CMIP based Light MIB: Design & Implementation

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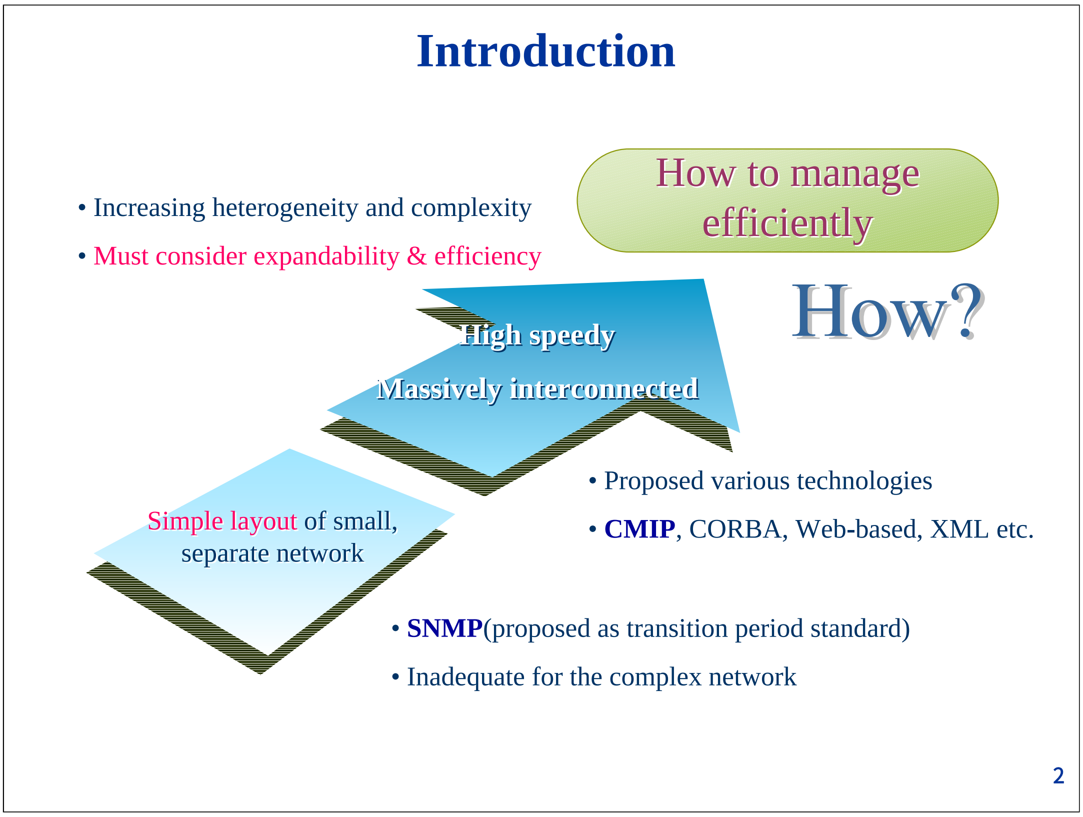
Abstract

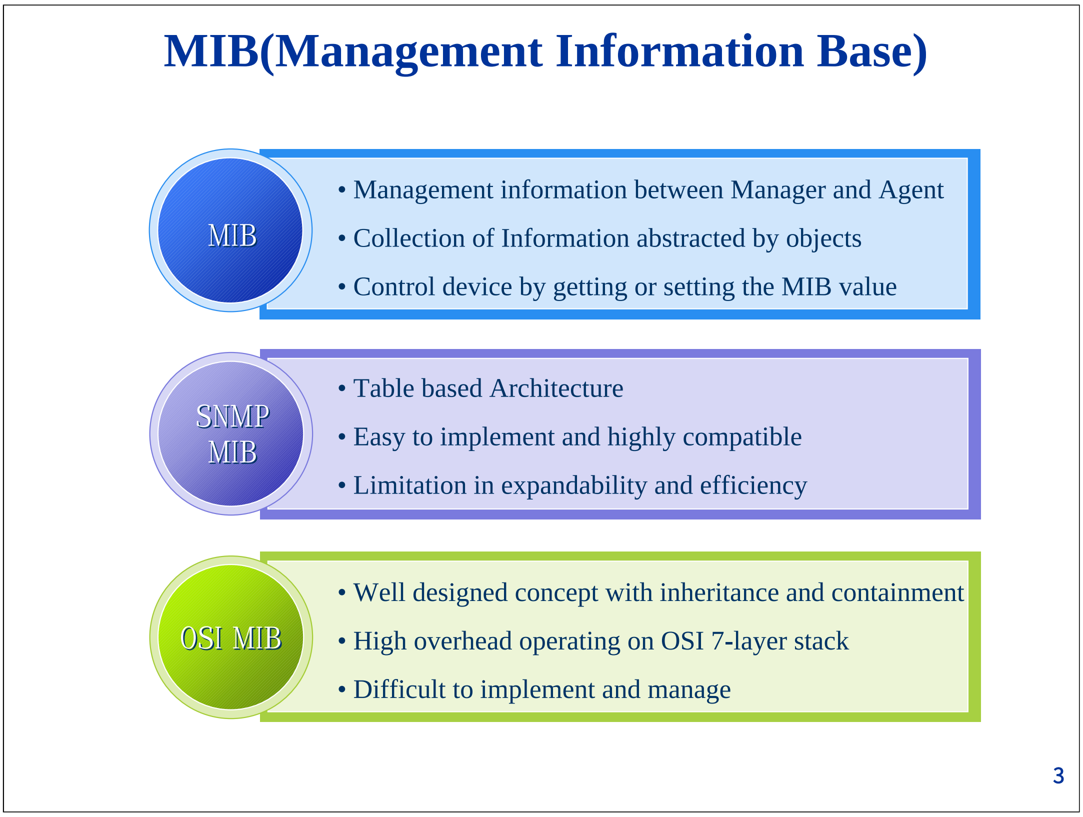
Various protocols have been proposed and developed to manage communication networks efficiently, which are becoming increasingly complex. Of those protocols, SNMP has been popular because it is easy to implement and widely available. However, it has problems in terms of scalability and security. CMIP is a good alternative to SNMP, and OSI MIB provides diverse features to model complex communication networks effectively. But CMIP has a large amount of overhead, operating on top of the 7 layer OSI protocol, and OSI MIB is hard to implement and complex to maintain. We present in this paper a Light MIB with a simple naming rule that carries a smaller overhead than the regular OSI MIB. The Light MIB reduces the amount of management information and network traffic, enhances performance, and allows easy implementation and management. We also apply the Light MIB to the model of the Synchronous Digital Hierarchy (SDH) as an example.



