

Chapter 30

Network Management

(SNMP)

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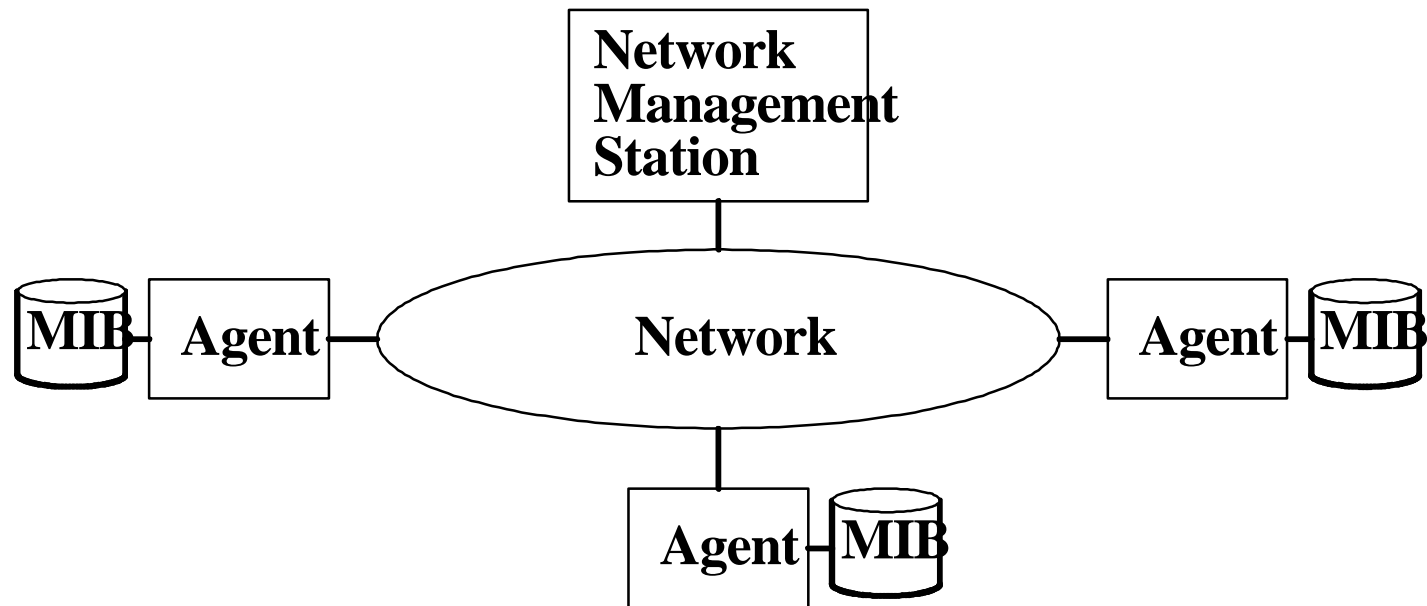
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- ❑ Network Management
- ❑ SNMP
- ❑ Management information base (MIB)
- ❑ ASN.1 Notation

