Analysis of Telecommunication Management Technologies

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ABSTRACT

The phenomenal success of IT and Telecommunication would not have been possible without any effective management framework. The management technologies have also been maturing with evolution of IT & Telecom. In this paper, we trace out some important traditional and current telecommunications management technologies in terms of their strengths and limitations. We analyze them in order to draw lessons and guidelines for emerging research in this field.

KEYWORDS

Network Management Technologies, Distributed Object Technologies, Web based Technologies, Autonomic services and network management vision.

1. INTRODUCTION

Telecommunication management is a fundamental factor in successfully operating networks and services. It provides various functions such as operation & maintenance (O&M), administration, performance, provisioning, accounting and security. Without it, neither a user can enjoy the benefits of any services nor can the business keep running smoothly.

Traditionally the management frameworks were designed keeping in view the demands of specific technology or network. These traditional schemes such as SNMP (Simple Management Network Protocol) and TMN (Telecommunication Management Network) were more technology specific, network centric, centralized and/or weakly distributed management schemes. In section 2 and Section 3 of this paper, SNMP and TMN are analyzed and their strengths' and limitations' are highlighted. In section 4, we study and analyze the enabling technologies such as distributed object technologies like CORBA, DCOM, JAVA/RMI and web based technologies such as Web Based Enterprise Management (WBEM).

The emergence of next generation networks & services has ushered in a new era of technological advancement. At this time, the focus is to have some technology-independent, network-agnostic and completely autonomic management framework for networks and its related services. In the section 5, autonomic vision for network and service management is presented, which focuses on the vision of autonomic management and collaborative domains or technologies needed to achieve the self governing, autonomic management paradigm. In section 6, the challenges and issues related to autonomic paradigm are highlighted and in section 7, we conclude our analysis of Telecommunication Management paradigms.

This paper is literature review of various popular telecommunication management schemes by understanding their fundamentals and pointing out their limitations in order to understand how future of network and service management is evolving. This study is a panorama of the past, present and the future of service and network management.

2. SNMP FRAMEWORK

Internet, the network of networks, has changed the landscape of almost every sphere of society, from technology to life style, from business to politics, it's every where but given all these advantages, it has also resulted in more complex and more heterogeneous network. Simple Network Management Protocol (SNMP) is popular management scheme to manage Internet, It was proposed by IETF in late eighties. It was widely accepted in industry due to its simpler design, and architecture.

2.1. SNMP Architecture

SNMP architecture is based on Manager-agent paradigm and it includes five basic components, manager, agent, managed device, management information and network management protocol**.** The manager is the brain of network management and it administrates and conducts Operations and Management tasks (O&M) for the managed devices. Agent is software that resides in managed devices and it facilitates the communication and management tasks between manager and managed devices. Managed device is network element that gathers information and makes it available to manager using SNMP agent. Routers, access servers, switches, hubs and printers etc can be termed as managed devices.

Every network consists of several resources and in order to manage these resources, we first need to identify and represent them. In SNMP, these resources are represented as managed objects by using the mechanism defined in the Structure of Management Information (SMI). The virtual collection of all such managed objects is called Management Information Base (MIB). Managed object normally contains three attributes, Object Identifier (OID), Type & syntax and Encoding [1].Object identifiers (OIDs) are used to identify managed objects where all managed objects are organized in tree structure. The upper level OIDs in tree represent different standard organizations, while Vendors define private branches including managed objects for their own products. SNMP is application layer protocol which is used to access managed objects. This management scheme is named after this protocol.

There are three versions of SNMP. The first version was termed as SNMPv1, its implementation is simple and contains small set of operational commands, and has poor security procedures. To resolve SNMPv1 loop holes, SNMPv2 was proposed that includes more operational commands, defines more SMI data types and attempts to provide better security procedures but unfortunately it could not completely resolve the security concerns and it was also not backward compatible. The latest and more advanced SNMP version is SNMPv3 which provides enhanced security, access control, remote configuration of SNMP parameters and it is also backward compatible with previous versions.