1. Introduction

As the communication networks have become very high speed and their capacity has become mass storage, complex networks have been built by network devices consisting of many different parts. Efficient network management is becoming increasingly crucial. To efficiently manage the communication networks, many protocols have been proposed and established. Common Management Information Protocol (CMIP) [1] and Simple Network Management Protocol (SNMP) [2] are the ones of the most widely used out of them. Methods of network management based on Web or using the Common Object Request Broker Architecture (CORBA) [3] platform also have been proposed or used. Initially, the SNMP was developed as a standard in the transition phase to manage Internet efficiently and easily. Even up to date, it is one of the most used network management standard because it is easy to implement and is compatible. However, since it has poor scalability and efficiency despite its many good features, it has been upgraded to address the drawbacks and a new technology has been required. Telecommunication Management Network (TMN) [4] based on the CMIP was proposed to exchange necessary management information freely and manage communication networks in real-time more efficiently by inter-working different kinds of communication devices with a variety of operation and management systems. Even if the CMIP is a well-configured and good concept of technology as an open standard of architecture for the operation and management of communication networks, it is not easy to implement because it is stipulated too comprehensively. Also, the system of the CMIP is very large and complex compared to that of the SNMP and it is difficult to manage the CMIP.

The purpose of this paper is to help configure the Light Management Information Base (MIB), which enables users to represent complicated relationships among managed objects in a simple way, by establishing a naming rule (i.e. an agreement between the Agent and the Manager) for an easy management system implementation while maintaining the basic architecture of the well-configured and expandable CMIP as an alternative of the SNMP.



2. Management Information Base (MIB)

2.1 Importance of MIB in managing network

The basic operation of network management is to exchange management information between the Agent and the Manager. Specific information or resources to be managed are abstracted into an object. The set of the objects is called Management Information Base (MIB). Managing networks means that a specific value is gotten from the MIB to check the device or a value is changed to control the device. Each object of the MIB is represented by Abstract Syntax Notation One (ASN.1) [5], which is the language standardized and developed under the International Telecommunication Union – Telecommunication Standardization Sector (ITU-T) X.208 and has a hierarchical tree architecture.

The term, MIB is used for the CMIP as well as the SNMP. The CMIP MIB is called Open System Interconnection (OSI) MIB to differentiate it from the table-based SNMP MIB. The major feature of the OSI MIB is as follows: The OSI MIB accepts an object-oriented concept and has the relationships of inheritance and containment as defined in X.720, X.721, and X.722 [6, 7, 8]. Particularly, Guidelines for the Definition of Managed Object (GDMO) defined in X.722 is a structured technical language, which enables users to specify managed object classes which have behaviors and attributes of the objects. The OSI MIB is written using the GDMO. The X.720 series of OSI MIB describes the concept of managed objects and types of attributes, operation, or notification in detail. The managed objects defined by the GDMO are encapsulated. The managed objects can be inherited to create a new managed object. Management Information Tree (MIT) is configured by the containment relationship. An object can include more than one object. If an object is included in another object, it shall be included in only one upper object. This containment relationship is applied at time of object creation to make hierarchical MIT architecture.

The SNMP is compared with the CMIP in terms of the MIB in this section. The SNMP manages objects based on tables while the CMIP MIB uses the concepts of inheritance and containment to configure Management Information Tree (MIT). Therefore, the CMIP is more complex and is not easy to implement compared to the SNMP. On the other hand, it has more scalability and more various functions. It is hard to determine which MIB is better and each MIB has its strengths and weaknesses.

SNMP vs. CMIP

	SNMP	CMIP
Schema	SMI	GDMO
Inheritance	Not supported	Supported
Object Relationship	Table	Containment Tree
Naming	Object Identifier	Distinguished Name
Scope, Filter	Not supported	Supported
Communication	Connectionless (connection-oriented in v2)	Connection-oriented
Acknowledgement	Not supported	Supported
Security	Not supported (Supported in v2)	Supported
Operations	Polling & traps	Event-driven
Service	Get, Get-Next, Set, Trap, Get-Response, Get-Bulk (v2), Get-Info-Req (v2)	M-Get, M-Set, M-Create, M-Delete, M-Action, M-Event-Report, M-Cancel-Get