Network Management

- ❑ Management = Initialization, Monitoring, Control
- ❑ Manage, Agents, MIB



SNMP

- ❑ Based on Simple Gateway Management Protocol (SGMP)
- ❑ Only Five commands

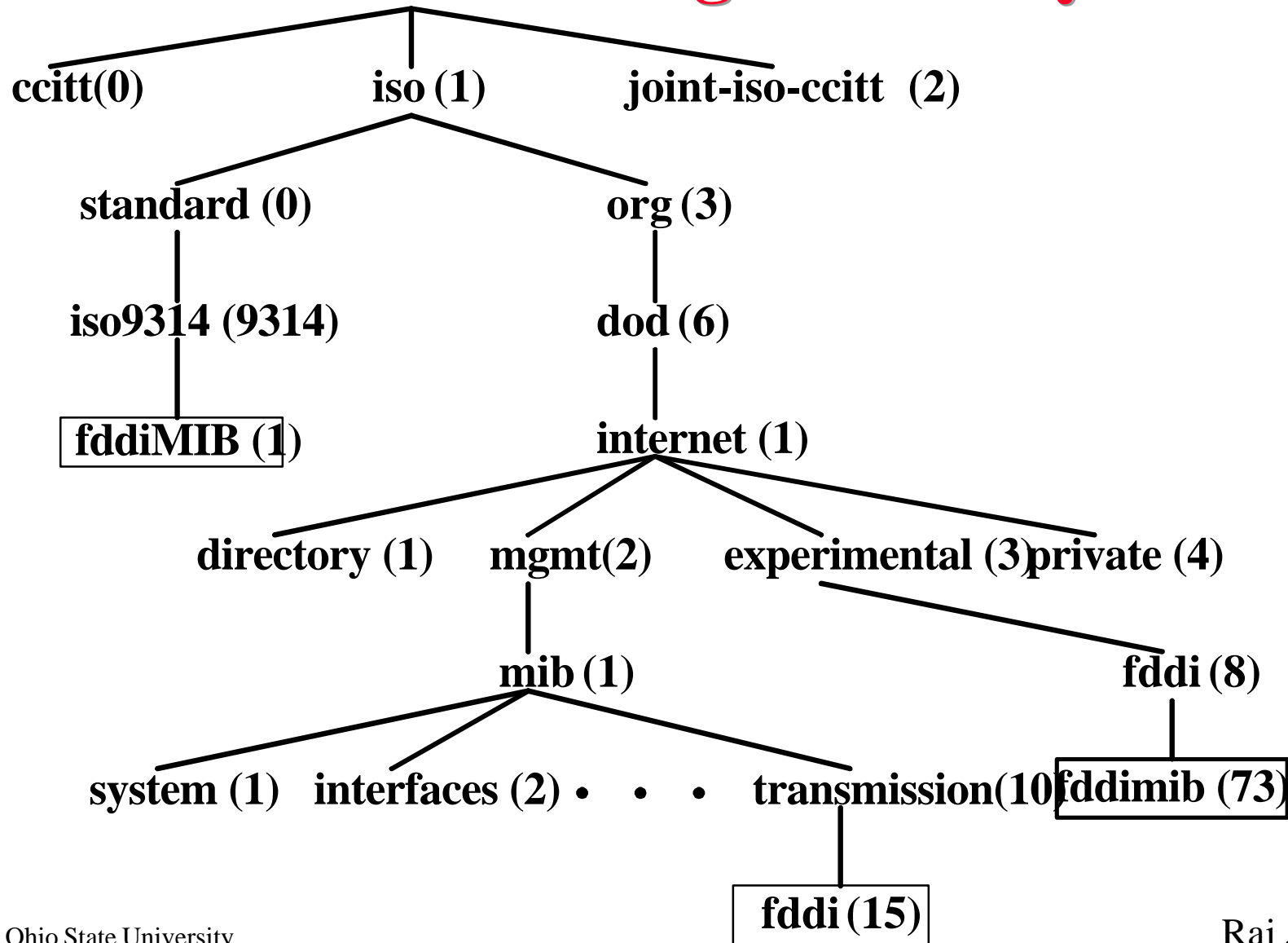
Command	Meaning
get-request	Fetch a value
get-next-request	Fetch the next value (in a tree)
get-response	Reply to a fetch operation
set-request	Store a value
trap	An event

Management Information Base (MIB)

- ❑ MIBs follow a fixed naming and structuring convention
 - ⇒ Structure of Management Information (SMI)
- ❑ All names are unique
- ❑ All nodes of the name tree are assigned numeric values by standards authorities
 - iso.org.dod.internet.mgmt.mib.ip.ipInReceives
 - 1.3.6.1.2.1.4.3
- ❑ Tables rows are referenced by appending the index

- ❑ All names are specified using a subset of Abstract Syntax Notation (ASN.1)
- ❑ ASN.1 specifies notation (that humans can read) and encoding (representation and ranges)
- ❑ Only INTEGER, OCTET STRING, OBJECT IDENTIFIER, NULL types
- ❑ Only SEQUENCE, SEQUENCE OF, CHOICE constructors

Global Naming Hierarchy



Variable	Category	Meaning
sysUpTime	system	Time since last reboot
ifNumber	interfaces	# of Interfaces
ifMTU	interfaces	MTU
ipDefaultTTL	ip	Default TTL
ipInReceives	ip	# of datagrams received
ipForwDatagrams	ip	# of datagrams forwarded
icmpInEchos	icmp	# of Echo requests received
tcpRtoMin	tcp	Min retrans time
tcpMaxConn	tcp	Max connections allowed