2.2. SNMP Limitations

Networks are expanding fast, more agents need to be added, the amount of data has increased multifold resulting in complex heterogeneous network, in such scenarios simpler SNMP protocol stack with fewer operational commands is inadequate and could not provide scalability [21] SNMP is based on connectionless protocol UDP which makes it unreliable because one is never sure whether operations Set, Get or even Trap issued are received or not, Moreover there is no means to be assured whether commands issued has worked as per requirement. Managed objects defined in SNMP are based on variable oriented and don't have inherited properties [2].SNMP wastes Bandwidth with unnecessary information carried out in each message like SNMP version, multiple lengths and data descriptors etc [39]. Business requirements and policies dictate the network is one of important demand of industry while SNMP doesn't provide any liaison between business requirements and technology, i.e., with changing business needs, SNMP framework can't reconfigure managed elements automatically.

3. Telecommunication Network Management (TMN)

Telecommunication networks have been growing with exponential pace, each new day brings with it a new innovation in technologies & services that put more demands for appropriate handling of such a large amount of information. TMN frame work was relied by many operators and service providers to fulfil their needs for efficient network operation. It is defined in the M.3000, M.3010 and other related documents by ITU-T [3]. ITU-T selected OSI Management standards for TMN framework. TMN frame work presents overall telecommunication network management frame work by introducing several management architectures at different levels of abstraction and these are presented below.

3.1. Functional Architecture

It defines different functionalities required to manage network entities. Network management performs various functions which are further decomposed into different logical functional blocks such as OSF (Operation Systems function) that is concerned with manager specific functions, MF (Mediation Function) enables mediation between various blocks, NEF (Network Element function) are functions related to network elements, QAF (Q Adapter function) enables communication between TMN based entities and non TMN based Entities, WSF (Work station function) enables humans to monitor and configure network[40], DCF (Data communication function) is responsible for internetworking between lower three layers. These all conceptual functionalities are essence of TMN frame work and provide overall building blocks over which telecom network management stands. Interaction between these logical functional blocks are termed as "Reference points" and various "reference points" are defined in TMN such as q, x, f, g, m etc [40].

3.2. Physical Architecture

Physical architecture of TMN frame work realizes functional architecture, here concepts gets actual shape. In Physical architecture, functional blocks are called as physical components or building blocks and reference points of Functional architecture are realized as interfaces. TMN's Physical Architecture defines the following building blocks; Network Element (NE),Mediation Device (MD),Q Adaptor (QA),Operations System (OS),Work Station (WS),Data Communication Network (DCN).These building blocks generally have one-to-on mapping with Functional blocks but it is also possible that each building block may contain one or more functional blocks.

3.3. Logical Layer Architecture

Different functionalities were divided into functional blocks as discussed in functional architecture, while Logical Layer Architecture (LLC) further extends this concept of abstraction for example Information managed by any functional block OSF etc can further be separated into various levels of abstractions [4]. Unlike SNMP Frame work, which traditionally focuses only upon network and element level, TMN provides service and business layers as well.

Business Management Layer is responsible for over all management, setting goals, conducting business level agreements and carrying out high level planning. Service Management Layer deals with various functions such as QoS management, fault management, accounting, customer coordination, service ordering etc. Network Management Layer is responsible for various functions such as over all network view, fault detection, optimizing network performance, coordinate all network activities and support the demands of service management layer etc**.** The important functions of Element Management layer include vendor specific management, Log records, mediation, updating firmware and fault detection etc. Network Element layer works as interface between proprietary information and the TMN infrastructure**.**

3.4. TMN Information Architecture

TMN Information architecture is based on X.700 OSI Management recommendations [5] .These recommendations includes object oriented approach, agent-model paradigm and OSI's common Management information protocol (CMIP).Unlike SNMP,TMN is based on rich protocol set CMIP/CMISE. Common Management Information Service Element (CMISE) provides access to

managed information in managed objects and it uses CMIP to send and receive requests and notifications between manager and agent**.** GDMO (Guide line for definition of Managed objects) is template language used to define managed objects in TMN, while ASN.1 is used for defining syntax rules and encoding attributes within system. The OSI Directory Service is used to store information about the TMN resources. Unlike SNMP, CMIP supports both connection oriented (UDP) and connectionless protocols (TCP). TMN has conceptual separation between networks that's to manage and network that is used carrying management tasks, while in SNMP, there is no such separation [40].