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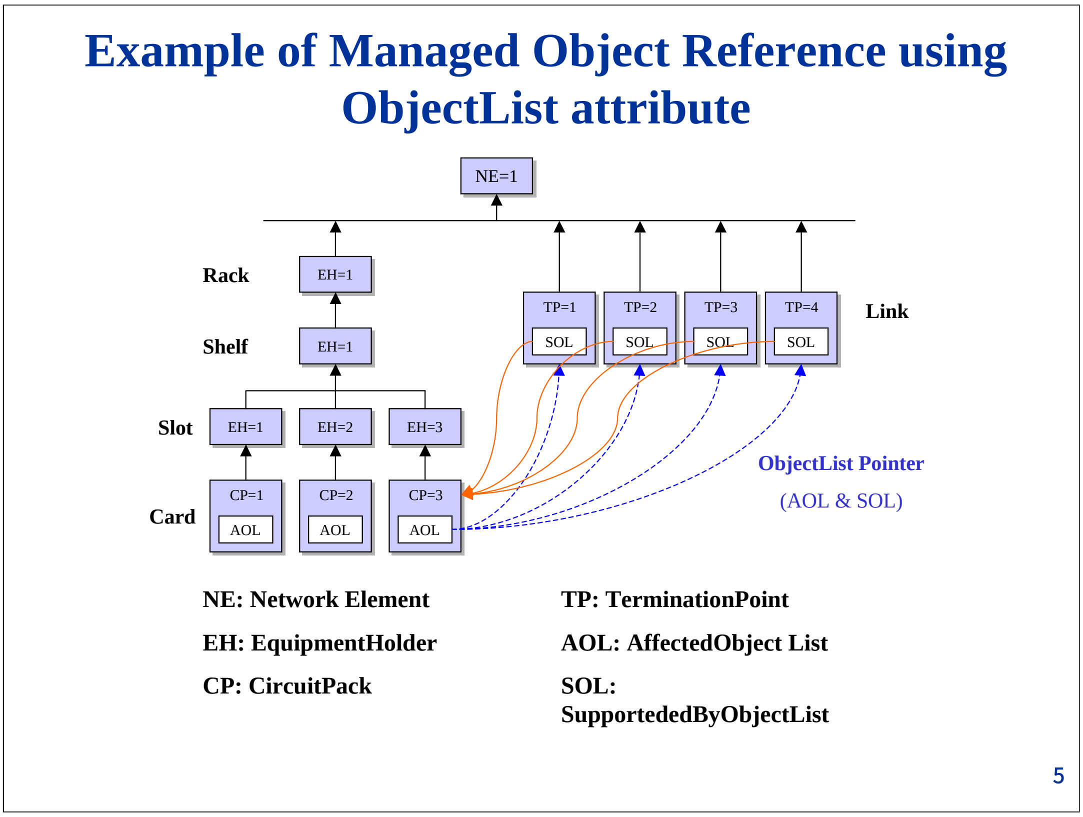
2.2 Comparison Between SNMP and CMIP

Initially, SNMP was developed for a short-term use, however is generally used for Internet management because it is easy to implement and is compatible. As Internet users have been increasing rapidly, the SNMP-based network management system has shown the limited ability of managing huge networks [9].

Above Table shows the differences between the SNMP and the CMIP. As shown in the table, the SNMP has limited functions in scope, filter or security etc. when compared to CMIP. Many problems have been fixed in a newer release of SNMP, SNMPv2 (SNMP version 2) and SNMPv3 (SNMP version 3) which allow more in-detail specification. In fact, so many new features have been added in newer release of SNMP losing its simplicity, but the fact is that changes to SNMP were necessary.

CMIP was designed to manage a bigger, more detailed network. A lot of shortcomings of SNMP have been complemented and various functions are added. Even if the CMIP can provide many functions, it also has drawbacks. CMIP takes more system resources than SNMP and has difficulty in implementation and management.

SNMP is by no means a perfect network management solution for current network. Some people believe that a combination of CMIP and CMIP shrinking to fit into smaller systems will eventually result in its widespread implementation. The purpose of this paper is to introduce the method of making the MIB architecture of the CMIP simple while accepting the well-defined functions of the CMIP.



3. Difficulties of Implementation Using the CMIP

3.1 Representation of Relationships among Managed Objects using ObjectList attribute

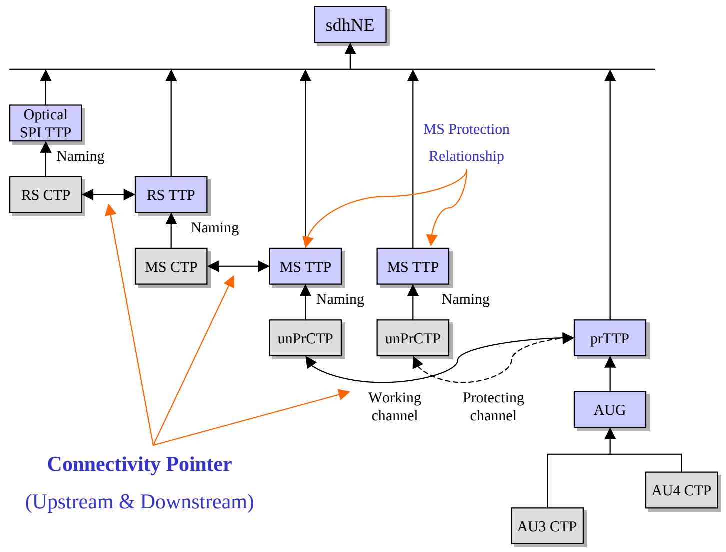
First, as an example of shortcoming of CMIP, This paper gives you MO(managed object) relation representation method using ObjectList attribute. The ObjectList is the 'SET OF' ObjectInstance and the DN exists within ObjectInstance as the type of choice.

Above Figure(Slide 5) illustrates the use of the ObjectList attributes for setting up a relationship between managed objects by exemplifying the implementation between CircuitPack (CP) and TerminationPoint (TP) managed objects. If the card mounted to Slot 3 is a link board and there are 4 physical links, the MIT can be configured with EquipmentHolder (EH), CircuitPack (CP), and appropriate TerminationPoint (TP) managed objects as shown in above Figure [18]. The EH models the managed object that can include devices(equipment), while the CP models a board and TP models an end point. The method proposed to represent the relationship between the link board and the link under the ITU-T M.3100 is as follows: AffectedObjectList (AOL) within the CP MO(Managed Object) and SupportededByObjectList (SOL) within the TP MO are used to create cross reference so that a managed object can have the DistinguishedName(DN) of the other managed object as shown in above Figure. The reference method using the ObjectList is mainly used to represent relationships among managed objects that were not expressed by the containment relationship in the MIT [18].

However, since the DN of a managed object shall be included in the attribute values of another managed object in order to use the method, it is difficult to implement or manage it and requires more space for these attributes. If management information is provided for the Manager, the traffic of network management information will increase. Also, both the Manager and the Agent shall analyze and reference the attributes of the ObjectList for the operation of inter-related managed objects. If these attributes should be dynamically updated, it will become more difficult to implement or manage.

