NEXOF-RA

NESSI Open Framework – Reference Architecture

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Deliverable D3.1c: Resource Infrastructure in the NEXOF Reference Architecture

Mike Fisher

Paul Mckee

Shimon Agassi

Evelyn Pfeuffer

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Change History

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0.2	4/06/2010	Draft	Mike Fisher (BT), Shimon Agassi (IBM)	Additional material on collaboration and PoC
0.3	10/06/2010	Draft	Mike Fisher (BT)	Formatting corrections and some revisions for consistency
0.4	11/06/2010	Draft	Mike Fisher (BT), Evelyn Pfeuffer (Siemens), Shimon Agassi (IBM)	Review comments and additional material
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EXECUTIVE SUMMARY

This document reports work carried out in NEXOF-RA WP3: Adaptive Service-Aware Infrastructure using a common format with similar reports on activities in WP1, WP2 and WP4.

It describes the relationship with the Open Process in the last reporting period, including a topic (Usage and Management Interfaces) to which community contributions were invited. This was investigated as a WP3 activity, with support from other NESSI stakeholders, including two NESSI Strategic Projects (RESERVOIR and SLA@SOI). Results of this investigation are briefly summarised. This formed part of a wider collaboration activity between the three NSPs which has achieved a harmonised and consistent view of the architecture for infrastructure resources based on a generalisation, abstraction and formalisation of best practice and experience.

Three patterns (Virtualisation of Computational Resources, Infrastructure as a Service, and Multi-tenancy Enabler) have been contributed to the Reference Architecture. An overview of these patterns is given.

Although no Proof of Concept associated with WP3 has been completed within the NEXOF-RA project, WP3 has contributed to the definition of a conceptual PoC ("Cloud Data-Center") based on the IaaS pattern, jointly with RESERVOIR and SLA@SOI, which describes how to validate some of the architectural approaches. This has been contributed to the process run by NEXOF-RA WP8. This PoC is aligned with a collaboration activity between the NSPs on aligning data models, monitoring capabilities and interfaces. It is jointly contributing to the OCCI (OGF) and the OVF (DMTF) standards. This has been contributed to NEXOF-RA WP9. Also, the collaboration has resulted in a WP10 scenario ("SaaS CRM Provider") that is describing a realistic application scenario for the "Cloud Data-Center" PoC. Apart from the contributions to NEXOF-RA, the collaboration will also be described in a specific RESERVOIR/SLA@SOI collaboration white paper as a supplementary deliverable to NEXOF-RA.

Document Information

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Authors (Partner)	Mike Fisher (BT), Paul Mckee (BT), Shimon Agassi (IBM), Evelyn Pfeuffer (SIE)			
Responsible Author	Mike Fisher		**Email**	
	Partner	BT	**Phone**	

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1 INTRODUCTION

1.1 Scope of the deliverable

This document reports work carried out in NEXOF-RA WP3: Adaptive Service-Aware Infrastructure using a common format with similar reports on activities in WP1, WP2 and WP4.

An additional document which aims to explain the results and conclusions of this workpackage in a form more accessible to readers who have not been involved in NEXOF-RA is formally delivered as Appendix B: Resource Infrastructure in NEXOF-RA.

1.2 Description of the work

The main focus of the work reported here is on the interfaces that resource infrastructure services expose so that they can be used and managed effectively to support a wide range of customers and applications. This complements previous work aimed at describing resource infrastructure services in abstract terms – focusing on what the user can do with them rather than the technology behind them.

Three patterns (Virtualisation of Computational Resources[1], Infrastructure as a Service[2], and Multi-tenancy Enabler[3]) have been contributed to the Reference Architecture. Each of these patterns is introduced in this document. In addition, the pattern "Cloud Migration Enabled by OSGi – step one", [4], although not produced within WP3 supports some of our objectives for interoperability and portability between infrastructure providers and has been used as an example of best practice to inform the development of the higher level WP3 patterns.

