A CIM (Common Information Model) based Management Model for Clouds

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***Abstract*— The recently emerged Cloud Computing paradigm poses new management challenges because of its complex, heterogeneous infrastructure. A cloud contains infrastructure (Servers, Storage, Networks), applications (web apps, database, backup etc.) from various vendors. Generally, different vendor products are managed (discovery, provisioning, monitoring etc.) by their own proprietary management software. Today, in clouds there is no standard way to manage infrastructure and applications using a single management framework. This will cause cloud management a complex task and creates interoperability issues. The Cloud infrastructure cannot be easily replaced due to dependency on the management software. In this paper we will present various independent CIM (Common Information Model) based Management models available as today, their applicability to cloud infrastructure, advantages etc.**

***Index Terms*—CIM (Common Information Model), DMTF (Distributed Management Task Force), Event, Indication, Association, Provider, Object Manager, Object Broker.**

I. INTRODUCTION

A cloud contains various hardware and software infrastructure like Servers, Storage, Networking and applications. The infrastructure could be from different vendors. Generally, each vendor provides his own management applications to manage the infrastructure. It is a fact that there is no single management solution that can manage such complex heterogeneous cloud infrastructure.

This paper aims at presenting the open standards (XML, HTTP/HTTPS) based CIM management framework for clouds by putting together various available CIM standards, finding gaps and proposing new enhancements to the framework.

II. PRIOR SOLUTIONS

Vendors develop proprietary management solutions for managing infrastructure. It is very difficult to replace one vendor's infrastructure with others because, the customer will also require to buy the management applications from the new infrastructure vendors. This will lead to a myriad of management applications creating challenges due to software upgrades, maintenance etc. This will throw further challenges to Cloud Orchestration flows as they have to be integrated with all the proprietary vendor software for management, provisioning and reporting related tasks. Each release of the software may cause changes to Cloud Orchestration Flows which will incur huge maintenance costs.

III. CIM BASED MANAGEMENT MODEL FOR CLOUDS

The Common Information Model (CIM) is conceptual information model for describing computing and business entities in internet, enterprise and service provider environments. It provides a consistent definition and structure of data, using object oriented principles. The CIM includes expressions for common elements that must be clearly presented to management applications like object classes, properties, methods and associations to name a few. CIM uses a set of terminology specific to the model and the principles of object oriented programming. The standard language used to define elements of CIM is Managed Object Format (MOF). Basically, CIM allows multiple parties to exchange management information about these managed elements. However, this falls short in expressing that CIM not only represents these managed elements and the management information, but also provides means to actively control and manage these elements. By using a common model of information, management software can be written once and work with many implementations of the common model without complex and costly conversion operations or loss of information.

Using CIM, we can model each and every entity (logical/physical) as a CIM Object. For example, we can model entire Data Center as CIM Objects. The data center can have multiple Hypervisors, Network Switches, Storage FC Fabrics and applications. Each Hypervisor can be associated to Data Center using a CIM entity called Association. Also, from Hypervisor to VMs, there can be parent-child relationships. Also, each Hypervisor may get storage form SAN Storage Arrays. All these relationships can be easily modeled using CIM.

A. Central CIMOM for Clouds

The central concept of CIM is an entity called CIM Object Manager (CIMOM) or CIM Broker. A central CIMOM can host the entire object model and relationships for a Cloud. It

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will discover the Cloud infrastructure entities using open standards based communication mechanisms (XML, HTTP/HTTPS) and store them in its Object Repository. Infrastructure vendors needs to agree upon the common CIM model for various types of infrastructure entities and support them. Based on the commonly agreed model, they develop CIM Providers for their infrastructure. The providers are software entities that run inside the CIM Object Manager and instrument the infrastructure using standard/proprietary means. There can be various CIMOMs at various layers in the overall Cloud Management. The vendor CIM Object Manager can be different from the central Cloud CIMOM, but not necessarily. Generally, the vendors CIMOMs can be embedded inside the device or can be a proxy based. The central CIMOM for cloud can aggregate information from CIMOMs from various vendors.