If we can find and refer to the other party's MO in one MO processing without ObjectList, it will make MIT structure simpler than traditional method.

Naming, Pointer relationships for the SDH Model



SDH: Synchronous Digital Hierarchy
TTP: Trail Termination Point
CTP: Connection Termination Point

SPI: SDH Physical Interface
RS: Regenerator Section
MS: Multiplexer Section

unPrCTP: unProtectedCTP
prTTP: protectedTTP
AU: Administrative Unit

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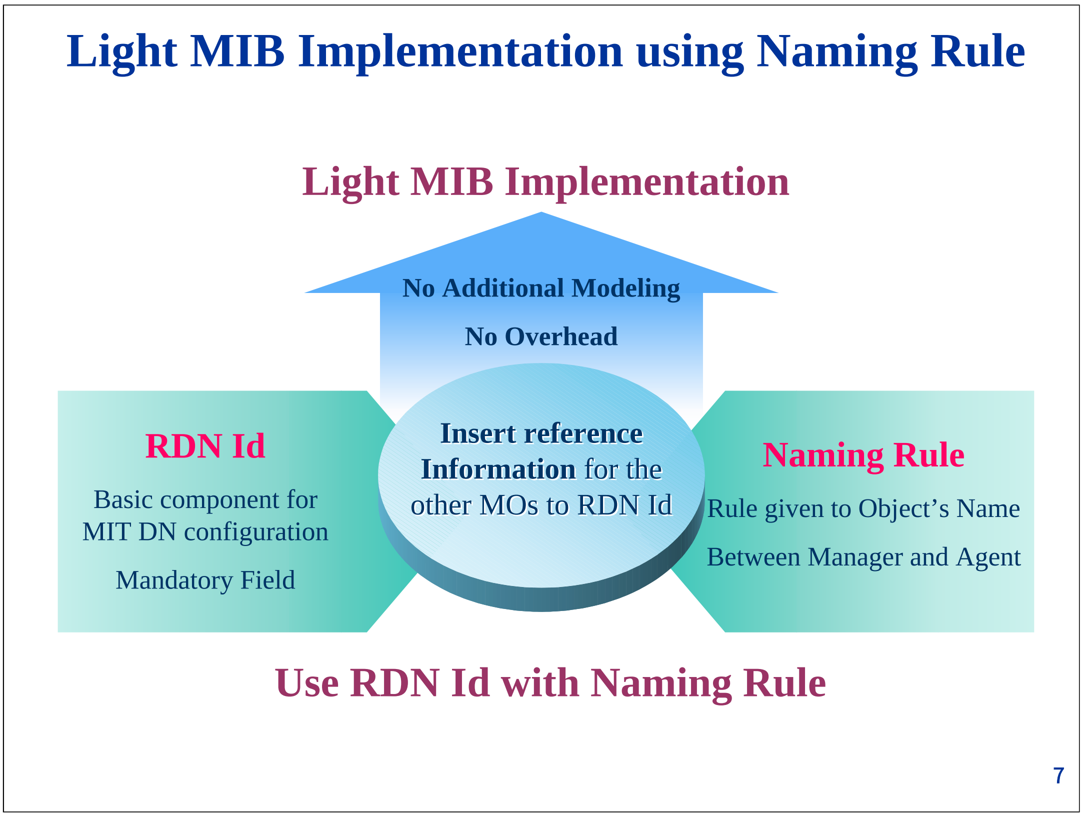
3.2 Complexity of Synchronous Digital Hierarchy (SDH) Implementation

We can also find the complexity of CMIP in SDH model. SDH is a technology for transferring synchronization data in optical networks. It is an international standard proposed and developed by ITU-T. Hierarchy structure is divided into the Physical Media layer, Regenerator Section layer, Multiplexer Section layer, and Path layer as shown above Figure(Slide 6)[19].

MO(Managed Object)s representing each layer are needed for layer-based management and was modeled by Trail Termination Point(TTP). MOs representing connections among hierarchies in the flow of signals are also needed. The Connection Termination Point (CTP) MO was modeled to play this role. Gray parts show the CTP MO in above Figure(Slide 6). The method of connections among hierarchies is as follows: Trail Termination Point (TTP) exists in each hierarchy. Above Figure shows Optical SDH Physical Interface TTP (Optical SPI TTP), Regenerator Section TTP (RS TTP), and Multiplexer Section TTP (MS TTP). Examples of the Path layer include Virtual Container 3 TTP (VC3 TTP) and Virtual Container 4 TTP (VC4 TTP) but is not illustrated in this Figure. The CTP is included under an upper layer (in this paper, a layer closer to the physical layer is an upper layer.) by the naming(containing). The relationship between the CTP and the TTP is represented by the Connectivity Pointer attributes using the DN pointing method. That is, the rsCTP MO is modeled to connect the opticalSPITTP MO with the rsTTP MO. The rsCTP MO with the containment relationship by the name binding, is instantiated under the opticalSPITTP MO. The rsCTP MO and the rsTTP MO use the Connectivity Pointer attributes to have the DN of another. Also, each MO uses this pointing attribute values to make cross-reference of another managed object [18, 19]. The Connectivity Pointer is classified into Upstream Connectivity Pointer and Downstream Connectivity Pointer depending on the flow of signals. Uni-directional MOs can have only one valid attribute. As for bi-directional MOs, they have valid values for both Upstream Connectivity Pointer and Downstream Connectivity Pointer [18].

The mechanism of the CTP and the Connectivity Pointer attribute exists to connect the Trail Termination Point of each SDH layer with that of another layer. If you want to represent the SDH layer structure fully using the relationship of naming and connectivity pointers from the physical layer to the Digital Signal 0 (DS0) layer or the Digital Signal 1 (DS1) layer, it will make the implementation much harder. Even if the implementation is successful, references in each layer will make management more complicated and the system with more free space and better processing will be needed.