Although no Proof of Concept associated with WP3 has been completed within the NEXOF-RA project, WP3 has contributed to the definition of a conceptual PoC ("Cloud Data-Center") based on the IaaS pattern, jointly with RESERVOIR and SLA@SOI, which describes how to validate some of the architectural approaches. This has been contributed to the process run by NEXOF-RA WP8. This PoC is aligned with a collaboration activity between the NSPs on aligning data models, monitoring capabilities and interfaces. It is jointly contributing to the OCCI (OGF) and the OVF (DMTF) standards. This has been contributed to NEXOF-RA WP9. Also, the collaboration has resulted in a WP10 scenario ("SaaS CRM Provider") that is describing a realistic application scenario for the "Cloud Data-Center" PoC. Apart from the contributions to NEXOF-RA, the collaboration will also be described in a specific RESERVOIR/SLA@SOI collaboration white paper as a supplementary deliverable to NEXOF-RA.

2 INITIAL POSITION

Resource infrastructure refers to the basic computational and communications capabilities (e.g. computing, storage and networking) which support the execution of the software components in NEXOF. The main architectural focus of WP3: Adaptive Service Aware Infrastructure is on how resource infrastructure components can be accommodated in an open service framework – essentially how heterogeneous and evolving hardware technologies can be incorporated in a flexible and extensible way. Resource infrastructure functionality is exposed as services, according to the same patterns used throughout the architecture. They can then make use of all the facilities provided by a NEXOF compliant implementation.

NEXOF-RA resource infrastructure patterns deal with mediation between the owners or operators of infrastructure resources and their users. This assumes a business model in which users can gain flexible access to infrastructure resources to meet their own particular needs, without requiring bespoke external support or long-term commitments. This is the same scenario as in cloud computing (or cloud infrastructure services).

The main architectural issues are:

- The description of (resource infrastructure) services in abstract terms – focusing on what the user can do with them rather than the technology behind them. This has been described in previous deliverables.
- The interfaces that resource infrastructure services expose so that they can be used and managed effectively to support a wide range of customers and applications. Our architectural approach to this problem is described in this deliverable.

3 CONTRIBUTION FROM THE OPEN PROCESS

3.1 Activities related to the open process

3.1.1 The proposed Topics

One topic (“Infrastructure Usage and Management Interfaces”) was proposed as part of the open process.

This topic addressed the interactions between ICT resource infrastructure (computing, storage, network and execution environments) and the applications or components which it supports. The scope included the interactions involved when an infrastructure service is being used – including information exchanges between application and infrastructure as well as facilities to allow the user to monitor and control infrastructural aspects of the service.

3.1.2 The Investigation teams

Respondents to the open call came only from NEXOF-RA participants or people closely associated with NESSI. It was therefore decided to run the activity outside the formal open process as a collaboration between NEXOF-RA and the NESSI Strategic Projects RESERVOIR and SLA@SOI, with some additional contributions from INRIA.

Table 1: IT List

WP10 System Requirements[1]	Investigation Team
R 10. How can the infrastructure enable the execution of all the other modules of the service value stack? R 4. How can services be managed?	NEXOF-RA, RESERVOIR, SLA@SOI, INRIA

3.1.2.1 *Usage and Management Interfaces Investigation*

Rationale

NEXOF services are underpinned by a flexible, heterogeneous set of resource infrastructure services. These will be provided by a number of independent stakeholders to meet specific technical and market needs, and we can already see examples emerging in the form of various on-demand computing or hosting services, typically with usage-based charging (e.g. Cloud computing, Platform as a Service). NEXOF aims at an extensible, decentralized global computing environment, which is open in the sense that there are no unnecessary barriers to interoperability.

[1] D10.1 Requirements Report

The NEXOF architecture should make it possible for users to deploy software components to any infrastructure resources which are appropriate to their needs, including both functional and non-functional, in support of their individual goals and commercial considerations. The architecture therefore needs to specify how software can be supported by a range of resource infrastructure services, identifying common features and capabilities.

