Towards an Information Model That Supports Service-Aware, Self-Managing Virtual Resources

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Abstract. The AUTOI project is creating a virtual communication resource overlay with autonomic characteristics to adapt the services and resources offered to meet changing user needs, business goals, and environmental conditions. Self-knowledge enables the network to reconfigure itself in the face of change to adapt its services according to business goals. The requirements of an information model, to support self-knowledge (concepts, characteristics and behaviour) are presented. This information model plus ontologies provide a common language to represent the self-management of the overlay. This position paper details the requirements in specifying such an information model and language, and describes how the model and language will be used within the project.

Keywords: Information model, service-aware, virtual resource, autonomic management.

1 Motivation and State of the Art

Current voice and data communications networks are difficult to manage, as exemplified by the stovepipe systems that are common in Operational and Business Support Systems. The desire to incorporate best of breed functionality, prohibits the sharing and reuse of common data [1], resulting in an inability to manage the increase in operational, system, and business complexity. Currently, the network is not aware of the needs of the business, so changing business requirements cannot change the services and resources offered by the network.

The AUTOI project [2] uses management overlays that control the virtualisation of network resources and services to implement this mapping of business to network functionality thus resulting in a more optimal use of network resources. Virtual

resource overlays can span heterogeneous networks and self-organises according to service requirements. In turn, the deployed services self-configure in response to changes in the overlay. Orchestration mechanisms mediate between different network operations (eg. mobility), enabling conflict resolution and fulfilment of customer requests. Fig.1 depicts the architecture of the AUTOI autonomic control loop. Knowledge is provided by the resources, services, environment, business requirements and relevant context. Orchestration takes the knowledge gathered and reasons over it in order to formulate decisions. Policy based management then enables the self-management of the resources and thus, is governed by the decisions of Orchestration.

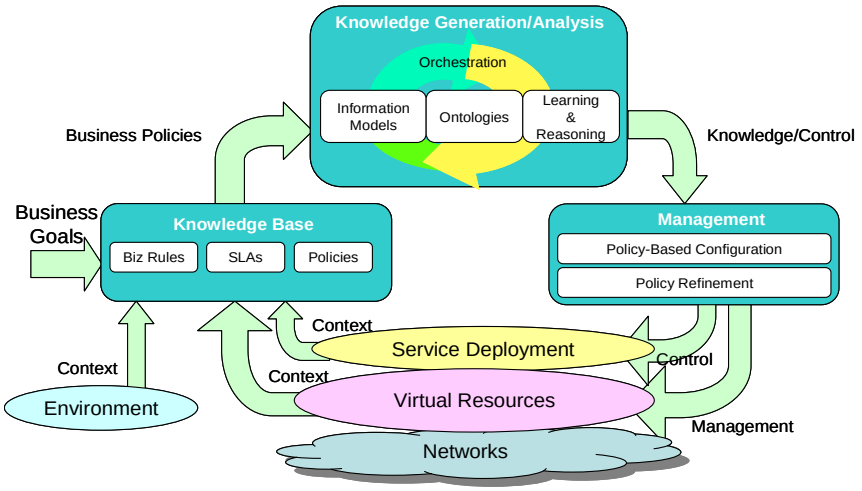

Fig. 1. Components of the AUTOI Autonomic solution

In [2], the AUTOI problem area and strategy were introduced. The next step is to establish requirements for the activities which will realise a solution. To dynamically orchestrate services, a common language is needed that systems can use to express their needs in a machine-programmable manner and translate those needs into a form that the network can understand. This language is built from a single information model, used to define facts and from ontologies, used to augment the facts with additional semantics. The AUTOI model, an extension of the DEN-ng information model [3], captures all necessary concepts concerned with service-oriented virtual resource orchestration. Just as an information model can be refined to guide the development of multiple data models, a common language can be refined to define a set of Domain Specific Languages (DSLs). DSLs are used to address the specific system tasks in an interoperable manner. The combination of the common language and a set of DSLs becomes the source of understanding across the disparate entities of the AUTOI architecture.

