An Architecture for Network Operations and Management Based on State and Services

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Abstract. This paper describes an architecture for network management that bridges the domains of operations support systems (OSS) and network monitoring systems (NMS) by means of information grid concepts and web services practices. Central to this architecture are the expanded definition and use of system state and the expanded reliance on semantic reasoning. The recent availability of open and collaborative tools will accelerate the development of the system described herein, known as State-Based Network Management.

1 Introduction

In an era of convergence and an environment of competition, the need for efficient network operations has never been greater. Web services, open systems, and semantic reasoning can help fill the gap between expectations and current capabilities. The ultimate expectation is for a provider or enterprise customer to allocate and reallocate resources as a function of dynamic requirements, mobility, and availability of network elements.

2 Architecture Overview

The notion of state in networking has been seen as overly simplistic and an impediment to scalability. For the purpose of network operations and management, this research proposes a distributed architecture, with agents at local nodes such as enterprise customer endpoints and provider edges maintaining their own local state instances. This research posits a more inclusive notion of network state based upon:

- The set of application requirements by endpoint, aggregated for QoS
- The set of all network elements in provider(s) inventory and available.
- The set of all provisioned resources (cross-reference of previous two items)
- The set of templates for configuring monitoring of all classes of

The architecture proposed by this research introduces a centralized state engine whose objective is to exactly fulfill the current set of telecommunications requirements by acquiring provider resources and monitoring them. This can be considered a *bridge* function between the two domains of network management: operations and business support systems (OSS/BSS) and network monitoring systems (NMS).

The notion of an information grid implies meshed interconnection and infers interoperability among collaborative systems based upon the following [1]:

- Insightful messaging between nodes
- Local state maintained within each node
- Local resources, functionality, and self-awareness
- Ability to coordinate passage of transit traffic

The syntax and semantics of inter-node communication are arguably the biggest challenges in development of an information grid in any domain. The key enabler for this project is a service-oriented architecture and a semantic web created for the telecommunications management domain, which implies common metadata and a common ontology accepted by participants [2].

Whereas in the current telecommunications paradigm, information is pulled into the network manager for action, this research embraces "smart push" between the NMS and the state engine. One motivation for this is the mitigation of the problem of massive (and duplicated) data sent to managers. The formal model for this "smart push" implementation is called Valued Information at the Right Time (VIRT) [3].

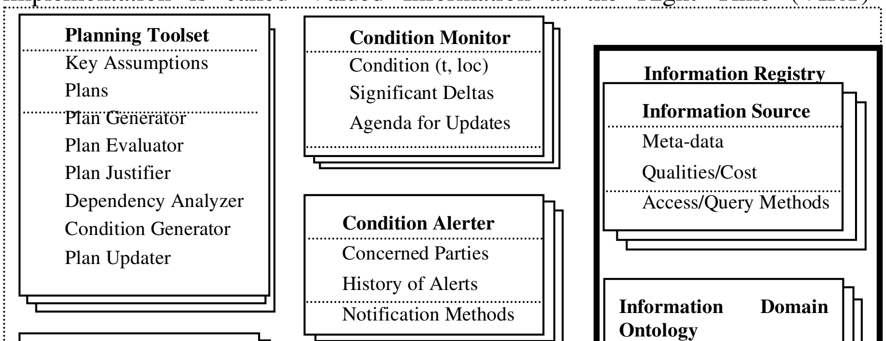

Fig. 1. Graphical representation of VIRT. The initial use case for VIRT was delivery of aviation weather enroute, hence the special and temporal reference.

The VIRT process can be viewed as always alert and able to execute a procedure when a state-changing event is detected. The basis for logical reasoning within VIRT is both the current plan and the justification for selection of that plan with respect to assumptions. Within VIRT, a set of semantic relationships rules would be developed that concern the stability of the assumptions and the dependency of the plan upon them.

The drawing below represents the information flows between components within the architecture proposed by our research. Nodes will be discussed below, and information flows are labeled by their protocol (e.g., XML or SQL).

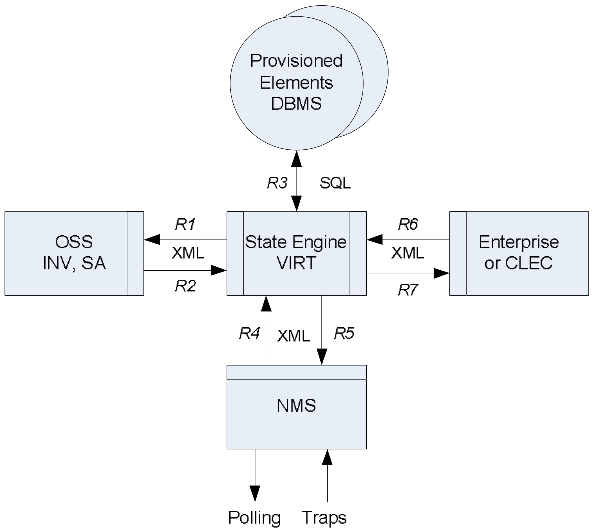

Fig. 2. Graphical representation of State-Based Network Management

In Figure 2,

- The central engine maintains state as defined previously and executes VIRT.
- The right box is an agent for the customer, knowing information about users, applications, and locations, and able to aggregate them.
- The upper database node is local to the central engine.
- The left is the collective OSS/BSS capability of one or more providers. The bottom node is an NMS for monitoring and event correlation

3 Evaluation of Concurrent Initiatives

This section introduces concurrent efforts whose work products are relevant to SBNM and are listed below. Note the presence of open source activities, which serve to accelerate development and increase collaboration.

- The OpenOSS Initiative comes from the Telemanagement Forum's reference architecture for Next Generation Operations Support Systems (NGOSS). Its prototype incorporated fault management (FM) and trouble ticketing (TT) functions using a service-oriented architecture [5], using commercial off-the-shelf (COTS) and open source software packages including OpenNMS [6].

- The OSS Through Java Initiative (OSS/J) is a consortium of OSS vendors implementing the Telemanagement Forum's Next Generation OSS architecture [7], which has defined interfaces using WSDL and an XML schema.
- OpenNMS functions include service polling, data collection, and event management; elements are defined in XML Acquires 200,000 datapoints from 20,000 elements in five minutes, limited by SQL record posting[9]. Over 5000 loads of latest build.
- The KING Next Generation Network Architecture uses centralized intelligence to provide adaptive, automatic, and autonomic network resource allocation by means of admission controls and policy-based routing [10].

4 Conclusions

This paper has contributed to the understanding of many concurrent initiatives that seek to improve network management. Most importantly, this paper has offered both an expanded set of requirements – application specific, QoS-aware, on-demand – and an architecture to fulfill them. SBNM serves to bridge the OSS and NMS domains by means of a common ontology and service oriented interfaces using XML.

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