Adaptive behaviour by both the infrastructure and the application is desirable to make the user experience more dependable. This means that the infrastructure provider needs knowledge of the components he is hosting that goes beyond the "black box". Infrastructure management facilities should be available to the infrastructure service user or application developer. These should include both access to monitoring information, such as whether there are any faults or performance issues, and control interfaces, such as the ability to request additional resources or to migrate components between geographical locations or service providers.

Objectives

The objectives of this topic were to address:

- information models, mechanisms and protocols for exchanging management information between user and resource provider or between resource providers, including the specification of deployment descriptors
- approaches to interoperability/portability between infrastructure providers, possibly including unification of interfaces or brokering

Placement in architecture

This topic is part of the Resources concern, specifically addressing the exposure of resource infrastructure functionality as NEXOF services.

Investigation team reports

Document "Infrastructure Usage and Management Interfaces" was published by NEXOF-RA in September 2009. The content is also described, with some revision and additional material in [FIX].

Setup of the team

The team comprised members of NEXOF-RA WP3, RESERVOIR and SLA@SOI. This core group undertook the bulk of the work of analysis and documentation of the report. In addition, INRIA was involved in a number of discussions.

Summary of activities

The two external contributors, (RESERVOIR and SLA@SOI) each provided an extensive summary of their respective architectures and interfaces. These were summarised, discussed and documented – emphasising the aspects directly related to the scope of the investigation. In this way, the team was able to identify some essential characteristics of architectural constraints relating to resource infrastructure, based on and consistent with the design and implementation experiences of RESERVOIR and SLA@SOI.

Results

Comparing the positions of both RESERVOIR and SLA@SOI and also considering their collaboration on standards in the OCCI Working Group of OGF and the Cloud Standards Incubator of DMTF, this investigation identified striking areas of similarity suggesting the existence of a common architectural pattern with broad applicability within NEXOF.

A three-layer management structure occurs in a number of places, in different contexts but with similar motivation. In RESERVOIR this is manifested in the Service Manager, VEE Manager and VEE Host construct, whilst in SLA@SOI it appears in the three core functional blocks of Infrastructure SLA Provisioning and Negotiation, Resource Allocation and Management and Infrastructure Reporting. It also appears in the SLA@SOI monitoring system as the Collection, Evaluation and Service layers.

It is possible to generalise the three-layer management structure:

At the lowest level we have technology-specific details of physical resources. In the case of the SLA@SOI monitoring architecture, this is concerned with the raw input data. In RESERVOIR, the VEE host that offers specific virtualisation technologies.

The middle level offers management of the individual resources. This covers the evaluation layer in the monitoring architecture and the VEEM in RESERVOIR. These provide some abstraction and contextualisation but still rely on knowledge of the technology being used in the bottom layer.

The uppermost layer, the service layer in SLA@SOI and the service manager in RESERVOIR provides the information regarding the underlying resources to users of resource infrastructure services.

This form of abstraction coupled with translation between high level service (or business) requirements and low level real resource configuration and management seems to be the fundamental pattern for the management of large sets of heterogeneous resources in a service-oriented world. It is a reflection of the role of the infrastructure service provider as a mediator between the low-level resource infrastructure provided by equipment vendors and the consumers of utility ICT resources.

It should also be noted that although part of the motivation for the three-layer pattern came from the virtualised management architecture described in the RESERVOIR project there is no specific dependency on virtualisation. The pattern addresses the abstraction and management of collections of similar resources and has no view of whether the resources are real physical resources or collections of virtualised resources running on real physical resources.

Innovation points

The three-level pattern (physical resources, infrastructure management, exposure) has a number of advantages in terms of clear separation of concerns and identification of appropriate reference points between resource infrastructure and other parts of the NESSI Open Framework.

Customers will be keen to avoid vendor lock in. The existence of a standard interface to the exposure facilitates choice and movement between resource infrastructure providers.

A resource provider in a future NEXOF compliant architecture will be responsible for constructing the middle layer to fulfil its own management strategies and the top layer to expose services which are compliant to general NEXOF standards and specifications. Resource infrastructure services will use the same description and discovery approaches as any other NEXOF (application) service.