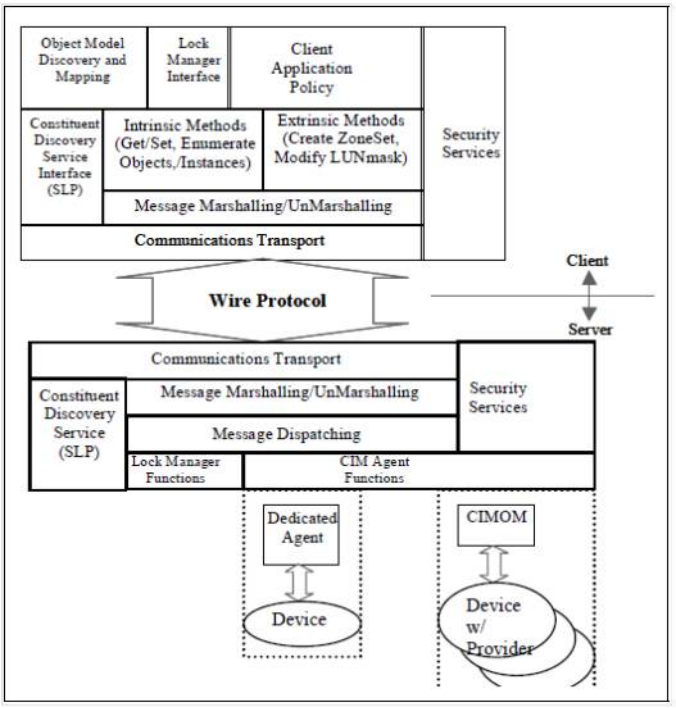

Fig. 1. Operational Model for CIM [2]

B. CIM Management Application for Clouds

The Cloud Management Application can talk to central CIM Object Manager using standard HTTP/HTTPs and XML based protocol. The Central CIMOM can gather the data from Vendor CIMOMs periodically and store it in the database. Upon receipt of a management requests from the management application, the Central CIMOM will either respond from its internal DB or contact a vendor CIMOM, if required. In turn, the vendor CIMOM providers will talk to the their infrastructure using the proprietary interfaces.

C. Provisioning requests

CIM Model provides methods called Extrinsic Methods for instrumenting various infrastructure elements. The so called extrinsic methods will be invoked on the CIM Objects representing actual devices.

D. Event Monitoring

CIM provides monitoring mechanisms using a method called CIM Indications (Fig. 3). Any events that occur in any cloud infrastructure can be modeled as CIM Events. The management application can subscribe to those events and take appropriate action or report to customers. For example, the central CIMOM can fire an event when an SLA for a customer is about to expire. The Management application will process and forward those messages to the Customer. Monitoring of infrastructure using CIM is more flexible. The Management Application can monitor the discovered entities and detect any changes that happen by subscribing to CIM Indications.

The CIM_Indication contain the state of changed object as an embedded object. The management application can process the object and can discover all the other objects that are affected.

For example, an indication can be defined on an hypervisor if the available storage level for a SAN LUN is reached below a threshold value. Such events can be monitored by CIM Object Manager and raise an event to the Management Application. The indication can contain the data about the affected entities like hypervisor, LUN Details. Based on the event received, the administrator can assign additional storage to the Hypervisor. CIM Provides an object based management schema using while different entities in clouds can be associated using CIM Associations. Management applications only need to know CIM Schema for the cloud. They can simply discover all the elements (applications, infrastructure etc.) using the standard schema. Any, management application can discover a cloud using the CIM Schema.

Communication between the central Cloud CIMOM and vendor based Object Managers is required to associate various events that happen in the Cloud.

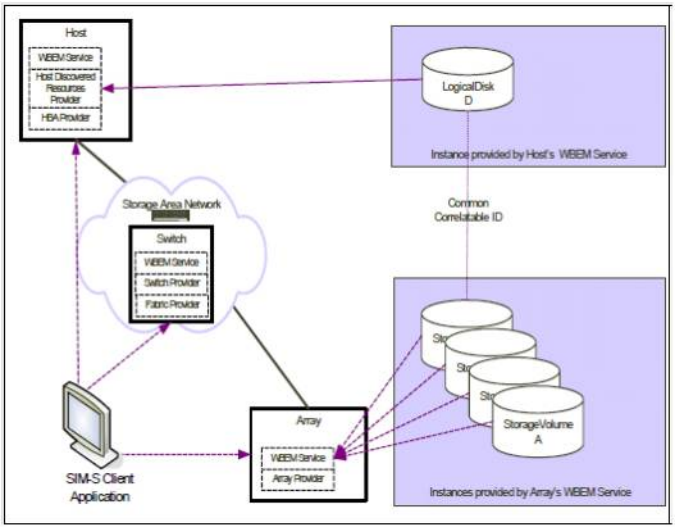

Fig. 2. Object Model/Server Relationship [2]

