TTM 4128 Exam June 10th 2010 - Solution

Enclosed : Shortened version of RFC 4022

Task 1. General (15 %)

Please provide short and precise answers.

(5%) Describe shortly the four models that constitute the OSI Network Management Model.

See overheads from lectures:

3.2 Network Management Model

OSI Network Management Model - 1

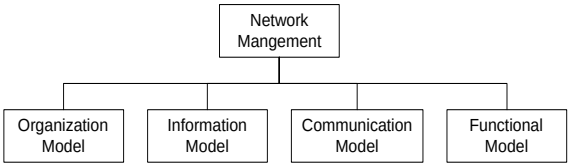

Figure 3.1 OSI Network Management Model

- **Organization Model**
  - **Network management components (*agent*, *manager*, *managed objects*)**
  - **Functions of components**
  - **Relationships**
- **Information model, which is *object oriented *)***
  - **Structure of Management Information (SMI) = Syntax and semantics for the definition of MIB objects. A MIB object is a managed object type.**
  - **Management information base (MIB) = The system of MIB objects.**

) This total description is also valid for SNMP except the *object-orientation

OSI Network Management Model - 2

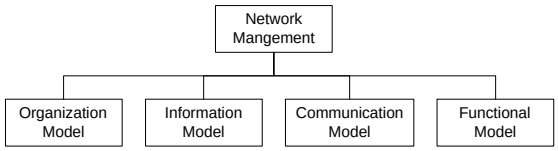

Figure 3.1 OSI Network Management Model

- **Communication Model**
  - **Management application layer processes**
  - **Layer management**
  - **Layer operations**
- **Functional Model**
  - **FCAPS** *(See Section 3.9)*
  - **Service management**
  - **Business management**

Service and Business management functionality is layered on top of FCAPS. In this context "service" is an administrative telecom services.

1.2. (5%) Explain the overall learning objectives of TTM4128? Which overall learning objectives does the OSI Network Management Model support?

See overheads from lectures:

Learning objectives

- **Knowledge**
  - To get a *basic understanding* of principles and architectures for management of networks and networked services
  - To get a *profound understanding* of SNMP as an architecture and platform for network management
  - To get a *profound understanding* of Web-based management
  - To get a *basic understanding* of some architectures for Adaptive Systems and Autonomic Communication
- **Skills**
  - To be able to communicate, reason and creatively think about management of networks and networked services
  - To be able to design, implement and use web-based platforms for network management
  - To be able to configure and use SNMP-based tools for network management

The OSI Network Management Model supports all learning objectives.

1.3 (5%) How do the various models of the SNMP Management Framework comply with the models of the OSI Network Management Model?
See overheads from lectures:

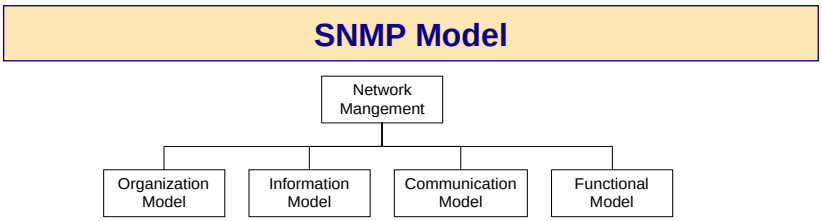

Figure 3.1 SNMP Network Management Model

- **Organization Model**
  - **Same as for OSI management model**
- **Information Model**
  - **Same as for OSI management model, but *scalar***
- **Communication Model**
  - **Messages less complex than OSI and unidirectional**
- **Functional Model**
  - **Application functions**
    - ➔ **Operations and notifications of the SNMP protocol**
    - ➔ **Administrative model**
    - ➔ **Security model**

Task 2. Web services (15 %)
Please provide short and precise answers.

2.1 (7.5 %) What is the vision of the semantic Web? What are the current main components of the Semantic Web? What is the application area of these components?

The semantic Web is the Web that carries semantics or meanings enabling users to search not only for documents that contain data, but also for the desired data itself, through “semantic” identification and location techniques
It supports software agents that are able not only to locate data but to perform meaningful tasks with data automatically and on the fly that must be done manually on the first version of the World Wide Web and episodically by computer users.