Three major information models are widely used today to capture semantics and behaviour of communication networks. The oldest is the Common Information Model

(CIM), standardised by the Distributed Management Task Force (DMTF) [4]. Its main focus lies on IT infrastructure including IP networks. CIM provides virtualisation extensions for systems [5] which include a high-level model for various types of platform virtualisation, including hypervisor-based virtualisation, logical and physical partitioning, and operating system containers. However, the CIM specifications for services, networks and resources do not consider resource allocation or associate business goals; thus an autonomic system will find it difficult to respond to context changes. The Shared Information and Data Model (SID) is standardised by the TeleManagement Forum (TM Forum) in [6]. It enables the design of services and network resources in conjunction with products and customers, thus providing the necessary associations to link resources to business activities. It can also be used as a toolkit that allows modellers to select what they need to model specific applications. However, the SID is limited with regard to modelling autonomic environments eg. the policy framework is inflexible and concepts such as context are missing [7]. AUTOI has chosen the DEN-ng model [3] [7]. DEN-ng provides multiple viewpoints of a communications network where business goals are used to govern all managed entities. It defines a policy model that governs the behaviour of managed entities using patterns and roles, enabling it to extensibly administer management functions and data [8]. A policy continuum [3] represents how different constituencies of a product formulate at different levels of abstraction. The context model [7] is coupled to the policy model in order to allow the creation of policies which adapt resources and services to sensed context changes It was used to build FOCALE [9], an autonomic networking architecture that defines a novel set of control loops that analyse data, compares the current and desired state of a managed entity, and reconfigures accordingly. DEN-ng is currently being adopted as the standard information model within the Autonomic Communications Forum (ACF).

The organisation of this paper is as follows. Section 2 presents the key requirements that AUTOI places on its information model. Section 3 presents some of the early work to extend the DEN-ng information model and the use of the information model within AUTOI. Finally, Section 4 provides a summary and future work.

3 AUTOI Modelling Requirements

In order to derive appropriate modelling requirements, it was necessary to divide the problem into five specific domains for analysis: (1) service, (2) resource and resource virtualisation, (3) management, (4) context, and (5) orchestration.

The information model should provide sufficient abstractions to enable **services** to express their requirements to the management overlay, which then translates those requirements into a particular virtualisation of some or all of the network resources. There are two types of service under analysis: Network and Application. *Network Service (Resource Facing Services in DEN-ng)*, refers to services which network resources provide, such as mobility, QoS, and security. These services depend on the availability and configuration of network resources. Virtualisation enables resources to be collectively treated as a set of programmable building blocks that are used to

construct services as directed by the management overlay. *Application Service (Customer Facing Services in DEN-ng)*, refers to the service being offered to the end-user or customer, such as voice and video.

Resources not only refer to physical and logical resources but also virtual resources. The physical and logical resources that provide network services, such as routers or servers, are modelled as virtual resources. Several virtual routers can be created that are associated with a physical router, and the physical topology of the network is then replaced by a virtual topology consisting of one or more overlay networks. These virtual resources are dynamic resources that can be modified to support one or more services running on top of them. This enables a robust and resilient provisioning of virtual resources in case of, e.g., highly loaded routers. The following requirements have been identified for the information model: (1) to serve as a blueprint for defining virtual resources based on higher-level business requirements; (2) enable virtual resources to represent the management of their relationships with their associated physical and logical resources and also their associated network and application services; (3) support mechanisms to define system virtualisation based on classical hypervisors (e.g. XEN); (4) support virtualisation behaviour such as aggregation and splitting of virtual resources; (5) support mechanisms to represent the configuration of virtual network resources, especially virtual routers and the virtual topology.

