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Resource Infrastructure in the NEXOF Reference Architecture

Abstract

Mike Fisher

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Abstract (for dissemination)	This document summarises the approach to resource infrastructure services (i.e. those associated with physical elements such as computing, storage, networking and other devices) in the NEXOF Reference Architecture. It is intended to provide a largely self-contained overview which can be supplemented for interested readers by more detailed project deliverables. Requirements on resource infrastructure services are presented and some of the architectural implications identified. An approach for description of resource infrastructure services, covering both functional and non-functional characteristics is proposed. This includes a measurement framework suitable as a basis for terms in a service level agreement.			
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Authors (Partner)			
Responsible Author	Mike Fisher	**Email**	
	Partner BT	**Phone**	

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1 EXECUTIVE SUMMARY

NEXOF – the NESSI Open Framework is a generic open platform for creating and delivering applications, enabling the creation of service-based ecosystems. This is a broad and ambitious vision, dealing with services in the Future Internet. As a first step in its realisation, the NEXOF-RA project (http://www.nexof-ra.eu) is developing a reference architecture for NEXOF. This document describes the approach taken within NEXOF-RA towards resource infrastructure in the NESSI Open Framework. It aims to provide a self-contained overview that will be accessible to readers without detailed knowledge of the project. Additional detail is available in other documents if required. Resource infrastructure essentially refers to artefacts and systems which are part of or interact directly with the physical world. Most obviously, it includes compute, storage and network (local and wide area) hardware and its supporting operating systems and management software.

Resource infrastructure is incorporated within the NESSI Open Framework as services – software representations of the functionality provided by physical infrastructure in forms suitable for use within more complex software systems. These software representations are just services within the NESSI Open Framework.

The principal architectural issue relating to resource infrastructure is the definition of the artefacts and processes that allow a physical resource to become a service in the service ecosystem. This will include details such as:

- How the service is identified, addressed and located
- How the functional and non-functional properties of the service are described
- What management capabilities the service possesses

NEXOF-RA has identified a number of requirements on the NESSI Open Framework. Some of these are particularly relevant to resource infrastructure services – specifically information models, federated management, evolution and heterogeneity.

Approaches for standard description of resource infrastructure services have been discussed in this document, including both functional and non-functional characteristics. In particular, a model for a flexible measurement framework is proposed, suitable to support comparison of services based and SLA-driven management.

Other architectural requirements, as they relate to resource infrastructure, will be the subject of future work.

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3 Introduction

This document describes the approach taken within the NEXOF-RA project towards resource infrastructure in the NESSI Open Framework. The intention is that it should be readable outside the project in the interests of promoting a common approach between other workers in this area, particularly current and future NESSI Strategic Projects.
The term “resource infrastructure” is described in more detail in Section 4 below, but it essentially refers to artefacts and systems which are part of or interact directly with the physical world. Most obviously, it includes compute, storage and network (local and wide area) hardware – the physical ICT infrastructure and its supporting operating systems and management software, which underpins all networked software and services.
In addition, our definition of resource infrastructure includes components such as sensors and actuators which form a bridge between software systems and the environments in which they operate.

The aim of this work is to establish how resource infrastructure should be accommodated within the NEXOF architecture. The NEXOF view of architecture is:

- The fundamental organisation of a system embodied in its components, their relationships to each other and to the environment, and the principles guiding its design and evolution[1]

This clearly applies equally to resource infrastructure and to software artefacts. The NEXOF architecture is predominantly a software architecture defined as:

- The structure or structures of the system, which comprises software elements, the externally visible properties of those elements and the relationships among them[1]

A major goal is therefore to represent resource infrastructure components as software elements, with particular emphasis on their externally visible properties. Essentially, we aim to indicate how tangible, physical assets can be brought into a virtual, software-based framework in which they can then be flexibly used to support many different applications.

The vision underlying the NEXOF Architecture is one in which many service providers coexist in a large scale networked ecosystem. Service providers will be able to make use of services from third parties in their own offerings. This specifically includes infrastructure services whose purpose is to enable the execution of application software.
The fundamental concern of the architecture as regards infrastructure services is to describe these services, their interfaces and characteristics, in ways that allow their consumers (frequently providers of higher level services) to use them effectively as dependable components of larger systems.

As a result, our main architectural concerns deal with the description of functional and non-functional characteristics of infrastructure services, their representation at appropriate levels of abstraction, and consistency in usage and management interfaces.