3.4 TMN Limitations.

Today's Industry demands are for low cost, off the shelf tools while Programmer of TMN's OSI Management Frame work is faced with expensive tools and complex APIs. TMN is based on object oriented approach but it again lacks from object location transparency because manager requires knowing complete detail of agent [2]. Its protocol stack is comprehensive but it brings more complexity that's why it's also considered as quite heavy weight protocol stack. TMN agents are also dumb and have no intelligence to handle on their own important management decisions. The comparison of TMN and SNMP is presented below in table 1.

Table 1. Comparison between SNMP and TMN

Areas	SNMP	TMN
Reliability	SNMP is based on connection less UDP and can't guarantee the delivery of messages.	TMN supports both TCP and UDP, thus message delivery is guaranteed.
Management View	SNMP traditionally focuses on network and element only	TMN provides better conceptual frame work called logical layer that provides Enterprise and service view of Network,
Programming approach	SNMP is based on variable oriented approach.	TMN is based on object oriented paradigm
Network management	In SNMP, there is no separation between network that's to manage and network that is used carrying management tasks,	TMN has conceptual separation between network that's to manage and network that is used carrying management tasks,
Complexity	SNMP has simple design and architecture.	TMN framework is comprehensive but complex. Data Modelling and abstracting are very complex.
Cost	SNMP is cost effective and open in standards.	TMN is more costly than SNMP due its complex architecture.
Protocol stack	SNMP is light weight protocol with fewer operational commands and it is inadequate and	TMN is based on heavy weight CMIP protocol stack. It provides

	doesn't provide scalability	comprehensive set of operational commands.

4. ENABLING TECHNOLOGIES

Traditional Management schemes which are based on centralized or weakly distributed paradigms [6] are not capable to fulfil the growing demand of next generation network and services. To address these burgeoning demands for effective management of next generation data and telecom networks and services, various players pushed for new management technologies. Some of important enabling technologies such as Distributed Object Technology (DOT), and Web based Technologies may resolve limitations of traditional network management schemes as presented below.

4.1 Distributed Object Technologies (DOT)

In traditional management schemes, whole management operation cycle can halt in case of failure of management station or malicious denial of service attack [7].Moreover, they are not robust schemes, in case of any link failure between manager and agent, the agent turns dumb and could not carry corrective procedures. Additionally they suffer from numerous problems such as low scalability, object location dependence, heavy bandwidth usage and over load of management station.

Distributed Object Technologies (DOT) may be employed to over come these issues related to traditional management frameworks, distributed object technologies (DOT) may be employed. Let us first discuss what really is this DOT all about? It is actually merger of object technology and Distributed System Technology. *DOT= Object Oriented Technology (OOT) + Distributed System Technology (DST)*. Object technology or object oriented Technology (OOT) is general term for object-oriented programming, object-oriented databases and object-oriented design methodologies. OOT reduce development time, increases quality, and has modular architecture [11] moreover it is cost efficient and reuses software and designs [8]. The basic concept of Distributed System Technology (DST) is based on idea that autonomous computers [8] are not only networked but can distribute workload across the each computer. In other words, we can say, all components should coordinate together in heterogeneous network environment in order to carry out small unit of related task. The combination of OOT and DST results in Distributed Object Technology that brings many advantages such as modularity, abstraction, software reusability, resource naming and location [2] etc.

There are three most acknowledged DOT paradigms, OMG's Common Object Request Broker (CORBA), Microsoft's Distributed computing Object Model (DCOM) and Java Soft's Java/Remote Method Invocation (Java/RMI).

