

# DISTRIBUTED NMS FOR AFFORDABLE COMMUNICATIONS

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## ABSTRACT

Distributed network management has been seen as the solution to tackle various problems in emerging networks. It is particularly applicable to networks in developing nations, which are resource constrained both in terms of bandwidth and computing power at management stations. This paper describes generalized multi-tier architecture for distributed management. A special case of this architecture, which is a two-tier NMS, is described in detail. This implementation will be used by n-Logue, a nation wide Indian ISP focussing on rural areas.

## 1. INTRODUCTION

### 1.1. Evolution of Telecom

Developing countries such as India are seeing a rapid evolution of their telecom infrastructure [1]. The Networks are moving from providing only 64Kbps circuit-switched voice to a wide array of services including low-bit rate voice, mobility, VoIP, dial-up and always-on Internet and streaming video. In order to provide these services, the infrastructure consists of diverse technologies such as WLL, FiLL, DSL, IP and others. Efficient, reliable operation of the networks requires management of numerous intelligent devices throughout the network.

At the same time, with deregulation, new operators are entering and wish to rapidly provide service over a wide area. In many areas, their backbone bandwidth may be inadequate, one new operator has in fact leased circuits from the incumbent. To keep costs low, this operator opted to use only intermittent dial-up for NMS, rather than dedicated leased lines to each remote area [2].

### 1.2. n-Logue Communications

n-Logue Communications is an unusual operator in that its focus is on providing affordable voice plus internet access in villages and small towns

throughout India [3]. As such, it has a far-flung network and must keep costs to a minimum. Network management is essential and the bandwidth consumed by management traffic must be kept very low.

### 1.3. The NMS Imperatives

Remote Management is accomplished from a central *Network Management System (NMS)* that communicates with *agents* in each network element. A protocol such as SNMP is used [4].

For the new operators described above, this model has significant disadvantages. First SNMP runs over UDP/IP and requires a permanent network connecting all the network elements to the NMS. It is not suitable for an intermittent dialup network. Second SNMP uses relatively verbose message formats and hence wastes scarce bandwidth [2].

We propose a multi-tier architecture for management of such emerging networks. At the lowest level, we have many inexpensive local management systems. These are loosely coupled to the central NMS at the higher level. The architecture and design are tailored to the peculiar needs of operators in developing countries. This architecture is implemented in the CygNet NMS [5] from NMSWorks.

### 1.4. Overview

In Section 2 we describe the n-Logue network in some detail and briefly survey various approaches to distributed NMS. In Section 3, we present our multi-tier architecture. Details of the design and implementation in the CygNet family [5] are in Section 4. Performance modeling is in Section 5. We close with summary and conclusion in Section 6.

## 2. BACKGROUND

### 2.1. n-Logue Network

n-Logue is an emerging ISP aiming to provide low-cost service in far-flung rural areas. The

topology of the n-Logue network is shown in Figure 1. n-Logue has a number of LSPs (Local Service Partners) distributed all over India.

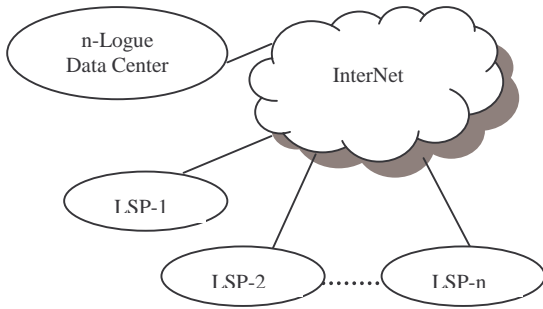


Figure 1. Topology of n-Logue network

The number of LSPs is currently around 25 and this number is soon expected to grow to hundreds. Each LSP in n-Logue has the following elements to provide voice and Internet services; corDECT WiLL system [6], Minnow servers [7], router and a leased line.

Managing all the elements in all of the LSPs with a single central NMS will not be feasible because the bandwidth utilized will be too high. To solve this problem, a multi-tier (distributed) NMS is required.