4. Configuration and Implementation of the Light MIB through the Naming Rule

4.1 RDN ID setting for Light MIB

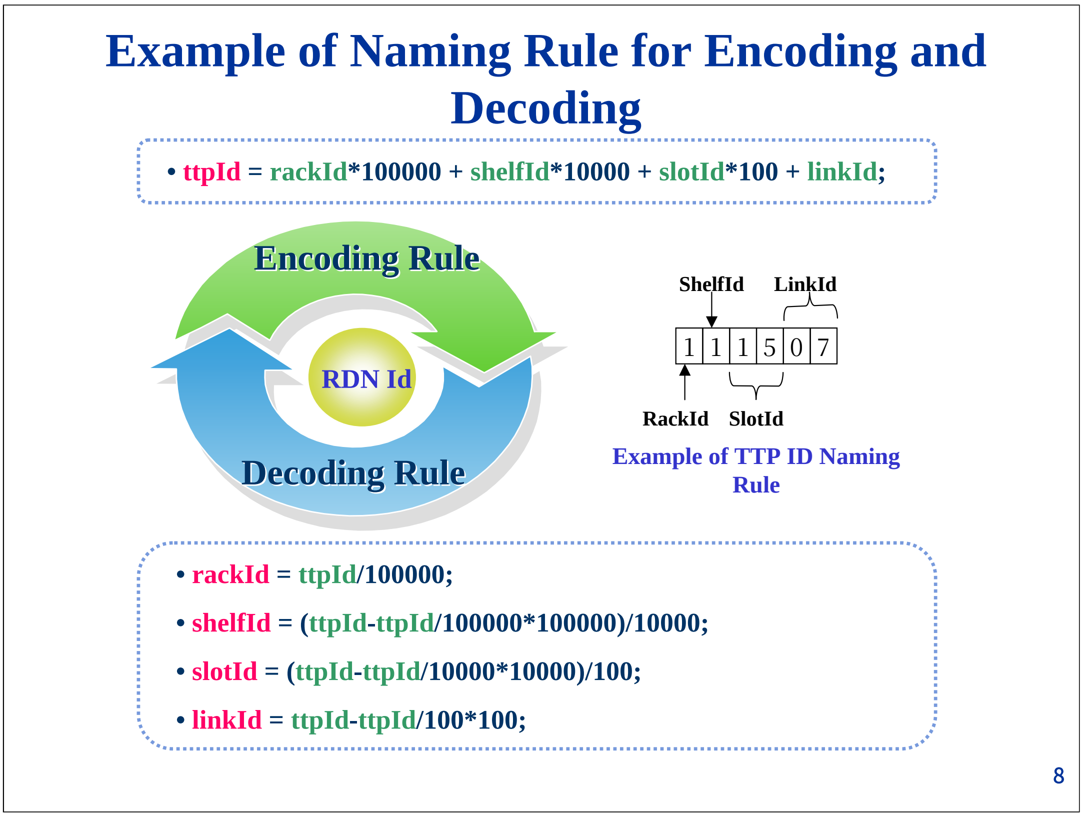
In the previous chapter, the method of referencing the ObjectList and using the Connection Termination Point MO and the attribute of the Connectivity Pointer were introduced to explain the difficulties of establishing a network management system as an example of SDH standard information model proposed by the ITU-T.

To ease the complexity of referencing the managed object through DN pointing method and to lower the volume of the MIB, this paper proposes a naming rule to insert data, which enables reference of other managed objects, to the RDN value that is unique within a same class of same level and is mandatory for object instantiation. The naming rule, which is a pre-agreed rule between the Agent and the Manager, can be considered as an application level protocol and is applied at the creation time. Since the DN configuration using the RDN field is a mandatory for creating and managing the managed object, no additional overhead or storage space are required for inserting an encoded reference managed object data to the RDN field. This method can save space for DN pointing attributes like ObjectList and does not require additional information modeling.

Someone can say this pre-defined naming rule destroys the purpose of standardization of OSI MIB and it also causes some problems in inter-working with traditional OSI MIB systems. These may be right for systems without knowing our naming rule because our proposed scheme can be regarded as a kind of protocol that have to be understood in advance for communication. However, the fact is that it is impossible to make small the volume of OSI MIB without even small change of standard.

In this paper, we are going to suggest how to make light MIB with as small change and as small cost in standard OSI MIB structure as possible. Proposed scheme needs changes only in naming RDN not in information modeling. If this scheme is standardized, it will be very beneficial.

Our scheme can be applied to any system with link cards of physical structure in the type of rack/shelf/slot/link and hierarchical Termination Point structure like SDH system.