4.1.1 CORBA

The Object Management Group (OMG) is international, non profit computer industry consortium, founded in 1989. Common Object Request Broker (CORBA) is OMG's vendor-neutral, open standard for distributed object technology and its first version was presented in October 1991, since then it has gone through various improvement and enhancements and current version is CORBA 3.0.2 presented in Dec 2002 [9].The heart of CORBA is object Request broker (ORB) and its main function includes, locating objects, marshalling/demarshalling, communication between servers and clients. Communication between clients and servers are not direct, it is always carried out through ORB moreover ORB objects are accessed through the use of interfaces, defined using Interface Definition language (IDL).Object adopters are used for activation. CORBA uses protocol IIOP (Internet-Inter ORB Protocol) for interoperability in distributed heterogeneous environment. CORBA has many advantages such as it is neither language nor operating system dependent paradigm, CORBA client and server can be written in any language and can be have different OS platforms. This provides extensibility to support any future language paradigm and OS. Moreover CORBA Server and clients are transparent to implementation and underlying architecture**,** thus system details are hidden from

developer and there is no need for server and clients to know underlying architecture. CORBA also provides location transparency and supports both synchronous and asynchronous communication [10].CORBA has also been adopted as standard by ITU-T to resolve interoperability issues in heterogeneous network environment [41]. The use of CORBA in TMN environment is studied in various papers [2,12,..] and The edge of CORBA over traditional TMN (OSI-SM) architecture is due to its DOT paradigm, light weight protocol stack, support for multiple language mappings, object location transparency, moreover CORBA is also easy to learn and less expensive than TMN framework. But there are some disadvantages of CORBA as well; it is less expressive object model than TMN OSI-SM, weaker access aspects and unsuitable architecture for Telecommunication Management [12].

4.1.2 DCOM

Microsoft COM technology enables communication between reusable software components**,** Its improved version was named as Distributed Component Object by Microsoft® [13] which extends advantages of COM to a networked environment. Due to COM binary specifications, DCOM components can be written in various programmable languages**.** DCOM uses application level protocol ORPC (Object oriented remote procedure call) to support remote objects. Microsoft Interface Definition Language (MIDL) is used for defining interfaces and Service Control Manager (SCM) is used to locate and activate an object in DCOM**.** Like CORBA, DCOM is also Language independent, available on other platforms but mainly linked to Windows OS platform. Though its workability has been extended to other operating systems to some extent yet it still lacks some key functions [14].For any organization that utilizes Microsoft based systems, DCOM may be frame work of choice.

4.1.3 JAVA/RMI

It is standard by Java Soft that relies upon Java paradigm only, it means both server and clients must be defined in Java to communicate. Remote Method Invocation (RMI) is built-in ORB of Java; through this remote objects are invoked. It uses protocol JRPM (Java Remote Method Protocol) in order to communicate with remote objects. JAVA/RMI also based upon the concept of Java object serialization that is used to marshal and demarshal objects as streams, while Java Virtual Machine (JVM) enables the object location and activation in this paradigm. Moreover, with JVM implementations, JAVA/RMI can support diverse platforms and operating systems. Java/RMI applications can interoperate with CORBA application by using RMI over IIOP protocol. The advantages of JAVA RMI includes its simplest and fastest way in developing distributed applications but due to its sole dependence over JAVA paradigm, it may not be suitable to use in heterogeneous environment. In addition RMI does not provide any specific session management support [7]. The summary of distributed object technologies [8, 14...] is presented in table 2.

Table 2. Comparison Table for DOT Technologies

Areas	**COBRA**	**DCOM**	**JAVA/RMI**
Parent Organization	OMG	Microsoft	Java Soft
Programming Language	Support Multiple languages	Support Multiple languages	Support Java
Protocol	Internet Inter ORB Protocol	Java Remote method Protocol	Object Remote Procedure Call
Interface Definition	Interface Definition Language (IDL)	Microsoft Interface Definition Language (MIDL)	No separate Language for Interface description, but it has Interface

			declaration concept available in the language.
Object Location And activation	Object Request Broker (ORB) for Location and Object Adapter is used for Activation.	Java Virtual Machine (JVM)	Service Control Manager (SCM)
Hardware Support	Almost all Hardware platforms	Mainly on Windows Platforms and some other platforms like Solaris.	Almost all Hardware platforms
Garbage Collection	No attempt for Garbage collection	Yes	Yes
Autonomous Management	No	No	No
Resolve all problems related to legacy management framework.	No	No	No