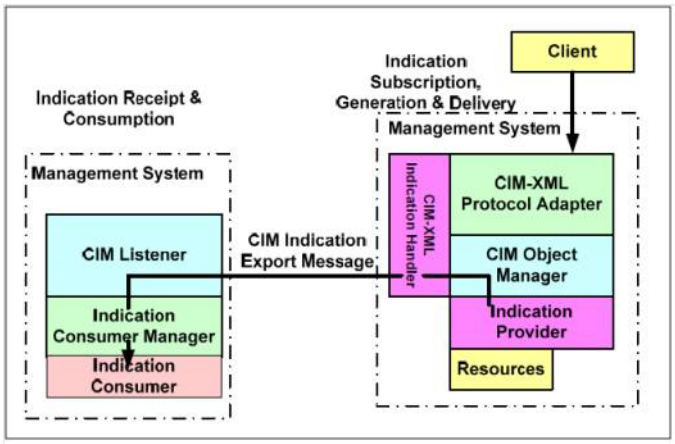

Fig. 3. Fault indication mechanism in CIM [5]

IV. Overview of existing CIM Management Models and Gaps

A cloud contains heterogeneous infrastructure and applications from different vendors. To manage such complex infrastructure of cloud there needs to be a standards based management framework available. CIM is a potential management model for modeling the complex cloud infrastructure. To achieve this, the management models to be supported by CIM are for:

- Servers/Hypervisors
- Storage Area Networks
- Networking Infrastructure
- Applications

A. Servers/Hypervisors Management

The recently emerged Cloud Computing paradigm leverages virtualization technology and provides the ability to provision resources on-demand on the pay-as-you-go basis. The new approach of Server Virtualization has added system management complexity and hence IT cost. The Distributed Management Task Force, Inc. (DMTF), the industry organization leading the development, adoption and promotion of interoperable management standards and initiatives, developed a new standard for managing virtualized environments[3]. With this new standard, DMTF reduces the complexity and cost. Also, because DMTF builds on standards already in place for server hardware, the method for managing virtual machines is complementary. This lowers the IT learning curve, and also lowers complexity for vendors implementing this support in their management solutions. The standard recognizes supported virtualization management capabilities, including the ability to:

- Discover inventory virtual computer systems
- Manage lifecycle of virtual computer systems
- Create/Modify/Delete virtual resources
- Monitor virtual systems for health and performance

DMTF's Systems Management Architecture for Server Hardware (SMASH) standard [4] is a suite of specifications that deliver architectural semantics, industry standard protocols and profiles to unify the management of the data center. The SMASH Server Management (SM) Command Line Protocol (CLP) specification enables simple and intuitive management of heterogeneous servers in the data center. The standard provides server management independent of machine state, operating system state, server system topology or access method, facilitating local and remote management of server hardware. The System Management Forum, part of DMTF's Interoperability Committee, will ensure that consumers of SMASH-based server management standards - both end users and the ISV community - receive interoperable management technology for multi-vendor server systems.

B. Virtualization Management (VMAN)

DMTF's Virtualization Management (VMAN) standard [7] includes a set of specifications that address the management lifecycle of a virtual environment. VMAN's Open Virtualization Format (OVF) specification provides a standard format for packaging and describing virtual machines and applications for deployment across heterogeneous virtualization platforms, while VMAN's profiles standardize many aspects of the operational management of a heterogeneous virtualized environment.

C. Storage Management

SNIA has already came up with a model to manage SANs (Storage Area Networks) with a specification called SMI-S [2]. SMI-S defines CIM Management Models for various SAN infrastructure entities like:

- Disk Arrays
- Switches
- Fabrics
- Tape Libraries
- HBA Management
- Multipath Management
- Volume Management
- Storage Virtualization

D. SNIA's Cloud Data Management Interface

The Cloud Data Management Interface defines the functional interface that applications will use to create, retrieve, update and delete data elements from the Cloud. As part of this interface the client will be able to discover the capabilities of the cloud storage offering and use this interface to manage containers and the data that is placed in them. In addition, metadata can be set on containers and their contained data elements through this interface.

This interface is also used by administrative and management applications to manage containers, accounts, security access and monitoring/billing information, even for storage that is accessible by other protocols. The capabilities of the underlying storage and data services are exposed so that clients can understand the offering.