4 Scope of Resource Infrastructure

Resource infrastructure services may be characterised as being services which have a close association with physical resources. They are generally basic services, in that they represent the exposure of physical resources as sets of capabilities described and exposed in a consistent way. Their purpose is to underpin more complex services and assemblies of services, using similar approaches to visibility and interaction as more general software services.
It is not possible to identify a comprehensive, standard set of resource infrastructure services. Any piece of equipment could, in principle, be incorporated. The approach taken here has been to consider some existing examples of resource infrastructure - servers and storage, experimental ICT infrastructures, sensors and actuators.

Even within this limited set of physical resource types, different users require different levels of abstraction. Each represents a distinct service offering and the details will depend on the expertise of the user, the kind of application or business process they want to run, and to what extent they need to customise service configuration themselves. Some distinct classes of service can already be observed in use today:

- Resource infrastructure services which provide a potentially complex computing infrastructure to support customised environments deployed either directly or in the form of a set of virtual appliances. This sort of service is becoming increasingly important with the emergence of cloud computing, specifically Infrastructure as a Service. Services of this class are dealt with in some detail by the RESERVOIR project in its High-Level Architecture Specification[2].

- Job submission services typically support the requirements of scientific and Grid computing in particular, an area which has been early to adopt a service-based approach to resource infrastructure.

- Application framework services, aimed mainly at software developers and vendors, are typically more varied and depend strongly on the software stacks offered in addition to the low level computing infrastructure. Such services are also included in the cloud computing landscape as Platform as a Service.

- Dedicated application-specific services are provided by service-enabled devices, such as environmental sensors or automated manufacturing lines. They may be built-in (available from the device firmware provided by the manufacturer) or dynamically deployed.

This classification should be viewed as providing some specific context for the development of the architectural principles for incorporating resource infrastructure within the NESSI Open Framework.

5 RESOURCE INFRASTRUCTURE SERVICES

5.1 Introduction

Resource infrastructure is incorporated within the NESSI Open Framework as services – software representations of the functionality provided by physical infrastructure in forms suitable for use within more complex software systems. It is clear that these software representations are just services within the NESSI Open Framework which therefore share common characteristics with all other services but may have some additional or specialised properties. They must therefore follow, but possibly refine, more general architectural principles and design patterns. Here we focus on the particular features and requirements which arise from a consideration of resource infrastructure.

The focus of this architectural perspective is on the interfaces and behaviour that are required to support interoperability between multiple providers of resource infrastructure services and their consumers. It is not appropriate to include details of how a provider of any particular functionality should engineer systems to deliver these services. However, it is clear from the heterogeneous nature of the developing marketplace for outsourced computing and storage resources (including various forms of hosting, Grid and Cloud computing), that the architecture must support a range of styles of infrastructure service – ranging from cheap (or free) best-effort to expensive, high quality and guaranteed. A basic requirement is that providers and customers can share a common understanding of any service that relates them.

5.2 Initial Conceptual Model

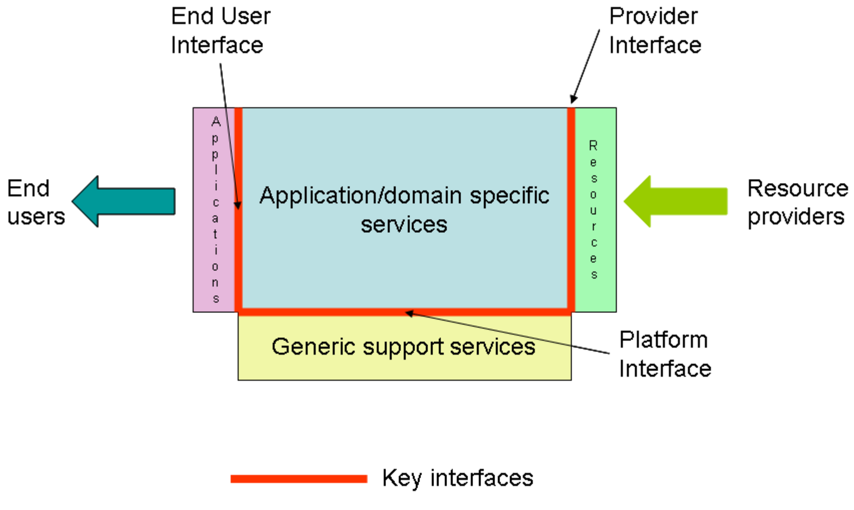

Figure 1: Architectural Context

We start with a vision of a networked service marketplace where the range of services and their usage patterns is essentially unbounded.

Figure 1: Architectural Contextillustrates the relationship of resource infrastructure to the broader NEXOF architecture. All the blocks shown are in

scope for NEXOF but the main focus is in the Generic support services and Application/domain specific services areas, together with the three interfaces labelled as Platform Interface, Provider Interface and End User Interface.