### 2.2. Distributed Management Approaches

A distributed management application consists of several manager processes (managers) running on different management stations. Each manager performs management functions either by directly interacting with agents or via other lower-level managers. Distributed management can be classified into categories ranging from centralized management at one end of the spectrum, through weakly distributed, strongly distributed to co-operative management at the other end [9].

In the centralized and weakly distributed paradigms, there is a well defined hierarchy of management stations and a manager can delegate tasks only to those strictly below it in the hierarchy. In the strongly distributed and co-operative paradigms, horizontal delegation is also allowed.

Another issue is the selection of a suitable management technology to implement the paradigm and whether delegation of management tasks is static or dynamic. For weakly distributed systems, it is customary to have static code

running at various lower level managers. Each manager knows the system being managed and is statically configured to manage it. A lower level manager can execute a pre-defined task when requested by a higher-level manager.

Dynamic delegation of management functions to intermediate level managers allows more flexibility [9]. Management operations can be instantiated by higher-level managers by downloading or transferring code to remote management stations on the fly.

### 3. MULTI-TIER ARCHITECTURE

In choosing a multi-tier architecture, there is a trade-off between flexibility and ease of implementation and deployment. A strongly distributed or co-operative architecture permits almost unlimited flexibility, while a weakly distributed architecture is much easier to implement correctly and efficiently. Further, most network operators have well-defined hierarchical structures for their networks and their personnel. Hence, we have chosen a hierarchical, weakly distributed multi-tier architecture for our multi-tier implementation.

#### 3.1. Topology

We partition the set of elements to be monitored into groups of manageable size based on some criterion, say geographical. A manager process monitors each group and these processes constitute the lowest layer of the management architecture.

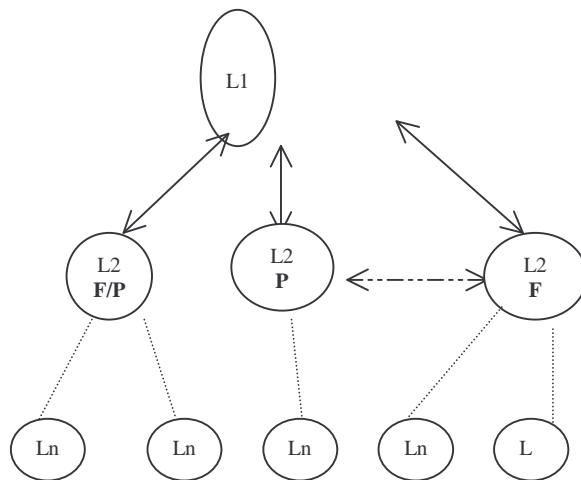


Figure 2. A hierarchical multi-tier management

One or more managers that run management process at higher levels in the hierarchy are a parent of each of these management stations.

This concept can be extended to as many layers as required.

Each cluster of network elements can have at most one parent i.e. exactly one manager. If we represent each management station by a vertex and draw a directed edge (i, j) between two vertices i and j, if i is managed by j, the topology of the resulting network corresponds to a directed acyclic graph (DAG).

#### 4. DESIGN AND IMPLEMENTATION

##### 4.1. The Centralized CygNet NMS

CygNet is an Integrated Network Management System designed to meet the needs of the network operator for efficient operation of a large, multi-vendor, multi-service network. This full-fledged NMS is implemented using Java and a R-DBMS for storage [13]. The main components of CygNet are

**FRCS** (Fault Reporting and Correction System), which provides the fault handling: notification of faults (mail, SMS and log), correlation, escalation, audit trails and reports.

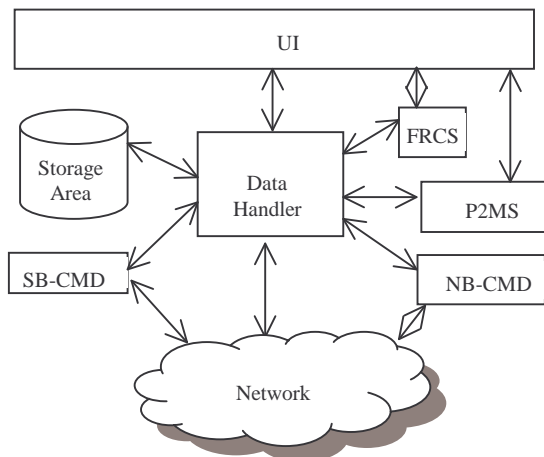


Figure 3. General Architecture of CygNet NMS

**P2MS** (Performance Planning and Monitoring System) generates reports on the past data collected about the network and helps the operator to plan for the future.