MIB Definition: Example

- ❑ ipAddrTable ::= SEQUENCE of ipAddrEntry
- ❑ ipAddrEntry ::= SEQUENCE {
ipAdEntAddr ipAddress,
ipAdEntIfIndex INTEGER,
ipAdEntNetMask ipAddress,
ipAdEntBcastAddr ipAddress,
ipAdEntReasmMaxSize INTEGER (0..65535)
}
❑ ipAddrEntry { ipAddrTable 1 }
❑ ipAdEntNetMask { ipAddrTable 3 }

SNMP Message Format

□ In ASN.1 Notation:

```
SNMP-Message ::= SEQUENCE {  
  version INTEGER {version-1 (0)},  
  community OCTET STRING,  
  data ANY  
}
```

SNMP Message Types

□ SNMP-PDU_s ::= CHOICE{
get-request GetRequest-PDU,
get-next-request GetNextRequest-PDU,
get-response GetResponse-PDU,
set-request SetRequest-PDU,
trap Trap-PDU
}

Message Types (Cont)

□ GetRequestPDU ::= [0]
IMPLICIT SEQUENCE{
request-id RequestID,
error-status ErrorStatus,
error-index ErrorIndex,
variable-bindings VarBindList
}

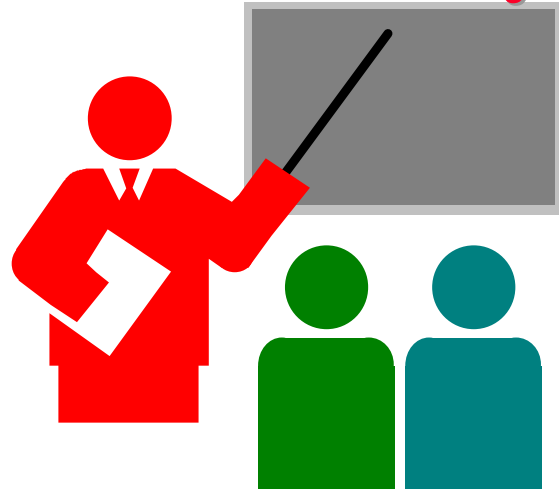
SNMPv2

- ❑ Improved security: authentication and integrity using Data Encryption Standard (DES)
- ❑ *inform request* \Rightarrow Multiple manager coordination
- ❑ *get bulk* \Rightarrow Better table handling
- ❑ Confirmation option for Traps
- ❑ Reference: RFC 1441

OSI Network Management Standards

- ❑ Common Management Information Protocol (CMIP)
- ❑ Common Management Information Service (CMIS)
- ❑ CMIP is the management (application layer) protocol
- ❑ CMIS is the service interface to CMIP
- ❑ M-GET (read attribute), M-SET (write attribute), M-EVENT-REPORT (report an event), M-ACTION (perform an action), M-CREATE (create an instance), M-DELETE (delete an instance)

Summary



- ❑ Management = Initialization, Monitoring, and Control
- ❑ SNMP = Only 5 commands
- ❑ Standard MIBs defined for each object
- ❑ Uses ASN.1 encoding

Homework

- Read Chapter 30 and RFC 1155, 1157

SNMP: References

- ❑ D. Comer, “Computer Networks and Internets,” Prentice Hall, NJ, 1997, Chapter 30.
- ❑ D. Comer, “Internetworking with TCP/IP,” Vol 1, 3rd Ed, Prentice Hall, 1995, Chapter 26.
- ❑ U. Black, “TCP/IP and Related Protocols,” 2nd Ed, McGraw-Hill, Chapter 11.
- ❑ R. Jain, “FDDI Handbook: High Speed Networking Using Fiber and Other Media,” Addison-Wesley, 1994, Chapter 12.
- ❑ M. Rose, “The Simple Book - An Introduction to TCP/IP based Internets,” Prentice Hall, 1991.

SNMP: RFCs

- ❑ [RFC2064] N. Brownlee, "Traffic Flow Measurement: Meter MIB", 01/03/1997, 38 pages.
- ❑ [RFC2039] C. Kalbfleisch, "Applicability of Standards Track MIBs to Management of World Wide Web Servers", 11/06/1996, 14 pages.
- ❑ [RFC2037] K. McCloghrie, A. Bierman, "Entity MIB", 10/30/1996, 35 pages.
- ❑ [RFC2013] K. McCloghrie, "SNMPv2 Management Information Base for the User Datagram Protocol using SMIV2", 11/12/1996, 6 pages. (Updates RFC1213)
- ❑ [RFC2012] K. McCloghrie, "SNMPv2 Management Information Base for the Transmission Control Protocol", 11/12/1996, 10 pages. (Updates RFC1213)
- ❑ [RFC2011] K. McCloghrie, "SNMPv2 Management Information Base for the Internet Protocol using SMIV2", 11/12/1996, 18 pages. (Updates RFC1213)