Vendors of IT equipment (servers, storage devices, switches, routers etc.) will increasingly need to sell to resource infrastructure providers if the anticipated shift to a utility model of IT infrastructure happens. The resource infrastructure provider will select equipment from appropriate vendors to make construction of an efficient and manageable infrastructure as straightforward and cost-effective as possible.

Impact on standardization

The analysis undertaken within NEXOF-RA WP3, in collaboration with the RESERVOIR and SLA@SOI projects has led to development of a broad consensus on some of the essential features that implicitly underlie the design decisions each project has made separately. In order to interwork effectively and still achieve the business goals of all parties, there needs to be some level of standardisation in the relationship between resource infrastructure services and the applications they support. This includes the description of application components and resource infrastructure services, which parameters are monitored and how measurements are accessed by both parties. Agreement is also needed on the management actions to be taken by the resource infrastructure provider in order to maintain the desired application behaviour as the application environment changes. Members of the RESERVOIR and SLA@SOI projects are engaging with relevant activities in DMTF and OGF with the intention of influencing standards for resource infrastructure services.

3.2 Collaboration with NESSI Strategic projects

NEXOF-RA, through WP3 has been instrumental in encouraging collaboration between RESERVOIR and SLA@SOI. Each of these projects has contributed strongly to defining relevant aspects of the NEXOF-RA architecture, providing their perspectives and technical solutions and validating the abstraction performed by NEXOF-RA and incorporated into the Reference Model and Reference Architecture.

The collaboration effort between RESERVOIR and SLA@SOI projects is still in progress, and aimed at a leveraged contribution to the NEXOF Reference Architecture in the areas of architectural patterns and standards, related to Service Oriented Infrastructure[5]

The collaboration areas include comparison of features, use-case analysis, architectural analysis, cloud interoperability standards [6] and a feasibility study for an interoperability proof of concept (PoC) – Infrastructure as a Service Scalability, described in outline below. The PoC will validate the analysis of the various interfaces and data models which need standardisation to enable interoperability among cloud service providers and infrastructure providers.

The collaboration contributed directly to the development of the NEXOF-RA Infrastructure as a Service (IaaS) architectural pattern and also to the emerging OGF OCCI standard, as well as to the extension of the DMTF OVF standard.

The architectural solution provided by the IaaS pattern fulfils some of the assumptions (preconditions) of the NEXOF-RA Platform as a Service (PaaS) pattern [7]. Since these two patterns are closely related, detailed discussions were required within NEXOF-RA and with relevant NSPs, to exchange ideas and concepts and achieve alignment. The main areas at issue were the interfaces for configuration, modification and monitoring IaaS services that are available to implementations of the PaaS pattern. In addition, use cases for sharing elasticity monitoring and VEE image creation were jointly agreed.

