with IPv6 capability and this fulfils any policy definition and management requirements that UCL may have.

The DVC system was until very recently lacking in this area. However IPv6 capability has now become available and so also fulfils this requirement.

5.2.2. Distributed Nature of System

Although there can be many Overlay Managers in operation, the nature of the X-Bone system is inherently centralised, with a single Overlay Manager responsible for the creation of complete overlays. This is one area where the DVC system has a clear advantage with its completely distributed, de-centralised and locally controlled VPN deployment mechanisms.

It is unlikely that the X-Bone architecture can be modified to provide the type of distribution that the DVC provides. However, the DVC system is in a position where modifications can be made to provide more of the features that the X-Bone already provides, such as hierarchical overlays.

5.2.3. PKI

The UMU system provides a fully standards-compliant, fully IPv6-enabled, web-based Certificate Enrolment and Management system.

The X-Bone provides a similar web-based system, albeit only for the applying for X.509 certificates. The current DVC system for certificate enrolment is a manual one, based upon e-mail. Integration of both systems with the UMU-PKIv6 would be very important for UCL during the deployment of an IPv6 VPN infrastructure. As mentioned earlier, such work has in fact begun, with the work on integration into DVC system currently being further ahead.

5.2.4. Topology

Whilst the X-Bone provides the capability to deploy different types of overlays, the lack of ability to define overlay network topology within the DVC system could still be an important drawback despite the different perspective of VPN deployment that the system takes as compared to the X-Bone (Edge-based VPNs as opposed to Host-based). In addition, the X-Bone has an increased flexibility with the new custom overlay definition options mentioned above.

5.2.5. Advanced Dynamic Features

The X-Bone also has capability for supporting some more advanced features such as dynamic routing and also dynamic DNS updating. Dynamic routing, making use of separate routing software such as Zebra/Quagga enables the X-Bone to provide aspects of dynamic routing of traffic across each overlay. The fully-meshed nature of the DVC system, with its coalition-based approach does not provide for such a routing infrastructure yet. The dynamic updating of DNS entries within the X-Bone enables each host to be dynamically allocated a hostname within the context of each overlay. DNS is handled differently within the DVC system, with each DVC node or site being responsible for running a DNS.

6. Limitations

Whilst we have done our utmost to meet the project deadlines as laid out within the initial DoW, it is unfortunately the case that we have been affected by the lack of availibility of required functionality at the originally given estimates for milestone completion.

The main challenge faced has been the lack of IPv6-capability within the technologies desired for deployment. This has only been stablised very recently within the X-Bone system, where a number of bugs have been discovered during UCL’s deployment attempts along the way. IPv6-capability has only recently been released in the DVC system. This has meant that timescales available for testing have been significantly shortened.

As a result, this deliverable was approved for a rescheduled submission date of month 26 in order that the extension provide a better opportunity for comparison and review of the systems. Never-the-less, we have met part of milestone 4.3.2 on time, with the successful deployment of IPv6-enabled overlays across multiple sites which include collaboration between 6NET, Euro6IX and the ICB (ISI).

7. Envisaged Deployment Scenarios

As it stands, a fully deployed IPv6-enabled VPN infrastructure does not provide on its own any benefits for the project. What will be important is the set of applications running over the VPN infrastructure. Essentially any 6NET project-related activity involving multi-site communication and interaction that requires a level of security over and above that provided by running directly over the underlying network, could be undertaken across the VPN infrastructure.

It is envisaged that the VPN infrastructure will provide a base network over which project activities can take place in a secure manner. In fact, the term “VPN infrastructure” has been used here, but does not have to be singular. With both the X-Bone and the DVC systems, multiple “overlays” or “coalitions” can be set-up in parallel between different sets of project partners, providing multiple base networks over which different sets of applications could be run.

We envisage the following scenarios for the final dynamic IPv6-enabled VPN infrastructure to be deployed across 6NET. It should be remembered however that the set of scenarios is not limited to only these and could easily be extended as more come to light.

7.1. Conferencing

General project-related audio/video conferences could be carried out across the infrastructure rather than across the underlying public infrastructure. This would provide a means for ensuring streams travel through specific paths appropriately encrypted.

7.2. Data Storage And Distribution

Provision of document repositories, web services and the use of file transfer mechanisms running over the VPN infrastructure will provide a greater degree of security for the distribution and exchange of sensitive project-related data.

7.3. IPv6-Enabled Grid Services

The 6NET WP5 activities into IPv6-enabling of the Globus toolkit could be combined with the VPN activity such that the IPv6-enabled Grid Services run over the VPN infrastructure. This would further demonstrate the diverse set of uses such a VPN infrastructure would have.