- ❑ [RFC1908] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Coexistence between Version 1 and Version 2 of the Internet-standard Network Management Framework", 01/22/1996, 10 pages.
- ❑ [RFC1907] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Management Information Base for Version 2 of the Simple Network Management Protocol (SNMPv2)", 01/22/1996, 20 pages.
- ❑ [RFC1906] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Transport Mappings for Version 2 of the Simple Network Management Protocol (SNMPv2)", 01/22/1996, 13 pages.
- ❑ [RFC1905] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Protocol Operations for Version 2 of the Simple Network Management Protocol (SNMPv2)", 01/22/1996, 24 pages.
- ❑ [RFC1904] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Conformance Statements for Version 2 of the Simple Network Management Protocol (SNMPv2)", 01/22/1996, 24 pages.
- ❑ [RFC1903] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Textual Conventions for Version 2 of the Simple Network Management Protocol (SNMPv2)", 01/22/1996, 23 pages.

- ❑ [RFC1902] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Structure of Management Information for Version 2 of the Simple Network Management Protocol (SNMPv2)", 01/22/1996, 40 pages.
- ❑ [RFC1850] F. Baker, R. Coltun, "OSPF Version 2 Management Information Base", 11/03/1995, 80 pages.
- ❑ [RFC1792] T. Sung, "TCP/IPX Connection Mib Specification", 04/18/1995, 9 pages.
- ❑ [RFC1757] S. Waldbusser, "Remote Network Monitoring Management Information Base", 02/10/1995, 91 pages.
- ❑ [RFC1749] K. McCloghrie, F. Baker, E. Decker, "IEEE 802.5 Station Source Routing MIB using SMIV2", 12/29/1994, 10 pages. (Updates RFC1748)
- ❑ [RFC1748] K. McCloghrie, E. Decker, "IEEE 802.5 MIB using SMIV2", 12/29/1994, 25 pages. (Updated by RFC1749)
- ❑ [RFC1743] K. McCloghrie, E. Decker, "IEEE 802.5 MIB using SMIV2", 12/27/1994, 25 pages.
- ❑ [RFC1742] S. Waldbusser, K. Frisa, "AppleTalk Management Information Base II", 01/05/1995, 84 pages.

- ❑ [RFC1724] G. Malkin, F. Baker, "RIP Version 2 MIB Extension", 11/15/1994, 18 pages.
- ❑ [RFC1697] D. Brower, R. Purvy, A. Daniel, M. Sinykin, J. Smith, "Relational Database Management System (RDBMS) Management Information Base (MIB) using SMIV2", 08/23/1994, 38 pages.
- ❑ [RFC1696] J. Barnes, L. Brown, R. Royston, S. Waldbusser, "Modem Management Information Base (MIB) using SMIV2", 08/25/1994, 31 pages.
- ❑ [RFC1695] M. Ahmed, K. Tesink, "Definitions of Managed Objects for ATM Management Version 8.0 using SMIV2", 08/25/1994, 73 pages.
- ❑ [RFC1628] J. Case, "UPS Management Information Base", 05/19/1994, 45 pages.
- ❑ [RFC1612] R. Austein, J. Saperia, "DNS Resolver MIB Extensions", 05/17/1994, 36 pages.
- ❑ [RFC1611] R. Austein, J. Saperia, "DNS Server MIB Extensions", 05/17/1994, 32 pages.
- ❑ [RFC1593] W. McKenzie, J. Cheng, "SNA APPN Node MIB", 03/10/1994, 120 pages.

- ❑ [RFC1592] B. Wijnen, G. Carpenter, K. Curran, A. Sehgal, G. Waters, "Simple Network Management Protocol Distributed Protocol Interface Version 2.0", 03/03/1994, 54 pages.
- ❑ [RFC1573] K. McCloghrie, F. Kastenholz, "Evolution of the Interfaces Group of MIB-II", 01/20/1994, 55 pages.
- ❑ [RFC1567] G. Mansfield, S. Kille, "X.500 Directory Monitoring MIB", 01/11/1994, 19 pages.
- ❑ [RFC1566] N. Freed, S. Kille, "Mail Monitoring MIB", 01/11/1994, 21 pages.
- ❑ [RFC1565] N. Freed, S. Kille, "Network Services Monitoring MIB", 01/11/1994, 18 pages.
- ❑ [RFC1559] J. Saperia, "DECnet Phase IV MIB Extensions", 12/27/1993, 69 pages.
- ❑ [RFC1514] P. Grillo, S. Waldbusser, "Host Resources MIB", 09/23/1993, 33 pages.
- ❑ [RFC1513] S. Waldbusser, "Token Ring Extensions to the Remote Network Monitoring MIB", 09/23/1993, 55 pages. (Updates RFC1271)