**Data Handler** collects all the information that is needed to generate the alarm and reports.

**User Interface** is used to configure CygNet and to view the reports, on-line views, logs and alarms generated.

**CygNet Mediation Device (CMD)** transfers management information between CygNet NMS components at different levels in a multi-tier management network. NB-CMD is North Bound CMD used to communicate with high level CygNet and SB-CMD is South Bound used to communicate with the lower level CygNet.

**Storage Area** is database or/and set of flat files where all the persistent data is stored.

##### 4.2. Multi-tier CygNet

Conversion of this centralised NMS to a multi-tier manager is achieved by the addition of powerful Mediation Devices (MD) as shown in Figure 4.

##### 4.3. mini-CygNet

The lower-level manager in an n-Logue type network must run on an inexpensive PC. mini-CygNet is designed for this purpose. It collects relatively less but important information about the network, offering a minimal user interface. mini-CygNet can run in low-end machines, co-existing with other applications. mini-CygNet has the same architecture as in Figure 3. It is implemented as a set of Perl scripts and flat files for data storage.

##### 4.4. CygNet to mini-CygNet Communication

CygNet and mini-CygNet communicate with each other to exchange three types of messages; configuration, faults and performance. CygNet Mediation Device at both ends implements this functionality. SCP (Secure Copy) is used to exchange the information reliably and securely.

XML files through SCP are used to transfer the configuration information messages.

The performance information and fault information sent from mini-CygNet to CygNet is processed and stored in the R-DBMS for later use.

#### 5. PERFORMANCE MODELING

One of the main reasons for using distributed management is that the bandwidth used by the management traffic will be low. In the following sections we discuss the bandwidth utilization comparison for centralized management approach and distributed management approach. Since traffic due to configuration management will be negligible, we consider traffic due to fault and performance management.

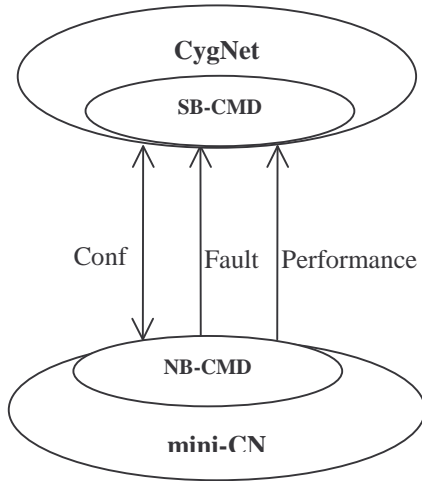


Figure 4. *CygNet mini-CygNet Communication*

### 5.1. Status polling

#### Centralized NMS

Bandwidth used in a day for status polling using centralized management depends on the number of elements monitored ( $N_E$ ), number of bytes in each ICMP packet ( $P_I$ ) (assuming ICMP packets are used to check the status of Network Elements) and the number of polls in a day. This is given by the ratio between number of seconds in a day ( $24 \times 3600$ ) and Polling Interval ( $I_P$ ). The bandwidth utilized by centralized NMS for status polling ( $B_{C,S}$ ) for a day is given by

$$B_{C,S} = N_E \times P_I \times (24 \times 3600 / I_P) \text{ bytes}$$

These calculations were validated against an implementation ( $P_I = 8$ ) of CygNet NMS in the field. Management data was collected and it was found to be 10% more than the theoretical calculation. This difference was because of the routing problems and retries due to few element failures.