4.2 Web Based Technologies

World Wide Web has earned mind boggling success in recent years and it has influenced other technologies as well. Web technology standards and protocols such as XML, HTTP etc are already in use and well-proven and their use in network management has also been gaining significant success. Web based network management technologies are based on open standard, provide interoperable integration across heterogeneous environment[15].The use of XML enables distributed applications to behave as loosely coupled while HTTP(-S) provides not only secure communication but it also enables communication to reach every nook and corner of the network without any restriction from firewalls. We will discuss here one such approach that is DMTF's Web Based Enterprise Management (WBEM).

4.2.1 Web Based Enterprise Management

Both traditional and current distributed technologies face interoperability issues due to different standards and uncommon models. This diversity of models and standards brought more complexity and more rise in costs, which pushed industry players to come up with some unified management standard. In 1996, various organizations such as Microsoft, Intel, Compaq, Cisco systems and other companies put joint effort towards achieving this goal [16]. Later in 1998, this work was advanced under the auspicious of Distributed Management Task force, Inc (DMTF). This initiative was named as Web Based Enterprise Management (WBEM) by DMTF and prime goal of this work was to unify IT & Telecom management standards with common information model .WBEM defines group of technologies and tools such as Common Information Model (CIM), WBEM access scheme, WBEM transport Encoding, CIM Object Manager (CIMOM), and XML APIs.

The Common Information Model (CIM) is based on object oriented representation and its core purpose is to provide a unified model to represent every type of data, platform, application, device, network etc [17]. The concept of schemas is very important aspect of CIM and the schema is defined in DMTF's document [17] as "*A set of data models that describes a set of objects to be managed*." The CIM consists of CIM schema and CIM specifications**;** The CIM schema describes exact modelling while CIM specifications concern with integration details with other management models. The language needed to express CIM schema in textual form is called MOF (Managed Object Format) while modelling language used to visualize CIM schema is UML (Unified Modelling Language) [17]. The WBEM Encoding scheme is denoted as xmlCIM and it uses XML (eXtensible Markup Language) to encode CIM information as per DTD (Document type definition) [30]. WBEM access scheme is based on CIM over HTTP, where HTTP is used for transporting data, while xmlCIM encoding is used for expressing payload. WBEM hosts communicate with each other in an open and standardized manner by exchanging XML documents via HTTP. HTTP protocol scheme is defined by DMTF as communication protocol but there are some other products available which are however based on WBEM, utilize other protocol schemes as well, like Microsoft's WMI uses DCOM as transport protocol within WMI environment [18] while XML-HTTP is used to interact with non WMI elements. Sun WBEM SDK uses RMI as default protocol for communication but it also provides support for XML-HTTP [19].CIM Object Manager (CIMOM) is central entity with CIM repository which is accessed to collect information about managed resources while an XML API is used to access main repository.

For widespread industry implementation of WBEM, open source implementation environment is encouraged. There are some important open source WBEM implementations such as; SNIA Open Source CIMOM (Java), WBEM services (Java), the open group's Pegasus (C++), SBLIM, openWBEM [32]. WBEM brings many advantages for example it is not only solution to persisting interoperability issues, but it also enhances management capabilities by abstraction and decomposition of business process and services. WBEM is also not without any loopholes, since WBEM is based on XML, which lacks from proper representation of relational data base and its description is not machine comprehensible, thus it is unable to provide any Meta data definition about web resources. The access protocol architecture's reliance over HTTP brings some inherent problems such as HTTP has no procedure to provide notification thus XML over HTTP lacks from better bi-directional communication [20].