The current main components of the Semantic Web are as follows:
- RDF is a datamodel for objects ("resources") and relations between them. It provides simple semantics for this datamodel. These datamodels can be represented in an XML syntax.
- RDF Schema is a vocabulary for describing properties and classes of RDF resources, with semantics for generalization-hierarchies of such properties and classes.
- OWL, derived from OWL+OIL adds more vocabulary for describing properties and classes: among others, relations between classes (e.g. disjointness), cardinality (e.g. "exactly one"), equality, richer typing of properties, characteristics of properties (e.g. symmetry), and enumerated classes

2.2. (7.5 %) Explain how XML can be used to represent semantics. Give an example to illustrate.

XML tags are used to represent semantics. XML tags are not predefined as in HTML. Everybody can define their own tags and hence introduce new semantics to the Web.

A simple example to illustrate that is as follows:

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<note>
<to>Tove</to>
<from>Jani</from>
<heading>Reminder</heading>
<body>Don't forget me this weekend!</body>
</note>
```

This document contains a note, which is defined by a simple XML Schema file called "note.xsd" that defines the elements of the XML document above ("note.xml"):

```
<?xml version="1.0"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
targetNamespace="http://www.w3schools.com"
xmlns="http://www.w3schools.com"
elementFormDefault="qualified"><xs:element name="note">
   <xs:complexType>
     <xs:sequence>
          <xs:element name="to" type="xs:string"/>
          <xs:element name="from" type="xs:string"/>
          <xs:element name="heading" type="xs:string"/>
          <xs:element name="body" type="xs:string"/>
     </xs:sequence>
   </xs:complexType>
</xs:element></xs:schema>
```

Task 3. TCP MIB. (30%)
Please provide short and precise answers.

3.1. (5%) In the enclosed RFC 4022 defining the TCP MIB there are object instances of types defined by different Macros. Select 3 of these types. What are the types you have selected used for?

In RFC4022 there are types defined from 5 different macros:

MODULE-IDENTITY
Used for administrative information about modules

OBJECT-TYPE
Used to define managed object types

OBJECT-IDENTIFIER
Used to defined nodes for administrative purposes

OBJECT-GROUP
Used to define object groups. An object group defines a set of managed object types.

MODULE-COMPLIANCE
It specifies the minimum set of defined MIB types of a MIB Modules that should be implemented. Defined object groups are used. OBJECTMANDATORY-GROUPS are required, GROUPS are optional

3.2. (5%) Describe the structure of valid nodes in the MIB-tree for *managed object types* defined by RFC4022

Managed objects types are types which instances can be accessed by managers via agent. The structure of valid nodes in the mob-tree is as follows:

tcp ::= {mib-2 6}

The scalars are subnodes of tcp from {tcp 1} to {tcp 19}.

The TCP Connection table is defined by
tcpConnnectionTable ::={tcp 19}
tcpConnectionEntry ::= {tcpConnectionTable 1}

The tabular elelemets of the table are defined as {tcpConnectionEntry 1} to {tcpConnectionEntry 8}

The TCP Listener table is defined by
tcpListenerTable ::={tcp 20}
tcpListenerEntry ::= {tcpListenerTable 1}

The tabular elelemets of the table are defined as {tcpListenerEntry 1} to {tcpListenerEntry 4}

3.3. (10%) Define an instance of tcpConnectionTable defined in RFC4022. The table shall have two rows and are placed in a WEB server with IP-address 129.241.200.19. The MIB Type InetAddressType has Syntax INTEGER unknown (0) ipv4 (1) ipv6 (2) ipv4z (3) ipv6z (4) dns (16). We use IPv4 addressing

Which attributes are index attributes? What are index attributes in general used for?