E. Networking Infrastructure Management

SNMP is the defacto standard for network management instrumentation. It is defined by the IETF and millions of devices have used it for many years. The idea behind defining a CIM based management model for Network infrastructure is not to replace SNMP, but, defining a mapping between SNMP Objects and operations and CIM Objects and operations respectively [5].

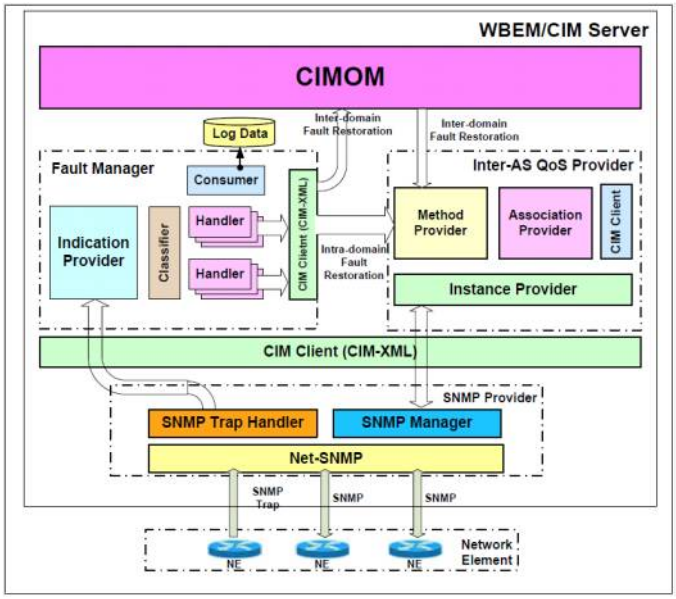

Fig. 4. Functional architecture of WBEM-based distributed fault management [5].

SNMP provider, which includes SNMP trap handler to receive SNMP traps from SNMP agent supported network devices, and then sends that trap to fault manager. According to the event type it invokes the appropriate method provider, which includes fault restoration and fault correction functions. When there is any link/node/path failure, SNMP trap handler receives the trap from the network device. Using CIM-XML, it relays the trap to the Fault manager module, which in turn identifies trap, classifies the failure and generates the corresponding indication instance. Indication provider in the fault manager checks the content and creates necessary indication instance. Once the corresponding indication instance is created, it is subjected to process by the filters. The filters are classifying the faults, i.e. acting as a classifier. Based on the scope of the faults (fault classification and fault notification), the faults will be delivered to the corresponding handlers. Once fault is received by the CIM Server from remote fault manager, appropriate fault restoration method is invoked.

F. Application Management

Application management requires CIM Objects (CIM Properties, CIM Classes, CIM Associations) for configuration and management of applications [6]. While there are already some small-scale examples in the literature of device configuration management using CIM, there has not been any real software example yet.

This area requires some work towards standardizing the CIM Models for various applications like web servers, database servers.

G. DMTF's new initiatives for IaaS Management

The Open Cloud Standards Incubator part of DMTF working on the management aspects of IaaS. The main focus of the Incubator is management aspects of Infrastructure as a Service (IaaS), with some common characteristics that might be applicable to other service stacks like the PaaS. IaaS is the capability provided to the consumer to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly limited control of select networking components (for example, host firewalls). (Source: NIST) [9]

V. ADVANTAGES

Provides a single unified management model for Clouds
It is a vendor independent management model based on open standards. This does not need any new investments as this model will be developed on open standards (XML, HTTP/HTTPS)

Provides interoperability with any vendor
Provides a better interoperability between different vendor products. The Cloud Service Provider can buy any CIM Compliant Infrastructure and manage.

Provides simplified and Robust Orchestrated flows
For any infrastructure provisioning requests, the Orchestrated flows won't change for infrastructure from different vendors. A single flow can create a VM and assign storage to it with any kind of infrastructure.

Simplified Event reporting
Using the supported CIM Indications, the management application can subscribe to various events from the infrastructure.

Extendable Management Model
Vendors can extend the CIM model and can implement additional capabilities/features.

VI. CONCLUSION

CIM is a open standards based management standard. This paper has presented the existing CIM standards for managing various Cloud infrastructure entities and potential gaps. A few of the gaps identified are:

- Defining and standardizing management model for applications.
- Defining and standardizing management model for network infrastructure. As SNMP became a defacto standard for Network Management, a mapping need to be defined between SNMP and CIM models.

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