Management is focussed on provisioning a management plane responsible for enabling the self-management of virtual network and service resources. The model needs to provide concepts that support the following management plane functions: (1) Resource management – usage, availability, (de)composition, virtualisation and assurance – for the self-* functions; (2) Adaptation to changes in network resource mobility, services and resources and direct changes to be made in the appropriate network device configuration and topology; (3) Sharing and reuse of information for self-management functions; (4) Sharing and reuse of information with the virtualisation and orchestration planes; (5) A policy-based framework that is capable of identifying and resolving conflicting goals between different management self-functions as well as between different planes; (6) A policy model that is capable of orchestrating self-organising behaviour using the policy continuum to provide translations between business, network, and implementation policies. The model should support the respective policy transformations.

Given the autonomic interplay between resource and service, handling **contextual** changes in resources and services is vital. In addition, user requirements and environmental conditions can change without warning. This implies that such potential changes must be continually inspected with respect to business objectives. Contextual abstractions in the following areas need to be provided as part of the information model: (1) Resource (Network & Service), (2) Service (Network & Application), (3) Network (Virtual, Physical & Logical) and (4) Business Requirements.

The **Orchestration** function co-ordinates and mediates between multiple types of network services and functions such as mobility, security and QoS. Intelligent components are *orchestrated* according to the current context (resource or service), changes in high level objectives (user needs and business goals), and environmental conditions [10]. Orchestration is dependent on the relationships between the concepts

discussed previously including: (1)Management & Context – A change in context will cause the orchestration function to analyse management tasks – their dependencies and ordering - in order to reconfigure the self-* components; (2) Service & Resource – changes in either entity may require re-configuration or re-organisation of that entity and/or the other entity.

4 Defining and using the AUTOI Information Model

We take the current DEN-ng information model as the basis for the information model. The problem domain only requires a subset of DEN-ng thus only particulars associated with the domains service, resource, management and context will be retained. This subset is then extended with concepts that are specific to the virtualisation requirements. These extensions will be submitted to the ACF for future standardisation.

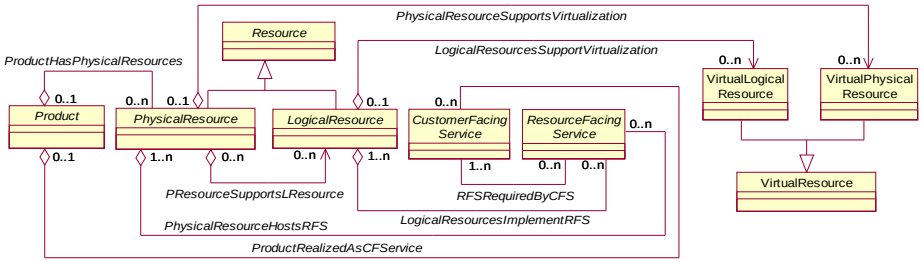

Fig. 2. Product-Service-Resource and Virtual Resource Relationships

Fig 2 illustrates an example of one subset of the early model. It demonstrates the representation of the mapping of the business goals towards resource allocation. This is achieved through the linkage of product (*the product procured by the customer)* to service (*customer facing* to *resource facing)* onto resource (virtual, logical and physical). The product-service-resource relationships come directly from DEN-ng, while the new concepts of *VirtualResource* and its relevant relationships have been added. The information model will be used primarily as a source of concepts for a set of DSLs [11]. A DSL is an abstraction mechanism which handles the complexity in a given domain by providing a customised programming language that represents concepts and rules specific to that application domain enabling developers to work directly with domain concepts. The AUTOI common language will be used to generate 3 domain-specific DSLs - service, resource and management.

5 Summary and Future Work

An information model that will support the self-management of a service-oriented virtual resource overlay is under creation in AUTOI. A subset of the DEN-ng

information model is used as the basis for representing business goals, services, logical and physical resources, policy management and context awareness. DEN-ng is being extended, to create the AUTOI information model, to include appropriate resource and service virtualisation concepts, along with management models to orchestrate the virtualisation process. The resulting model and associated ontologies will be used to generate DSLs in the areas of service, resource and management. Future work in the AUTOI project will include the validation of the generated DSLs (and thus the extensions to the information model) against defined scenarios in the areas of seamless mobility management and service assurance.

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