The principal architectural issue relating to resource infrastructure is the definition of the Provider Interface that allows a physical resource to become a service in the service ecosystem. This will include details such as:

- how the service is identified, addressed and located
- how the functional and non-functional properties of the service are described
- what management capabilities the service possesses

With specifications of these externally visible properties, an artefact from the Resources area may be promoted to become part of the Application/domain specific services area where is available for use in NEXOF applications.

6 Requirements for Resource Infrastructure Services

Resource infrastructure services are expected to meet a number of requirements within the scope of NEXOF-RA. The approach taken to derive requirements for the NEXOF architecture was based on collecting user scenarios. The results of this analysis are available in the NEXOF-RA Requirements Report[3]. Some of these scenarios have particular relevance to resource infrastructure.

6.1 Requirements Arising from General Scenarios

Service Procurement: Having identified that it would be advantageous to use a service to provide some functionality, it must be possible for a potential consumer to express his requirements, identify a set of candidate providers and make appropriate selections. The terms and conditions relating to the relationship between provider and consumer of the service are defined in a Service Level Agreement (SLA). While the service is being used, both consumer and provider will collect and analyse performance information. Payment for use of the service will be made.
This scenario leads to the following architectural requirements relevant to resource infrastructure:

- uniform representation for services of different types
- standard representation of SLAs
- ability to federate major functional components such as execution environments (i.e. combine components from multiple providers)

Service Lifecycle Support: When a potential service provider identifies an opportunity to offer a new service, a service developer or integrator designs the service (either from scratch or including existing service components). The provider must then be able to expose (e.g. publish SLA templates) the service, establish SLAs with users, deploy service instances and manage them effectively in life. The provider must also be able to withdraw a service in a managed way.
This scenario leads to the following architectural requirements relevant to resource infrastructure:

- consistent way to describe functional and non-functional service characteristics
- consistent approach to monitoring and control
- ability to add a new service without interfering with existing services
- ability to remove a service with predictable consequences for all actors

6.2 Requirements Arising from Scenarios Involving Resource Infrastructure

Some of the NEXOF-RA user scenarios include significant interactions with the physical world – through sensors, actuators and control systems.

Management services for grid and service platforms: The management and maintenance of large ICT infrastructures (such as a large Grid computing environment) can be achieved by means of services. Components of the infrastructure are owned by multiple organisations so trust and collaboration issues are important. Management services may include: cross-domain management information (monitoring and control), services to support virtual organisations and services to support scheduled or reactive maintenance activities in part of the infrastructure.
This scenario leads to the following architectural requirements relevant to resource infrastructure:

- standards to support interoperability between infrastructure management services
- ability to accommodate heterogeneous resource infrastructure and management technologies within a federated environment
- ability to share information across independent domains
- ability to add and remove managed components (e.g. resources)

e-Health: assisted living: Assisted living systems aim to support people with a chronic illness or those with a need for constant medical surveillance, while allowing them to live at home. They include devices such as blood pressure units and blood glucose meters operated by the patient or health workers – including the possibility of remote operation. Some monitors may continuously survey essential vital functions. Each device transmits results to a local computer which provides instant analysis and tracks trends. The computer can also access environmental information via the Internet. Medical practitioners can access the information collected for diagnostic purposes. The assisted living system can also trigger an alarm in case of emergency to call an ambulance and provide information to the ambulance crew and receiving hospital.
This scenario leads to the following architectural requirements relevant to resource infrastructure:

- technical interoperability between different devices
- integration of monitoring devices with software based on different domain-specific standards

Traffic management: large scale emergency handling: Across a large geographical area, there are several, loosely coupled traffic management systems operated by local and regional authorities. These must be integrated since traffic is not constrained by administrative boundaries. According to predictable situations, they coordinate traffic control devices (traffic lights, directions of tidal flow lanes, lane closures etc) to optimise vehicle throughput and possibly air pollution and noise. There are many devices monitoring traffic density, vehicle speeds, air pollution, traffic light status etc. These devices may be in service for a long time (many years), leading to diversity in technology and vendor. In addition to managing normal conditions, the systems must be able to

respond in emergencies, such as a serious accident. Emergency services must be directed to the location of the accident and traffic must be diverted to alternative routes.
This scenario leads to the following architectural requirements relevant to resource infrastructure:

- integration of heterogeneous devices
- heterogeneity and constant evolution

Assisted Industrial Maintenance (using 3D virtual environments): An industrial plant is maintained by a service technician with support from an expert engineer at a remote location. The engineer can observe the work carried out by the technician and can give instructions or advice.
The engineer has access to a 3D virtual world representing the industrial plant and can interact with it. The service technician can share the 3D virtual world and interact with the maintained systems either directly or via the virtual world. This scenario extends remote maintenance by including a local technician working together with the expert engineer. The result is that critical or very expensive equipment can be maintained or repaired without having a (scarce) expert on site.
This scenario leads to the following architectural requirements relevant to resource infrastructure:

- heterogeneous platforms that support high dependability
- device integration

6.3 Architectural Requirements on Resource Infrastructure

It is obvious from the scenarios described above that there are some clear common requirements relevant to resource infrastructure services. These may be summarised in the following set of architectural requirements on resource infrastructure:

- Standard information models
    - uniform representation for services of different types
    - standard representation of SLAs
    - consistent way to describe functional and non-functional service characteristics
    - ability to share information across independent domains

- Federated management
    - ability to federate major functional components such as execution environments (i.e. combine components from multiple providers)
    - consistent and uniform approach to monitoring and control
    - standards to support interoperability between infrastructure management services

- Evolution

- ability to add a new service without interfering with existing services
    - ability to remove a service with predictable consequences for all actors
    - ability to add and remove managed components (e.g. resources)

- Heterogeneity
    - ability to accommodate heterogeneous resource infrastructure and management technologies within a federated environment
    - technical interoperability between different devices
    - device integration
    - integration of heterogeneous devices
    - integration of monitoring devices with software based on different domain-specific standards
    - heterogeneity and constant evolution
    - heterogeneous platforms that support high dependability

Support for these four characteristics – standard information models, federated management, evolution and heterogeneity is the main concern of the NEXOF-RA approach to resource infrastructure. In the next section, some results addressing standard information models for resource infrastructure services are introduced. The other aspects will be the subject of future work.

7 Standard Descriptions of Resource Infrastructure Services

7.1 Functional and Structural Description

As discussed in Section 4, above, resource infrastructure in the context of the NESSI Open Framework has a broad scope even today. There are several initiatives to standardise descriptions, although clear consensus has not yet emerged. The principal focus is generally on describing the functional or structural characteristics of resource infrastructure services. Such descriptions are well-suited to support service discovery, where a potential user aims to identify candidate services which could meet his needs. Following the classification of resource infrastructure services introduced above:

- Computing infrastructure services: There is a good level of consistency in standards for this type of service. CIM-based OVF[4] is probably the most generally applicable approach for virtualised views of infrastructure, and appears to have strong vendor support. In addition, the approach taken by the GENI[5] project is a relatively lightweight approach which is well-suited to describing physical infrastructure.

- Job submission services: There is a range of commonly used middleware, both commercial and proprietary. The GCM Interoperability Deployment specification[6] provides a generic representation that can accommodate a range of different Grid systems in a uniform way.

- Application framework services: This is a varied and heterogeneous category. Details of the computing infrastructure operated by the service provider are typically not exposed as part of the service description, except as they relate to capacity or dependability. Tying these services to specific software does not in general restrict the ability of a service consumer to choose between alternative providers. Availability of particular software is generally part of the functional requirements of the consumer.

- Dedicated application-specific services: There is a trend towards embedding Web Services at the device level to provide access to this sort of functionality. The Device Profile for Web Services (DPWS)[7] comes originally from applications in home automation. However, it has already found application in factory automation and other domains. In parallel with the work on DPWS, the OPC[8] foundation is actively developing the OPC Unified Architecture (OPC-UA).

7.2 Non-functional Description

In addition to the functional characteristics of a resource infrastructure service, consistent approaches to describing the non-functional or quality characteristics are required. These include parameters such as availability, performance and security. It must be possible for service offerings to be compared in a meaningful way and this should involve comparison of their (measurable) non-functional characteristics – not just what does a service do, but how well. This is also required to achieve a uniform representation of SLA terms.

7.3 Measurement Framework

A model of service metrics has been developed in NEXOF-RA to address this problem. The components of this model are shown in Figure 2.

Figure 2: Measurement framework conceptual metamodel

- **SLA Object:** identifies the SLA principles that are measured by a specific set of metrics. An example of a concept that could be interpreted as SLA Object is “Network Availability”
- **SLA Parameter:** A parameter describes an observable property of a service whose value can be obtained from a source of measurement, and which contributes to one or more SLA Objects. An example of a SLA Parameter for the “Network Availability” object is the “Response Time”. The same Parameter can contribute to more than one Object.
- **Metric:** A Metric defines a specific measurement methodology, including units, which contributes to the evaluation of one or more SLA Parameters.