- ❑ [RFC1512] J. Case, A. Rijsinghani, "FDDI Management Information Base", 09/10/1993, 51 pages. (Updates RFC1285)
- ❑ [RFC1470] R. Enger, J. Reynolds, "FYI on a Network Management Tool Catalog: Tools for Monitoring and Debugging TCP/IP Internets and Interconnected Devices", 06/25/1993, 216 pages. (FYI 2)
- ❑ [RFC1461] D. Throop, "SNMP MIB extension for MultiProtocol Interconnect over X.25", 05/27/1993, 30 pages.
- ❑ [RFC1452] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Coexistence between version 1 and version 2 of the Internet-standard Network Management Framework", 05/03/1993, 17 pages.
- ❑ [RFC1451] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Manager to Manager Management Information Base", 05/03/1993, 36 pages.
- ❑ [RFC1450] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Management Information Base for version 2 of the Simple Network Management Protocol (SNMPv2)", 05/03/1993, 27 pages.
- ❑ [RFC1449] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Transport Mappings for version 2 of the Simple Network Management Protocol (SNMPv2)", 05/03/1993, 24 pages.

- ❑ [RFC1448] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Protocol Operations for version 2 of the Simple Network Management Protocol (SNMPv2)", 05/03/1993, 36 pages.
- ❑ [RFC1447] K. McCloghrie, J. Galvin, "Party MIB for version 2 of the Simple Network Management Protocol (SNMPv2)", 05/03/1993, 50 pages.
- ❑ [RFC1446] J. Galvin, K. McCloghrie, "Security Protocols for version 2 of the Simple Network Management Protocol (SNMPv2)", 05/03/1993, 51 pages.
- ❑ [RFC1445] J. Davin, K. McCloghie, "Administrative Model for version 2 of the Simple Network Management Protocol (SNMPv2)", 05/03/1993, 47 pages.
- ❑ [RFC1444] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Conformance Statements for version 2 of the Simple Network Management Protocol (SNMPv2)", 05/03/1993, 33 pages.
- ❑ [RFC1443] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Textual Conventions for version 2 of the Simple Network Management Protocol (SNMPv2)", 05/03/1993, 31 pages.

- ❑ [RFC1442] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Structure of Management Information for version 2 of the Simple Network Management Protocol (SNMPv2)", 05/03/1993, 55 pages.
- ❑ [RFC1441] J. Case, K. McCloghrie, M. Rose, S. Waldbusser, "Introduction to version 2 of the Internet-standard Network Management Framework", 05/03/1993, 13 pages.
- ❑ [RFC1414] M. St. Johns, M. Rose, "Ident MIB", 02/04/1993, 13 pages.
- ❑ [RFC1389] G. Malkin, F. Baker, "RIP Version 2 MIB Extension", 01/08/1993, 13 pages.
- ❑ [RFC1382] D. Throop, "SNMP MIB Extension for the X.25 Packet Layer", 11/10/1992, 69 pages.
- ❑ [RFC1381] D. Throop, F. Baker, "SNMP MIB Extension for X.25 LAPB", 11/10/1992, 33 pages.
- ❑ [RFC1369] F. Kastenholtz, "Implementation Notes and Experience for The Internet Ethernet MIB", 10/23/1992, 7 pages.
- ❑ [RFC1354] F. Baker, "IP Forwarding Table MIB", 07/06/1992, 12 pages.
- ❑ [RFC1315] C. Brown, F. Baker, C. Carvalho, "Management Information Base for Frame Relay DTEs", 04/09/1992, 19 pages.