4 CONTRIBUTION TO THE REFERENCE ARCHITECTURE

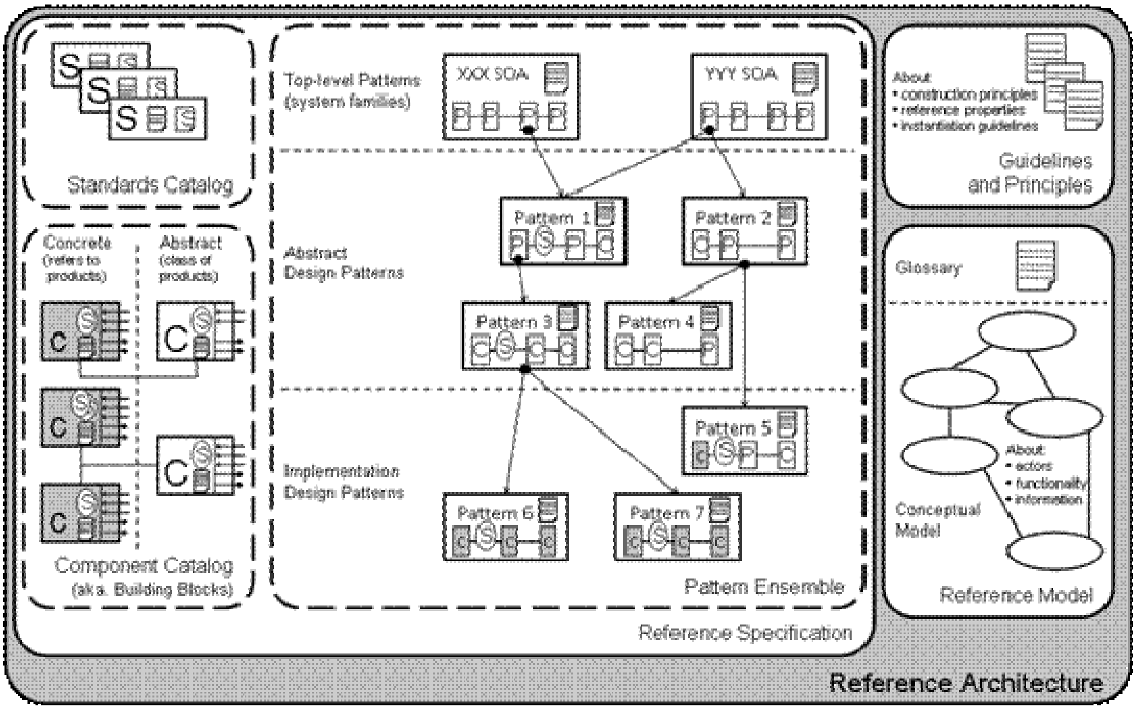

Figure 1: NEXOF-RA Reference Architecture

4.1 Contribution to the Reference Model

Various contributions to the Reference Model have been provided. These include definitions of actors, functionality and information derived from the architectural patterns described below. In addition, regular reviews and contributions to the NEXOF-RA Glossary have been undertaken to ensure consistent use of terminology within NEXOF-RA, with close alignment to usage in RESERVOIR and SLA@SOI.

4.2 Contribution to the Reference Specification

Several patterns have been developed and described in accordance with the requirements of the Reference Specification. These are described below.

4.2.1 Virtualisation of Computational Resources

4.2.1.1 Abstract

The Virtualisation of Computational Resources (VCR) pattern describes specific features of a solution which allows physical computational resources to be incorporated within resource infrastructure services. These services are described and accessed without specific reference to the details of the physical resources involved. There is an assumption here that the software to be supported by the resource infrastructure services are designed to run on virtualised computational resources. In other words, there are no explicit or implicit assumptions about the characteristics or relationships between specific elements of computing hardware. Resource requirements for deployable software units and their composition are expressed in abstract terms and can then be mapped onto physical infrastructure transparently to the “owner” of the software under consideration. Software assemblies satisfying these constraints are termed Virtualised Services (VS) in this pattern.

4.2.1.2 *Requirements*

Tight coupling between software components and the physical hardware on which it runs (computers, storage devices, networks etc.) limits flexibility and makes it difficult for either computing infrastructures or software to change independently – for example, to respond to new requirements or to take advantage of innovations with the potential for improving performance or reducing cost. This is particularly important where computing resources are managed as an infrastructure so that a common approach can be used for a range of independently developed applications rather than deploying bespoke infrastructure for each application.

Reducing this coupling has benefits in improved support for evolution and extensibility. In general terms, virtualisation refers to the abstract representation of resources so they can be logically assigned to specific roles. This assignment can be dynamic and automated in many cases.

4.2.1.3 *Applicability*

A major motivation for the VCR pattern is to increase flexibility in the deployment of software systems by decoupling the requirements of software components from the physical characteristics of computational resources. This gives benefits in adaptation to new operating environments, including portability between different physical infrastructures and scalability of software systems.

Availability of computational resources can be improved by the use of the VCR pattern. The ability to move VEEs between different VEEHs, in response to hardware failure or changing load patterns can be exploited to ensure greater resilience from the point of view of the user.