```
TcpConnectionEntry ::= SEQUENCE {
      tcpConnectionLocalAddressType   InetAddressType,
      tcpConnectionLocalAddress       InetAddress,
      tcpConnectionLocalPort          InetPortNumber,
      tcpConnectionRemAddressType     InetAddressType,
      tcpConnectionRemAddress         InetAddress,
      tcpConnectionRemPort            InetPortNumber,
      tcpConnectionState              INTEGER,
      tcpConnectionProcess            Unsigned32
   }
```

The Indexing attributes are { tcpConnectionLocalAddressType, tcpConnectionLocalAddress, tcpConnectionLocalPort, tcpConnectionRemAddressType, tcpConnectionRemAddress, tcpConnectionRemPort }

The indexing attributes are used for non-ambiguous selection of rows.

An instance example:

1 129.241.200.19 80 1 129.241.61.254 1688 5 40
1 129.241.200.19 80 1 129.241.61.255 2432 7 60

3.4. (10%) A manager shall access the values of tcpConnectionState in the defined instance of tcpConnectionTable. The manager has no knowledge about the content of the table. The manger will access the table by using *getnext-request.*

Describe the principal sequence of commands and responses exchanged between the manager and the agent. Object identifiers used must be defined. (Version and Community is not used in this case).

getnext-request
iso.org.dod.internet.mgmt.mib2.tcp.tcpConnectionTable.tcpConnectionState

getnext-response iso.org.dod.internet.mgmt.mib-2.tcp.tcpConnectionTable.
tcpConnectionState.1.129.241.200.19.80.1.129.241.61.254.1688 = 5

getnext-request iso.org.dod.internet.mgmt.mib2.tcp.tcpConnectionTable.
tcpConnectionState.1.129.241.200.19.80.1.129.241.61.254.1688

getnext-response iso.org.dod.internet.mgmt.mib-2.tcp.tcpConnectionTable.
tcpConnectionState.1.129.241.200.19.80.1.129.241.61.255.2432 = 7

getnext-request iso.org.dod.internet.mgmt.mib2.tcp.tcpConnectionTable.
tcpConnectionState. 1.129.241.200.19.80.1.129.241.61.255.2432

getnext-response (“endofmibview”)

Which net-snmp commands can be used to traverse tables?

snmpgetnext, snmpgetbulk, snmpwalk and snmptable

Task 4. CIM and CIM /WBEM. (15 %)
Please provide short and precise answers.

4.1. (5%) What is the CIM Extension Schema?

A CIM Extension schema is a collection of classes/objects, attributes and methods that are used to model management objects. Such schema:
- Represents technology and platform-specific extensions to the CIM Common Model
- Specific to environments such as operating systems. Vendors extend the model for their products by creating subclasses of objects.
- Applications can then transverse object instances in the standard model to manage different products in a heterogeneous environment

4.2. (5%) Explain three different ways to express CIM specifications?

There are three different ways to express CIM specifications, namely: MOF, UML, and XML:
- MOF (Managed Object Format):
  - Based on the Interface Definition Language (IDL) to represent management information
  - This expression is represented as ASCII or Unicode
- UML (Unified Modeling Language):
  - UML class diagrams
  - Using a UML tool, e.g. Visio, Rational Rose, etc.
- XML (eXtensible Markup Language)
  - XML grammar describes CIM metaschema
  - Detailed in DTD (Document Type Definition) specifying tags such as CLASS, INSTANCE and QUALIFIER

4.3. (5%) List the most important elements of the CIM meta schema

- Schema is a group of classes with single owner. Schemas are used for administration and class naming
- Class is a collection of instances that support the same type. Classes can have Methods, participate in associations (relationships) and methods (behaviour)