8. Infrastructure Deployment

8.1. Accomplished Achievements

We have deployed successfully, across multiple sites, the final release of X-Bone version 3.0. This has been used to construct multiple (non-recursive) overlays, each with differing topologies. The deployment involves five nodes located at UCL, one node located at UMU and two nodes at ISI.

In addition to the X-Bone deployment, we have also run successfully a (unicast point-to-point) VIC session across an overlay (using the beta2 release).

We have also deployed successfully the IPv6-enabled version of the DVC system. This deployment consists of a single node at UCL forming part of a 4-node coalition, which includes UMU, NRNS and DRDC.

8.2. Planned Future Deployments

The current X-Bone deployment forms a core deployment involving a small number of partners and external collaborators involved heavily in the VPN activities. Following this, the next step is to expand the deployment to involve a larger number of 6NET partners.

A similar strategy is planned for the deployment of the DVC system whereby a core deployment will be carried out upon the IPv6 version release, followed by wider-scale 6NET deployment.

8.3. Applications Over VPN Infrastructure

As mentioned earlier, some basic tests have been carried out for running applications across the VPN infrastructure. The following have been tested successfully across the core X-Bone deployment:

- Basic pings between nodes over multiple hops across the VPN (using static routing)
- SSH between nodes over multiple hops across the VPN (using static routing)
- Video conference (video only) using a unicast, point-to-point VIC session over multiple hops across the VPN (using static routing and beta2 release)

In addition, basic web access has been tested across the IPv4 DVC deployment.

It is aimed that the conference tests soon be extended to include audio and also run using multicast. This will involve some additional software installation such as that of Xorp [4] for example, for multicast routing enablement.

9. Future Work

The main future task from the infrastructure deployment perspective will be to extend the size of the deployments to include a larger number of nodes from 6NET partners. The success of this will of course depend upon the participation of more 6NET partners willing to install and run an X-Bone node and/or a DVC node.

For X-Bone deployment, UCL has created an installation CD to provide a simpler installation method for this specific deployment. Further details can be found at [3]. The X-Bone port has also recently been added to the FreeBSD ports collection. For DVC deployment, a similar installation method is already provided by the developers.

Dynamic DNS and Dynamic Routing are two further features that need to be enabled across the X-Bone infrastructure.

The extension of the range of applications to include multicast-based conference applications as suggested earlier will require multicast routing software. Xorp could provide a means for enabling this capability and will be investigated further.

Another thing that needs further investigation is the types policies that would be relevant and required for exchange within such a VPN infrastructure. A basic set of policy mechanisms already exists in the form of server/service/port mappings within the DVC policy editing tool and some initial investigations are being discussed between UCL, UMU and DRDC regarding the subject.

10. Conclusion

We have deployed extended IPv6-enabled X-Bone VPNs as required by the milestone, as well as carrying out initial preparations for deployment of the DVC. Further, we have made a start into going some way beyond the requirements by carrying out an initial test video conference over the VPNs. Further, this has been undertaken as part of a multi-project (6NET/Euro6IX/ICB) collaboration effort.

Technically, the two VPN technologies (ISI X-Bone and DRDC DVC) are mature and ready for wider scale deployment, though not completely free from installation and configuration problems. We propose parallel 6NET deployments of both the X-Bone and the DVC systems. The former has been carried out albeit with a smaller number of sites than initially hoped for, and is awaiting further partner cooperation for a more wider extension to the deployment. The latter is currently undergoing core deployment and testing before extended 6NET deployment.

There has been the same difficulty as other deployments within 6NET in that there is very little activity by users to take advantage of the 6NET technical capabilities. This is an area which will be addressed as having high priority in the 6NET project meeting in March 2004.

By itself, a VPN infrastructure is not much use. Although an initial test video conference has been tested across the X-Bone deployment, much work and testing still needs to be carried out in order to demonstrate real collaborative applications making use of the IPv6-enabled VPN infrastructure in order to prove its viability as a useful infrastructure.

Finally an uncredited success for 6NET is to be highlighted. The VPN activities have led to two other activities (ISI X-Bone and DRDC DVC) becoming IPv6-enabled. This really is a WP7 success, and it will be so communicated to the WP7 Work Package leader.

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12. Abbreviations

ACL	Access Control List
CMC	Certificate Management Messages using CMS
CMP	Certificate Management Protocol
CMS	Cryptographic Message Syntax
DNS	Domain Name Server
DoW	Description of Work
DRDC	Defence Research & Development Canada
DVC	Dynamic VPN Controller
GUI	Graphical User Interface
ICB	International Collaboration Board
ISI	Information Sciences Institute
PBNM	Policy-Based Network Management
PKI	Public Key Infrastructure
UMU	Universidad de Murcia
USC	University of Southern California
VIC	Videoconferencing Tool
VPN	Virtual Private Network
XML	eXtensible Markup Language
Xorp	eXtensible Open Router Platform