- ❑ [RFC1289] J. Saperia, "DECnet Phase IV MIB Extensions", 12/20/1991, 64 pages.
- ❑ [RFC1285] J. Case, "FDDI Management Information Base", 01/24/1992, 46 pages. (Updated by RFC1512)
- ❑ [RFC1271] S. Waldbusser, "Remote Network Monitoring Management Information Base", 11/12/1991, 81 pages. (Updated by RFC1513)
- ❑ [RFC1253] F. Baker, R. Coltun, "OSPF Version 2 Management Information Base", 08/30/1991, 42 pages.
- ❑ [RFC1252] F. Baker, R. Coltun, "OSPF Version 2 Management Information Base", 08/21/1991, 42 pages.
- ❑ [RFC1248] F. Baker, R. Coltun, "OSPF Version 2 Management Information Base", 08/08/1991, 42 pages. (Updated by RFC1349)
- ❑ [RFC1243] S. Waldbusser, "AppleTalk Management Information Base", 07/08/1991, 29 pages.
- ❑ [RFC1239] J. Reynolds, "Reassignment of Experimental MIBs to Standard MIBs", 06/25/1991, 2 pages. (Updates RFC1233)

- ❑ [RFC1238] S. Satz, "CLNS MIB - for use with Connectionless Network Protocol (ISO 8473) and End System to Intermediate System (ISO 9542)", 06/25/1991, 32 pages.
- ❑ [RFC1231] E. Decker, R. Fox, K. McCloghrie, "IEEE 802.5 Token Ring MIB", 02/11/1993, 23 pages.
- ❑ [RFC1230] R. Fox, K. McCloghrie, "IEEE 802.4 Token Bus MIB", 05/23/1991, 23 pages.
- ❑ [RFC1229] K. McCloghrie, "Extensions to the Generic-Interface MIB", 08/03/1992, 16 pages.
- ❑ [RFC1228] G. Carpenter, B. Wijnen, "SNMP-DPI - Simple Network Management Protocol Distributed Program Interface", 05/23/1991, 50 pages.
- ❑ [RFC1227] M. Rose, "SNMP MUX Protocol and MIB", 05/23/1991, 13 pages.
- ❑ [RFC1189] L. Besaw, B. Handspicker, L. LaBarre, U. Warrior, "The Common Management Information Services and Protocols for the Internet", 10/26/1990, 15 pages.

- ❑ [RFC1158] M. Rose, "Management Information Base for Network Management of TCP/IP-based internets: MIB-II", 05/23/1990, 133 pages.
- ❑ [RFC1157] M. Schoffstall, M. Fedor, J. Davin, J. Case, "A Simple Network Management Protocol (SNMP)", 05/10/1990, 36 pages. (Updates RFC1098) (STD 15)
- ❑ [RFC1156] K. McCloghrie, M. Rose, "Management Information Base for Network Management of TCP/IP-based internets", 05/10/1990, 91 pages. (Updates RFC1066)
- ❑ [RFC1155] K. McCloghrie, M. Rose, "Structure and Identification of Management Information for TCP/IP-based Internets", 05/10/1990, 22 pages. (Updates RFC1065) (STD 17)
- ❑ [RFC1147] R. Stine, "FYI on a Network Management Tool Catalog: Tools for Monitoring and Debugging TCP/IP Internets and Interconnected Devices", 04/04/1990, 126 pages. (FYI 2)
- ❑ [RFC1109] V. Cerf, "Report of the second Ad Hoc Network Management Review Group", 08/01/1989, 8 pages.
- ❑ [RFC1098] J. Case, C. Davin, M. Fedor, "Simple Network Management Protocol SNMP", 04/01/1989, 34 pages. (Updated by RFC1157)

- ❑ [RFC1095] U. Warrior, L. Besaw, "Common Management Information Services and Protocol over TCP/IP CMOT", 04/01/1989, 67 pages.
- ❑ [RFC1067] J. Case, M. Fedor, M. Schoffstall, J. Davin, "Simple Network Management Protocol", 08/01/1988, 33 pages.
- ❑ [RFC1066] K. McCloghrie, M. Rose, "Management Information Base for network management of TCP/IP-based internets", 08/01/1988, 90 pages. (Updated by RFC1156)
- ❑ [RFC1065] K. McCloghrie, M. Rose, "Structure and identification of management information for TCP/IP-based internets", 08/01/1988, 21 pages. (Updated by RFC1155)
- ❑ [RFC1052] V. Cerf, "IAB recommendations for the development of Internet network management standards", 04/01/1988, 14 pages.
- ❑ [RFC1022] C. Partridge, G. Trewitt, "High-level Entity Management Protocol HEMP", 10/01/1987, 12 pages.
- ❑ [RFC1021] C. Partridge, G. Trewitt, "High-level Entity Management System HEMS", 10/01/1987, 5 pages.