This approach to modelling gives a complete description of a measurement framework to support SLAs, from low-level instrumentation to customer dashboards and reports related directly to the SLA. The model has been formalised in a XML Schema which extends the work of the NextGRID project[9] on metric specification. The schema definition is reproduced in Annex A, below.

7.3.1 Candidate SLA Parameters for Resource Infrastructure Services

It should be clear that the requirement to support heterogeneous resource infrastructure services requires a flexible way of defining measurements in a consistent way, such as that described above, rather than a standard set of metrics. However, from observation of existing and emerging approaches across the range of resource infrastructure services, it is possible to identify a number of specific features that will be generally applicable.

Metrics associated with CPU (architecture, number of cores, performance), memory (capacity, performance), persistent storage (capacity, input/output bandwidth and latency) and network (protocols, bandwidth, latency) will be required to describe Infrastructure as a Service offerings. Most of these have reasonably well-established approaches to their definition but in general these are probably not yet sufficient for a user to compare services from different providers without reading the small print.

Job submission services may require a similar set of metrics to resource-based services although less detail of the configuration is expected to be required – metrics based on some idea of aggregate capacity are more appropriate. Such metrics contribute to SLA Parameters such as throughput or time to complete and are application-dependent.

Application framework services (Platform as a Service) require metrics which are based on the characteristics of the software stacks they offer. Response times and transaction rates are typically the parameters of interest to users. Since a given application framework service typically supports applications of similar type (e.g. web servers, web applications, widely used enterprise applications – salesforce, Oracle, SAP etc), characterisation of applications is expected to be feasible. Definition of custom metrics for particular applications is a viable approach and can support comparison of providers – if a customer is running a specific software package, the basis for comparison should be clear.

Device services focus on physical effects. These can clearly cover a very wide range of activities. Metrics will include aspects such as the number of operations performed in a specified time or the precision of a measurement or manipulation.

8 CONCLUSION

The aim of NEXOF architectural specification as it applies to resource infrastructure is to allow a wide range of ICT systems to be incorporated into an open service framework. This involves heterogeneous offerings from many service providers, each of which is free to make their own commercial and operational decisions when constructing their own infrastructure and exposing its functionality as services.

Four architectural properties of resource infrastructure services have been identified: standard descriptions, federated management, evolution and heterogeneity.

Approaches for standard description of resource infrastructure services have been discussed, including both functional and non-functional characteristics. In particular, a model for a flexible measurement framework has been proposed, suitable to support comparison of services based and SLA-driven management.

Support for the other architectural requirements, as they relate to resource infrastructure, will be the subject of future work.

9 ANNEX 1: NEXOF-RA MEASUREMENT SCHEMA

This XML schema is a candidate formalisation of the measurement approach described in this document. The type of the <metric> element in this version is MetricType, defined in the NextGRID SLA schema[9].

```
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	<schema xmlns="http://www.w3.org/2001/XMLSchema"
	targetNamespace="http://www.nexof-ra.eu/NEXOF-RA_measurement_v1.0"
	xmlns:tns="http://www.nexof-ra.eu/NEXOF-RA_measurement_v1.0"
	xmlns:ng="http://www.nextgrid.org/sla/2006/08"
	elementFormDefault="qualified">

	<import namespace="http://www.nextgrid.org/sla/2006/08"/>

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		</sequence>
	</complexType>

	<complexType name="SLAParameterType">
		<sequence>
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			<element name="source" type="anyURI" />
			<element name="metric" type="ng:MetricType" />
		</sequence>
	</complexType>

	<element name="SLAObject" type="tns:SLAObjectType" />
	<element name="SLAParameter" type="tns:SLAParameterType" />
</schema>
```

10 REFERENCES

[1] NEXOF-RA Glossary
[2] RESERVOIR High-Level Architecture Specification, http://reservoir.cs.ucl.ac.uk/fileadmin/reservoir/delivarables/080531-D1.1.1-c.pdf, 2009
[3] NEXOF-RA Requirements Report, http://www.nexof-ra.eu/sites/default/files/D10.1-20090331.pdf
[4] OVF Specification v1.0, September 2008. http://www.dmtf.org/vman
[5] Global Environment for Network Innovations (GENI), http://www.geni.net/
[6] Grid Component Model (GCM); GCM Interoperability Deployment ETSI TS 102 827, v1.1.1, August 2008
[7] Devices Profile for Web Services (DPWS), Version 1.1, OASIS, June 2009, http://www.oasis-open.org/specs/
[8] OPC Foundation, http://www.opcfoundation.org
[9] NextGRID Consortium, “NextGRID SLA Schema,” available at: http://www.nextgrid.org/GS/management_systems/SLA_management/NextGRID_SLA_schema.pdf , 2008.