5. AUTONOMIC MANAGEMENT

The Autonomic Management is not a completely new concept but it is actually result of several year researches around Artificial Intelligence (AI) and its application in management plane. The Autonomic systems promise to provide autonomous, guaranteed and smooth operation of network and services. The Autonomic Management concept aspires to bring human like intelligence to telecommunication management tasks. It is a set of self-X functions such as self-healing, self-diagnosis, self correction, self-configuration, self,-optimization and self governing etc. The capability of Network entities to understand and to react in all types of scenarios is a new vision. This Autonomic vision intends to bring multiple advantages to management plane such as (i) To address problems related to existing network management schemes such as, complexity and simplicity, diversity and ubiquity etc [35] (ii) integrating any new solution with legacy networks and services without any complications. (ii) Bridge the gap between Business and network & enabling business rules to dictate necessary changes in network as per new policies [30] (iv) Limit human intervention to minimum and Use him/her for initiating high level business policies or correct some fatal maintenance issues. (v) Based on future proof, dynamic, flexible and policy driven autonomic solutions. Unlike traditional network management approaches, it will also be a network-agnostic, technology independent and service centric approach. The comparison between traditional management schemes and autonomic management is presented below in table 3.

Table 3. Comparison Table for Traditional Management Vs Autonomic Management

Aspects	Traditional Management Paradigm	Autonomic Management paradigm
Human dependency	More human intervention.	Lesser human intervention.
Intelligence	Most of the Network elements are dumb. They can't carry self-x functions.	Most of the Network elements are intelligent and they can do self-x functions
Time and cost	Takes more time to diagnose, and correct the fault. Requires frequent maintenance.	Takes shortest possible time to correct the fault and it requires lesser maintenance thus it reduces total cost.
Shift of paradigm	Technology specific and network oriented management solutions. In each network, the network management system is provided independently for PSTN,PLMN and WLAN	Technology independent, and network agnostic solutions.
Management functions and implementations.	The management functions and implementations are often isolated and vertically distributed in transport, switching and access networks.	The management functions and implementations are autonomous, well coordinated and self aware.
Business and Network gap.	There is gap between Business and network. The requirements of business can't dictate networks to function as per their policies.	Bridges the gap between Business and network. It enables business rules to dictate necessary changes in network as per new policies

5.1 Related work

IBM's Autonomic Computing was pioneer work towards autonomic management of IT resources which enable self management using a *"monitoring, analysis, planning and execution"* control loop [23]. It provides self CHOP functionalities such as self-Configuration, self-Healing, self-Optimization, and self-Protection in order to bring a autonomous characteristics to IT resources. This conceptual autonomic framework influenced the idea of autonomic networking. Various efforts have been undergoing by industry as well as research organizations to come up with some autonomic management framework for networks and services, for example ANA (Autonomic Network Architecture) project is a joint research project between European and North American universities and research institutes to design and develop novel autonomic architecture [24], ANA has released documentation on Autonomic functional blocks and ANA Prototype Software to demonstrate and validate architectural principles with a real implementation. The CASCADAS (Component-ware for Autonomic Situation-aware Communications, and Dynamically Adaptable Service) project works on framework to enable distributed component-ware framework for autonomic and situation-aware

communication capable of providing dynamically adaptable services [25]. The four key technology enablers in this project work are Situation awareness, Semantic Self-organization, Self-similarity, Autonomic Component-ware. The ACF (Autonomic communication Forum) is another international research group working in this direction to provide some framework for autonomic management [26]. Autonomic Internet (AUTOI) is EU funded project under 7th FWP (Seventh Framework Programme), it is also linked with ACF Objectives and aims to achieve an autonomous framework for future internet.*"* [27]. Haggle is a full Future and Emerging Technologies (FET) Integrated Project funded under the Situated and Autonomic Communication program of the Information Society Technologies priority area of the European Union's Framework Programme 6 (FP6) and "*This projects focus on new autonomic networking architecture designed to enable communication in the presence of intermittent network connectivity, which exploits autonomic opportunistic communication "*[28].EMANICS (European Network of Excellence for the Management of Internet Technologies and Complex Services) is supported by the European Commission Information Society Technologies 6th Framework Program and it focuses on management plane for future internet and it addresses challenges like scalability, automation, security and dynamics. [29]. FOCALE (Foundation, Observation, Comparison, Action and Learning Environment) is proprietary effort to set up autonomic management architecture for orchestrating the behaviour of heterogeneous and distributed computing resources [30]. There are also various other projects going on around the world to realize autonomic management objectives.