Utilisation of physical resources can be improved by exploiting the ability to match resources closely to the requirements of the systems they support. There is the potential to share physical resources between different applications. In addition, the possibility of moving software components after initial deployment means that computational resources do not have to be sized according to the maximum anticipated usage levels.

Migration of software components adds complexity to management systems – both in terms of coordinating the migration itself and in tracking the relationship between software components and physical resources. Similarly, the technologies required to support server virtualisation introduce a performance penalty when compared with dedicated physical hardware. The indication from RESERVOIR is that the virtualisation overhead for an application is below 10%.

4.2.2 Infrastructure as a Service

4.2.2.1 *Abstract*

The IaaS solution follows a three-layer architecture that allows the requirements for separation of management concerns and for the hiding of lower layer details from upper layers.

The top layer, **Service Manager (SM)**, supports the operations necessary to establish the business context between the IaaS Provider and the higher-level Service Provider (customer of the IaaS Provider). Their business relationship includes service definition and selection, SLA establishment, monitoring and billing. The SM also monitors contracted SLA compliance and protects SLAs by requesting virtual resources on demand from the Virtual Resource Manager.

The middle layer, **Virtual Resource Manager** is the virtual infrastructure management layer. It uses monitoring and control interfaces offered by the **Virtual Resource Host** to construct an integrated, coherent resource infrastructure. The Virtual Resource Manager hides the details of mapping virtual resources to physical resources (placement) and resource management at runtime from the SM layer.

The bottom layer, Virtual Resource Host, is responsible for managing the virtual resources specific to the underlying virtualization technology, hiding the heterogeneous infrastructure details from Virtual Resource Manager layer.

4.2.2.2 *Requirements*

NEXOF services are underpinned by a flexible heterogeneous set of resource infrastructure services. These will be provided by a number of independent suppliers to meet specific technical and market needs. Adaptive behaviour by both infrastructure and application is desirable to ensure a dependable user experience, and to minimise operational costs. This means that an application and its supporting infrastructure should have information about each other provided through standardised abstractions of interfaces to support interoperability between infrastructure providers.

4.2.2.3 *Applicability*

For the user of the IaaS pattern there are a number of potential negatives whose magnitude may vary according to specific circumstances and should form part of a careful evaluation of the technology. When an application is essentially outsourced to a 3rd party managed infrastructure it moves from an internal location with high local network connectivity and many layers of security to a shared infrastructure. The **performance** of the system may be affected by bandwidth constraints on connections, increased latency, increased traffic to support consistency etc, this will have to be balanced against any cost saving. There will also be at the very least a perception of lower **security** as the application and associated data are no longer within the organisations security domain and information may be being sent over public networks.

4.2.3 Multi-tenancy Enabler

4.2.3.1 *Abstract*

The pattern described in the full document enables multi-tenancy through the use of multiple instances of an application and an adapter layer in combination with virtualization. The use of virtualization achieves better resource efficiency, by enabling dynamic allocation of compute resources to the multiple instances of the application.

4.2.3.2 *Requirements*

Multi-user capability is a core requirement for cost effective service offerings in the SaaS and PaaS business models in which software and platforms are made available as services and accessed over the Internet. In Multi-tenancy Enabler a single application or service instance serves multiple client instances (tenants). Obviously this raises a number of important issues surrounding isolation and security, reliable performance for all users and user specific customisation. Monitoring and logging needs to be provided on a per-tenant level and each tenant may have a different SLA. There are a number of potential solutions for the implementation of multi-tenant systems but it must be appreciated that they require extensive planning and development as they are complex software applications. For many applications a single user solution will already exist and this pattern makes use of the existing single user software together with resource virtualisation to produce a multi-tenant solution with lower software development costs.

4.2.3.3 *Applicability*

The pattern is a multi-instance (isolated) solution, used in combination with virtualization to achieve higher resource efficiency. It can be applied to many types of applications, platforms or even computational resources provided that each instance has multi-user capability. If each tenant of the offered service has their own instance, all end-users from that tenant organization access the same instance.