4.2 Example of Naming Rule

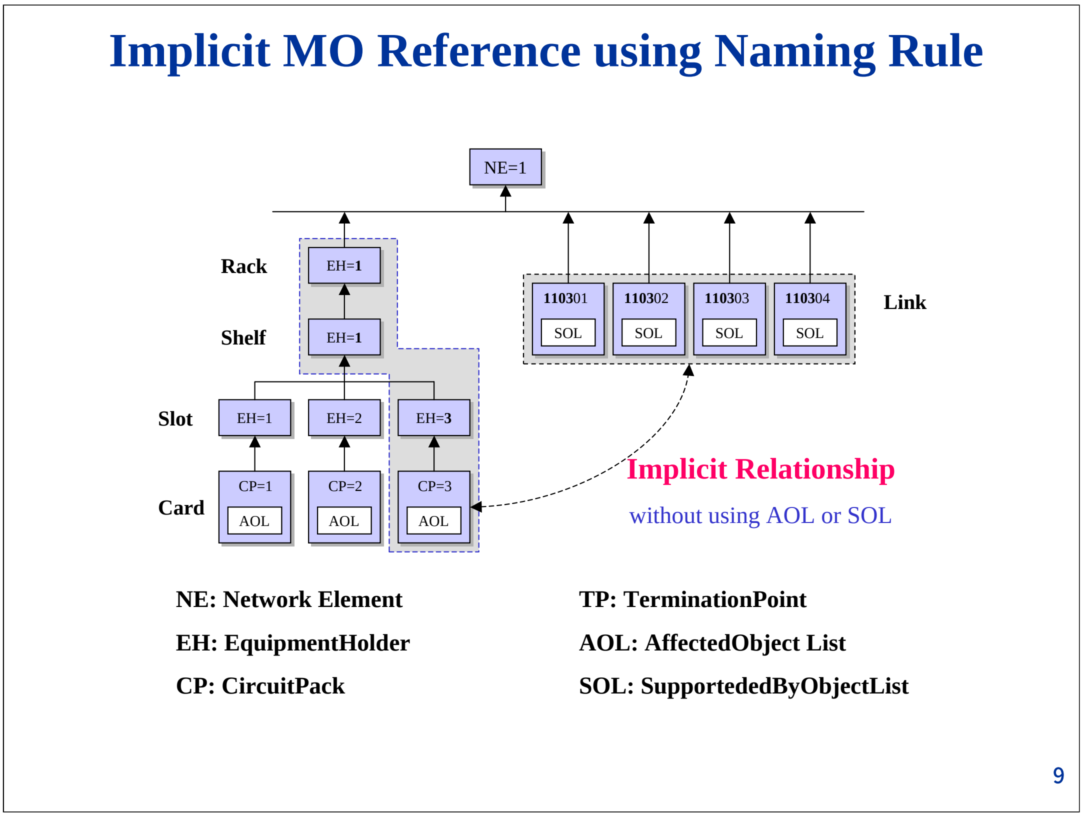
Above Figure(Slide 8) shows an example of the TTP ID Encoding Rule, which configures the TTP ID by inserting the physical link board's location of the rack, shelf and slot.

In the example shown in above Figure(Slide 8), the RackId, ShelfId, SlotId, and LinkId shall conform to the physical configuration actually set on the managed system (Network Element). Six digits are used to define the TTP ID for RDN value. The field indicating the rack information is located on the first digit, the shelf information on the second digit, the slot information on the next two digits, and the link information on the last two digits.

The encoding rule above is based on the assumption that the number of shelves per rack can be expressed within a single digit in most cases and that the number of slots and links hardly exceed two digits. Shall equipment require a higher digit for any of the fields, the digits of each field could be extended accordingly. Based on the encoding rule above, the TTP ID of the Link No.7 of a card located on Slot No. 15, Shelf No. 1, Rack No. 1 would be defined as 1*10^5 + 1*10^4 + 15*10^2 + 7 = 111507. Of course, the naming rule for RDN ID defined herein shall be shared between the Manager and the Agent.

The TTP ID Naming Encoding Rule, if C coded, can be expressed as shown in above Figure(Slide 8). On the other hand, since the information on the rack, shelf, slot and link are fixed on the encoded TTP ID, the original values can be derived using a proper decoding rule as shown in above Figure(Slide 8). This shows an example of a decoding rule using C code. The variable *ttpId* shall be declared in the 'int' type rather than in a real number type, and the integers can be derived through simple four function operations using operators such as '/' and '*'.

Since the decimal digit used for encoding and decoding in the naming rule was adopted in this paper for easy description and comprehension of the concepts proposed, other types of the naming rules can equally be applied. For binary number IDs, the RDN value can be easily encoded and decoded through masking naming rule by BIT operations such AND, OR, and SHIFT.



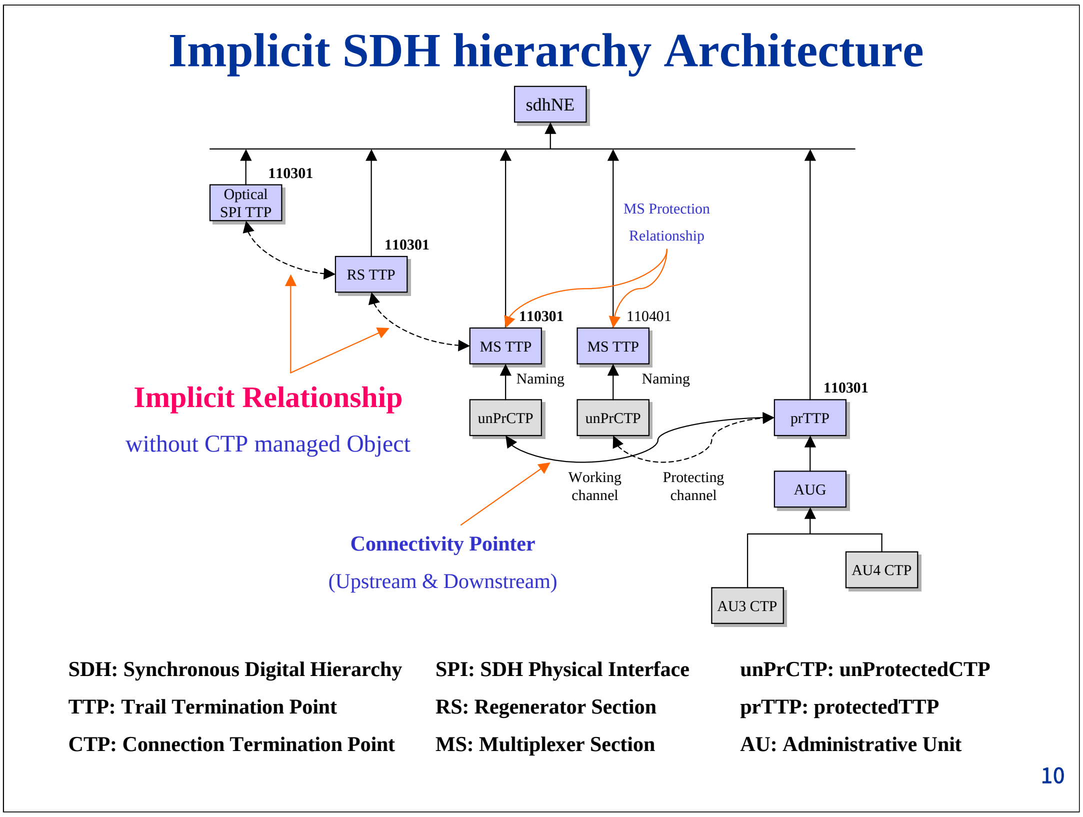
4.3 Advantages of Using Naming for Light MIB Configuration

4.3.1 High readability only through RDN ID

The first advantage of configuring the Light MIB through naming rule is the high readability on managed objects. In previous systems, as shown in previous Slide 5, the related attribute values must be read and analyzed in order to refer the related managed object since ObjectLists, such as the AffectedObjectList (AOL) and the SupportededByObjectList (SOL), were used to represent the relation between the link board and the link.