#### Distributed NMS

Bandwidth used in a day in case of distributed management depends on packet length for bulk status transfer ( $P_S$ ) and transfer interval ( $I_T$ ) where  $P_S$  is given as

$$P_S = N_E \times 4 \text{ bytes}$$

The 4 bytes are used for Element-ID (3) and Status (1). Bandwidth utilized by distributed NMS for status polling ( $B_{D,S}$ ) in bytes is given by

$$B_{D,S} = P_S \times (24 \times 3600 / I_T) \text{ bytes} \\ = N_E \times 4 \times (24 \times 3600 / I_T) \text{ bytes}$$

### Comparison

Using the above analytical model for typical parameter values, Table 1 shows the comparison of the bandwidth used in both the designs. For small number of  $N_E$  the bandwidth used by centralized and distributed approach is negligible. For large number of  $N_E$  with small polling interval the bandwidth used by centralised NMS is much larger than the distributed NMS.

Centralized NMS			Distributed NMS		Ratio
$N_E$	$I_P$ in secs	BW in bps	$I_T$ in secs	BW in bps	C/D
5	900	3.73	3600	0.14	26.64
25	300	56	3600	0.37	151.4
100	300	224	3600	1.2	186.7
100	60	1120	600	7.2	155.5

Table 1. *Comparison of Centralized and Distributed NMS for status polling*

### 5.2. Performance polling

#### Centralized NMS

Bandwidth used in a day for performance polling, using centralized management depends on number of elements ( $N_E$ ), number of OIDs per element ( $N_O$ ) (assuming SNMP is used to collect the data), packet length for SNMP query per OID ( $P_O$ ) in bytes (assuming more OIDs are sent in each packet), number of bytes for each additional OID ( $P_{AO}$ ) and polling interval ( $I_P$ ). The bandwidth utilized  $B_{C,P}$  is given by

$$B_{C,P} = N_E \times (P_O + (P_{AO} \times (N_O - 1))) \times (24 \times 3600 / I_P) \text{ bytes}$$

The above equation is traffic in one direction (In/Out) and since in most of the SNMP messages the query and response are almost the same, total bandwidth used is twice as that of  $B_{D,S}$ . This model was applied in the field, there was a difference of about 12 %, measured traffic was 12 % less than the calculated traffic. The difference was because of the assumption ( $P_O = 75$  bytes and  $P_{AO} = 15$  bytes) about the SNMP packet size,  $P_O$  and  $P_{AO}$  were different for various elements/OIDs and this assumption of  $P_O$  and  $P_{AO}$  was the one that was nearly matching.

### Distributed NMS

Bandwidth used in a day for performance polling using distributed approach depends on packet length for bulk performance transfer ( $P_p$ ) and the interval between the transfer of this information ( $I_T$ ), where  $P_p$  is given as

$$P_p = 18 \times N_E \times N_o \text{ bytes}$$

The 18 bytes are split as 4 for time stamp, 4 for Poll-ID and 10 for Polled value. Bandwidth used by distributed NMS for performance data collection is given by

$$B_{D,p} = P_p \times (24 \times 3600 / I_T) \\ = (18 \times N_E \times N_o) \times (24 \times 3600 / I_T)$$

### Comparison

Using the above analytical model for typical parameter values, Table 2 shows the comparison of the bandwidth used in both the designs. Similar to status polling, for large number of  $N_E$  bandwidth used by distributed NMS is much less compared the centralized NMS.

Centralized NMS			Distributed NMS		Ratio
$N_E$	$I_p$ in secs	BW in bps	$I_T$ in secs	BW in bps	C/D
5	900	16	7200	0.5	32
25	300	250	14400	1.25	200
100	900	333	14400	5	66.6
100	60	5000	28800	2.5	2000

Table 2. Comparison of Centralized and Distributed NMS for performance polling

## 6. SUMMARY AND CONCLUSIONS

We have presented a weakly distributed multi-tier architecture that is well suited for large telecom operators. A performance model shows that the distributed management yields substantial savings in bandwidth compared to a centralised NMS for large networks especially when the number of elements is large. This architecture has been implemented in the CygNet NMS. It is deployed in the n-Logue network. Our performance model has been validated on an actual implementation in the field for the centralized NMS.

### 6.1. Future work

The current implementation has only two levels of management stations. An immediate extension is to increase this to more. Another extension is to use the same paradigm to deploy management function dynamically using the DISMAN approach.

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