5 CONTRIBUTION TO THE POCS

5.1 Cloud Data Center

5.1.1 PoC Description

The Cloud Data Center PoC is based on the RESERVOIR-SLA@SOI collaboration. The PoC is a conceptual one as the demand on integration work between both projects was identified as being too great to realize the PoC within the available resources. However, the conceptual PoC has already resulted in important results on the necessary integration of data models, interface standards and monitoring capabilities. These are pre-requisites to realizing the integrated functionalities of the PoC. The RESERVOIR-SLA@SOI collaboration is ongoing and will continue after the end of NEXOF-RA under the leadership of Telefonica (previously IBM).

This is the first example of NEXOF-RA patterns being tested and validated outside of the NEXOF-RA project. It is anticipated that after the end of NEXOF-RA, the Reference Architecture will be enhanced with additional patterns and PoCs by other projects as a community activity supporting sustainability of NEXOF-RA results.

The specific requirements from the IaaS pattern to be evaluated in the PoC are derived from a Customer Relationship Management (CRM) SaaS cloud scenario based on the SAP use-case of RESERVOIR and SLA@SOI. This scenario is included in NEXOF-RA WP10.

5.1.2 Scope of the PoC with respect the Reference Architecture

The PoC will evaluate architectural alternatives by comparing the use of traditional datacentre infrastructure to the IaaS cloud federated approach (with multiple IaaS providers) as proposed in the IaaS pattern ("Cloud Data-Center").

The IaaS pattern is an important feature of the NEXOF-RA architecture for resource infrastructure. It expresses the decision to separate the usage of infrastructure resources from the details of their construction through the introduction of an interface which provides a level of abstraction. One anticipated benefit of this approach is that it should improve the scalability of application deployments which use it, and also offer elasticity – the ability to match the quantity of resources deployed to the load – thereby reducing the need for accurate demand forecasting.

The aim of the IaaS Scalability PoC is to prove the claim of the IaaS pattern that by using it, the quality attribute of scalability is improved, In other words, that via the IaaS architectural pattern and the cloud functionalities contributed by the NESSI Strategic Projects, enterprise CRM software hosting in the cloud can be scalable (and elastic), while satisfying the constraints of meeting SLA commitments and managing SLA compliance and protection at run-time.

The NEXOF-RA Cloud Data-Center PoC combines two aspects which enhance use cases from the RESERVOIR and SLA@SOI projects:

- provisioning of automated elasticity to allow scaling of an application to meet dynamic demand, based on a federated set of IaaS providers (from RESERVOIR)
- SLA compliance monitoring and enacting (from SLA@SOI).

It therefore describes an architecturally based integration between core innovations contributed by each project to the domain of Infrastructure as a Service.

This conceptual exercise is valuable as it helps to reveal critical points of integration. It should be noted that the Cloud Data-Center PoC and the CRM SaaS scenario exclude some important features of a full solution, including federation of trust and security mechanisms and federated provision of storage services. The scenario and conceptual PoC can be used by other projects as a foundation for clarifying further needs for integration and alignment of standards. In particular, contributions to NESSI or to the Future Internet Core Platform activities on resource infrastructure are anticipated to build on these results.

6 Appendix A: Contribution to other WPs

In addition to the specific contributions described elsewhere in this document, WP3 has contributed to other workpackages via the patterns (the patterns themselves, Glossary terms, abstract and concrete components for the Component Catalogue, input to the Standards Catalogue). In addition WP3 has provided specific consultancy, review and support relating to resource infrastructure.

7 APPENDIX B: RESOURCE INFRASTRUCTURE IN NEXOF-RA

See the document D3.1c_ext Resource Infrastructure in NEXOF-RA for a more detailed and readable description of the main results of this workpackage.

REFERENCES

[1] “Virtualisation of Computational Resources in E-SOA”, NEXOF-RA Pattern http://www.nexof-ra.eu

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