However, as shown in above Figure(Slide 9), by inserting a reference data into the RDN ID using the naming rule, information of the other managed object can be easily derived through a proper encoding/decoding rule without using the DN pointing method such as the ObjectList related attributes, and the implicated relationship can be established using only the RDN value.

The cross-reference of managed objects were complicated by the use of AOL and SOL in Slide 5. However, the example above Figure(Slide 9) illustrates that the system easily recognizes the No. 1/2/3/4 link of slot No. 3, shelf No. 1, rack No. 1 only by reading the RDN value of the TTP managed object, using the Decoding Naming Rule. Conversely, if the CP managed object attempts to refer the TTP managed object, the implicated reference of the TTP managed object is enabled by encoding the TTP RDN, from the RackId (1), ShelfId (1), SlotId (3), and the LinkId (1~4), which are derived from the containment expressed in MIT naming. In addition, the CP can refer all related TTP managed objects at a time through Scoping and Filtering, which are one of the best advantages of the CMIP. To this end, the Filtering option shall be set between the maximum value and the minimum value of RDN, which is encoded using data, such as RackId (1), ShelfId (1), SlotId (3), and the total number of ports (usually represented by the circuitPackType [18] attribute), derived from the containment relations represented by the naming in MIT. The Scoping shall be set so that the TP MO Class is within the scoping range. For a board with 4 links as shown above Figure(Slide 9), the Filtering shall be set as TP MO Class and as RDN ID values between 110301 and 110301 + 4 (number of link) - 1 = 110304.



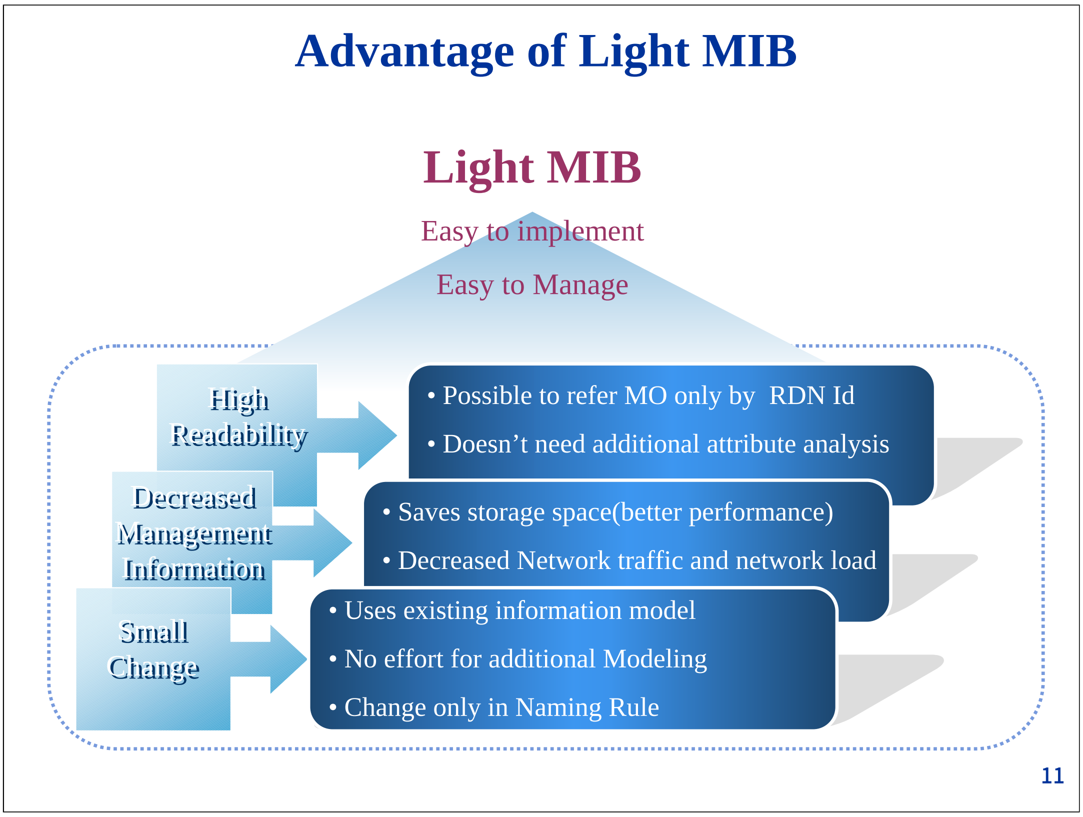
4.3.2 Decreased Management Information

The second advantage is less management storage space and network traffic. Compared to Slide 6, above Figure(Slide 10) shows that the rsCTP and msCTP managed objects are omitted. In the fixed layer structure implemented by the SDH transfer layer, adjacent layers having the same RDN value can be considered as related. Thus, the CTP managed object is unnecessary for understanding the entire structure. In other words, since the RS layer, rsTTP, is naturally positioned next to the physical layer, opticalSPITTP, in the fixed layer structure, the rsCTP managed object is not required for the comprehension of the entire structure and can be omitted. However, when the managed object, rsCTP, is omitted, the problem of representing the relation between the opticalSPITTP and rsTTP remains. As shown in Slide 5, the containment derived from the naming of rsCTP and the pointing method using the ConnectivityPointer were previously used, increasing the complexity.