- Association is a class that contains two or more references. It represents a relationship between two or more objects
- Triggers generate Indications when property/object changes state
- Indication is an object created as a result of a trigger
- Qualifiers are used to characterize named elements, and control sub-typing.
- Reference defines the role an object plays in a relationship
- Property Data Types include signed and unsigned integers, floats, and strings.

Task 5. A Network Management Application (25%)
Please provide short and precise answers.

We are considering a network management system as illustrated in Figure 1. A user on a PC X can by using a web browser retrieve a value of an MIB object instance. The user provides as input:

- the IP address of the managed component (agent)
- a community name configured in the agent
- a MIB object name or an ‘alias’ name, e.g. *hrSystemUptime* or *hostuptime*

The **manager** communicates with the agents by using *net-snmp*. In the agents a *net-snmp* daemon `snmpd` is running with a different community name in each of the agents. Some of the agents are configured to accept snmp version 1 (v1) commands and the others version 2 (v2c) commands.

5.1. (15%) Design an application running in the same component as the manager that provides the service specified above. Explain your design including the technologies and protocols that are used.

Using ontology, we create an OWL file. In the file we build a model in which define MIB object names and their 'alias' names. The model also includes some properties that allow an inference of relations from 'alias' names to respective MIB object names. For example, hostuptime is related to hrSystemUptime.

Then, we create a semantic web application (e.g., using Jena Framework) to be executed on the Manager side. This application reads the OWL file and creates an inferred model from it by applying a reasoner. Using the inferred model, the application can look an MIB object name up given an alias name. It can also execute snmpget command to an agent to get a value of an MIB object instance. To execute a correct command, it also needs a table mapping the agents to its configured snmp version.
Using web services application (e.g., Apache Axis), we deploy a web service (server side) that will also run on the manager. Hence, the web services application can be accessed by using a web browser.

5.2. (10%) A user gives the following input on a web browser in PCX.

- *123.12.13.14*
- *abc* (community name)
- *hostuptime*

Explain how your designed application works. Explain what happens from the user activates the web browser until the user receives the result. The types of messages exchanged must be defined.

The user gives input hostuptime and 123.12.13.14 (the IP address of an agent) and abc (a community name) on a web browser in PC X. These input are sent to the manager. They are encapsulated in SOAP request which is placed as a payload of an HTTP GET message. Then, the application deployed on the manager will look the MIB object names of hostuptime up and should give hrSystemUptime as the result. The application will also find the snmp version configured in the agent from the mapping table. Thereafter, an snmpget command is constructed with version -v 2c and community name -c abc options. An snmp get-request message is sent to the agent which has IP 123.12.13.14, retrieving the value of hrSystemUptime object on the agent. The agent sends the result to the manager using an snmp get-response message.

The result is further forwarded to PC X, encapsulated as SOAP response in an HTTP response message.

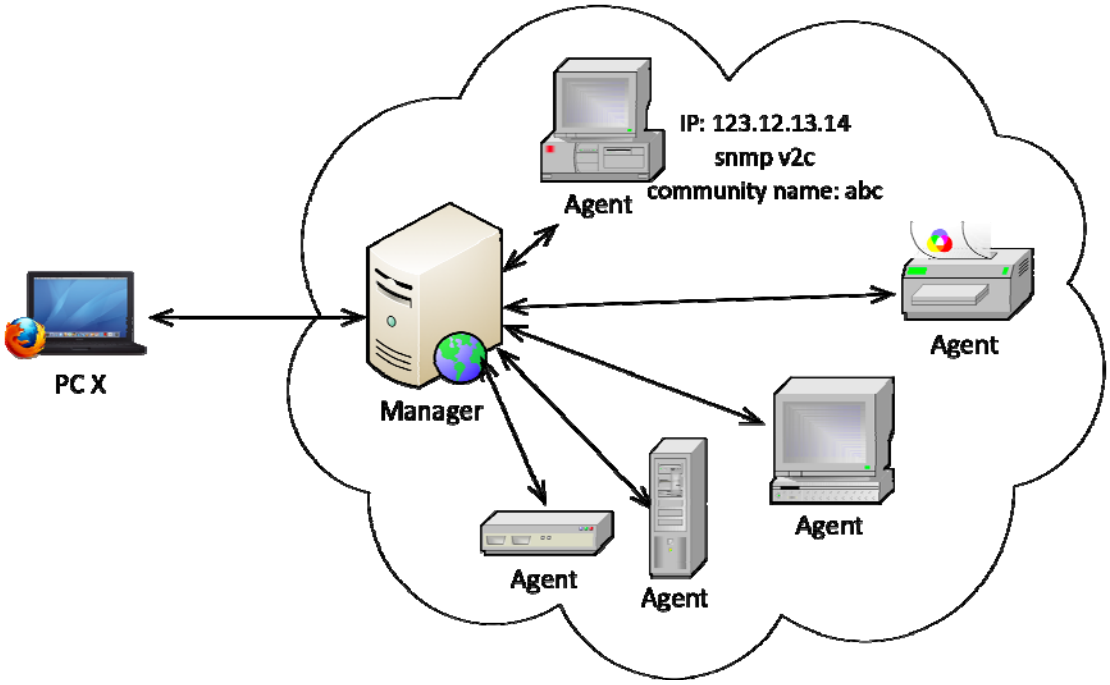

Figure 1.