5.2 Autonomic Fundamentals

To achieve autonomic vision, it is important to establish some collaboration among different disciplines, which can be utilized to design and implement autonomic systems, such as Policy based management, Semantics and Ontology, Algorithm and Protocol design, etc. hereafter a description of the important disciplines are presented to understand their possible use in realizing autonomic vision.

5.2.1 Policy Based Management (PBM)

Traditional telecommunication management schemes focus on monitoring network status and require more human-machine interaction. While PBM intends to reduce the human-on-the-loop by providing run time reconfiguration and addition of new policies without harming any network operation [38]. The PBM is an active research area to realize autonomic vision. The architecture of PBM consists of Policy Management Tool, Policy Repository, Policy Decision Point (PDP), and Policy Enforcement Point (PEP). Policies are defined through Policy management tools and these predefined policies and guide lines are stored in policy repository, while PDP takes decisions as per those policies, and these policy decisions are distributed to PEP, while PEP functions like an agent in order to enforce those policies.

In order to exchange policy information between PDP and PEP, IETF (Internet Engineering Task Force) defines the COPS (Common Open Policy Service) protocol. COPS is reliable due to its dependence upon TCP protocol and it provides message level security and integration, moreover diverse client specific information is supported without bringing any change in COPS protocol itself. SNMP may be considered to be used but it is not preferred due to its various limitations such as unreliability because of UDP and unavailability of Policy Information Base (PIB).In PBM, policy information is represented through the Policy Core Information Model (PCIM) which is an extension to DMTF's CIM model, and PCIM was produced jointly by DMTF and IETF [31]. An access protocol is required to access Policy Registry and in PBNM, IETF's Light Weight Directory Access Protocol (LDAP) could be used to access policy repository.

5.2.2 Ontology in Autonomics

As we discussed in previous sections, different organizations such as IETF, ITU, DMTF, OMG, and TMF have been using their own vocabulary and specifications for modelling service and network information and data and this is an apparent challenge to integrate data from diverse resources in

distributed, scalable and transparent manner. This heterogeneity can be resolved by using Ontology. Ontology is defined as common vocabulary source that provides shared understanding between concepts and relationship between them [42]. Through the use of ontologies, one can attain semantic integration, sharing and reuse of capabilities and knowledge inference. Ontology is used to capture various kinds of knowledge related to network, business goals, and policies. Not only the new knowledge could be discovered and learned but constraints between knowledge are captured and resolved with the use of logic reasoning techniques [42]. Thus through Ontological modelling and reasoning techniques, telecommunications management can become more autonomous.

Ontologies are to be shared and hence require some compatibility between various sources. OWL (Web Ontology Language) has gained popularity as industry de facto standard for ontology based language. It has been a W3C recommendation since 2004 [43]. OWL is built on top of the Resource Description Framework which is itself built upon the XML syntax. OWL is family of languages that comprises of three languages, OWL Lite, OWL DL, OWL Full. OWL Lite is simpler in terms of expressiveness compared to other family members but it is supposed to be easy for tool builders. OWL DL provides maximum expressiveness with computational guarantees in finite time. OWL Full provides rich expressiveness but without computational guarantees. The use of any particular OWL language depends upon the scope and complexity of the application domain.