However, in the Light MIB configured under the naming rule, TTP classes of all layer structures created from a single link are created with the same RDN value. In the example shown above Figure(Slide 10), instances having the same RDN value, 110301, such as the opticalSPITTP, rsTTP, and msTTP, all represent the TTP layer structure of link No.1, slot No.3, shelf No.1, rack No.1, and are considered to have implicit inter-relationships. For example, if the rsTTP with the RDN value of 110301 needs to refer a related msTTP, the msTTP instance with the RDN value of 110301 could be easily used. However, when necessary for another function like representing the MS protection relationship such as the unPrCTP (unProtectedCTP) [20], like representing the payload such as the au3CTP/au4CTP [19], or like representing the cross connection relationship [18], the CTP MOs are not deleted. The deletion of some CTP MOs and the reduction on used attributes eventually decreases the managed information, which means smaller storage space for the managed data and less network traffic for management.

For the state management or fault management of omitted CTP MOs, all needed functions are moved to same level TTP MOs and similar functions can be managed with one group concept. For the same kind of alarms, we can discriminate those using newly defined probableCause or using additionalInformation or additionalText of notification field. For example, some functions of rsCTP with RDN 110301 can be managed as one group with rsTTP with RDN 110301.

In the CTP MO omission, if it is difficult to manage as group or if it is necessary for other functions that cannot be represented in same level TTP, CTP must be maintained for standard OSI MIB structure.



4.3.3 No Additional Information Modeling

The third advantage is that the previous OSI MIB modeling does not need to be changed at all. Since the configuration of the Light MIB using the naming rule is an agreement between the Agent and the Manager, defined in the created instance, the configuration can be implemented by simply setting the encoding/decoding rules accordingly without modifying the information model designed under the Guidelines for the Definition of Managed Object (GDMO) of the ITU-T. In addition, since no additional management information modeling is required, the Light MIB can be easily applied to the previous system with small change for RDN Id, implemented by the existing OSI MIB, providing high compatibility. The concept proposed in this paper is that the Light MIB can be configured by deleting the overhead section while a well-configured information model is maintained.

5. Conclusion

The SNMP and CMIP, which are most commonly used for managing networks, have been crosschecked in this paper. The SNMP is simple and easy to implement, but is not appropriate for managing complex and ever-growing networks, due to its poor expandability and efficiency. The CMIP provides high stability and supporteds various functions, but yields problems such as complicated processing and difficulties in implementation and management. With these problems in mind, this paper has introduced a method, applicable to the development of a CMIP-based TMN network management system, of implicitly representing the inter-connectivity of the managed objects by using the naming rule, which is an agreement between the Agent and the Manager. The advantage of this method is in configuring the Light MIB, which is easier to implement and manage, by reducing the volume of the MIB while maintaining the well-designed OSI MIB of ITU-T without destroying the overall structure. The use of this proposed scheme will reduce the number of managed objects and enable a simple structure since some managed objects no longer need to manage the ObjectList, ConnectivityPointer attributes and some CTP managed objects can be deleted.

Conclusions

- **Importance of Network Management**
  - ❑How to manage complex and ever-growing network efficiently
- **SNMP(Simple Network Management Protocol)**
  - ❑Simple and easy to implement but limited functions
  - ❑Not appropriate for managing complex and ever-growing network
- **CMIP(Common Management Information Protocol)**
  - ❑Provides high stability and supported various functions
  - ❑Heavy overhead and complicated implementation and management
- **Light MIB using Naming Rule**
  - ❑Easy to implement and manage with small change
  - ❑Maintains well-designed existing MIB of ITU-T
  - ❑Save storage space of Agent and Manager by reducing the volume of MIB
  - ❑Decreases management traffic and enhances the network performance

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References

[1] ITU-T Recommendation X711, Information Technology - Open Systems Interconnection - Common management information protocol: Specification

[2] J. Case, M. Fedor, M. Schoffstall, J. Davin RFC1157 Simple Network Management Protocol http://www.ietf.org/rfc/rfc1157.txt

[3] OMG's Corba Website, http://www.corba.org

[4] ITU-T Recommendation M.3010, Principles for a Telecommunications management network

[5] ITU-T Recommendation X.208, Specification Of Abstract Syntax Notation One(ASN.1)

[6] ITU-T Recommendation X.720, Information Technology - Open Systems Interconnection : Management Information Model

[7] ITU-T Recommendation X.721, Information Technology - Open Systems Interconnection : Definition of Management Information

[8] ITU-T Recommendation X.722, Information Technology - Open Systems Interconnection : Guidelines for the Definition of Managed Objects

[9] Hong Taek Ju, J.H.Youn, W.K.Hong, "SNMP-XML Translator and Gateway for XML-based Network Management", KNOM Review, Vol.5, No.1, 2002. 6.

[10] ITU-T Recommendation X.710, Information technology - Open Systems Interconnection - Common management information Service

[11] The 3rd Generation Partnership Project Agreement, http:://www.3gpp.org

[12] Ssangyong Information & Communications Corp.white paper http://www.pnk.co.kr/white/ss/smnp/3.html

[13] ITU-T Recommendation G.707, Network Node Interface for the Synchronous Digital Hierarchy (SDH)

[14] ITU-T Recommendation G.781, Structure of Recommendations on Equipment for the Synchronous Digital Hierarchy (SDH)

[15] ITU-T Recommendation G.782, Types and Characteristics of Synchronous Digital Hierarchy (SDH) Equipment

[16] ITU-T Recommendation G.783, Characteristics of Synchronous Digital Hierarchy (SDH) Equipment Functional Blocks

[17] ITU-T Recommendation G.803, Architecture of Transport Networks Based on the Synchronous Digital Hierarchy (SDH)

[18] ITU-T Recommendation M.3100, Generic Network Information Model

[19] ITU-T Recommendation G.774, Synchronous Digital Hierarchy (SDH) Management Information Model and Management

[20] ITU-T Recommendation G774.03, SDH Management of Multiplex Section (MS) Protection For the Network Element View

[21] ITU-T Recommendation G774.10, SDH Multiplex Section (MS) Shared Protection Ring Management for the Network Element View