5.2.3 Algorithms and Protocols for Autonomics

The design of algorithms and protocols are vital for autonomic vision. .Various efforts are going in this direction to achieve algorithms to suit autonomic vision. One such effort is the use of game theory and economic models which can be effective to enhance existing protocols [35]. Game theory provides us with a set of effective tools to understand interactions [37] and it studies the behaviour of rational agents in competitive and collaborative situations. Autonomic management can benefit from various biological models and algorithms as well. The study of ant colonies, honey bees, flock of birds and human nervous system etc can help to derive new models and algorithms for autonomic vision. The SemAnt algorithm is presented in paper [36]; it takes inspiration from ant colony model and is designed for the task of querying routing in peer to peer networks. BISON was one of European project that focused on developing biological inspired algorithms. They developed number of algorithms for calculating network-wide measures, content search and topology management [34]. Genetic algorithms are also a hot research area that uses the principles of evolution, genetics and natural selection theory in order to optimize business processes and they find their best use in the wake of limited resources. Population Based Incremental Learning (PBIL) algorithm is based on genetic algorithm that is studied for machine learning purposes. Hidden Markov Model, Baum-Welch learning and K-Means learning are also employed for machine learning and all these algorithms and protocols are vital for shaping up the autonomous behaviour.

6. CHALLENGES

Nevertheless autonomic concept is not lesser than any technological breakthrough but it is also surrounded by several challenges before getting completely mature or successfully standardized. One such challenge is from Policy Based Management (PBM) schemes such as, there is no particular policy specification language that is standardized, various organisations have own propriety languages such as IBM's Trust Policy Language (TPL),Imperial college's Ponder Language, Lucent Bell's The Policy Definition Language, which result in severe interoperability issues. The current architecture of PBM is not favourable to those networks which keep on changing their business policies because it favours relatively static policies [33]. Several LDAP implementations lack from simple change notification mechanism, referential integrity and transactional integrity [33].There is no mechanism specified for coordinating between more than one management tools, moreover the policy based management tools are also heavily overloaded .In PBM there is no specific means to avoid and/or resolve any potential policy conflicts. These issues should be addressed properly so that PBM can effectively be utilized to bring automaticity to management paradigms.

Ontology based Modelling and Reasoning techniques seems attractive solution for knowledge representation but again few questions arise which need to be answered. Can all types of knowledge be represented and/or transformed by using ontological modelling? Moreover there are some de facto standardized languages such as OWL but there is need of unified standardized ontology language because in the absence of any standardized language, it will be hard to share and reuse ontologies across different applications within the same domain or across inter-related domains. The family of OWL languages has also some limitations, for example OWL Full is powerful language with rich expressiveness but given this richness, it has poor reasoning support. OWL DL has efficient reasoning support but we loose compatibility with RDF [38].OWL Lite is easier to learn and implement but it doesn't provide good expressive power.

The design of any algorithm or protocol for autonomic management also faces some challenges. During designing algorithm, few things should be kept under consideration. As we know that autonomic communication systems will be based on decentralized paradigm that's why decentralization related issues such as Synchronization and low reliability should be dealt well during algorithm design process [35].In complex environment, genetic algorithms may not provide exact solution but can give best possible solution but it may also give bad solutions if problem is not modelled properly [22].One algorithm design challenge related to changing environment, that's to say how an algorithm should behave in wake of change of environment? Because in changing environment, there may be conflict of interests between User demands, application requirements and network concerns [35].

7. CONCLUSION

This paper presents an understanding of various network and service management frameworks and their likely path towards emerging paradigm of autonomic management paradigm. This review work has also led us to some important guide lines or challenges regarding various management frameworks. It's learnt from their analysis that traditional schemes are no more efficient management schemes due to continuous growth in the complexity on one hand and technological advancements in network & services on other hand, therefore a new set of enabling technologies were required. Various stack holders produced new schemes which were based on distributed paradigms, object orientation and interoperable framework. However those enabling technologies resolve many problems related to traditional management schemes but they were also not free from loop holes, besides they can't fulfil the burgeoning demands of more adaptive and autonomous management plan.

Now hot buzz word is autonomics which envisions a paradigm that is autonomous, service centric, future proof, and technology agnostic. These all promises of autonomic vision could be met as soon as issues related to autonomics could be resolved, making autonomic vision a reality. Our future work will be focused on addressing these challenges related to autonomics.

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