Lecture 6:
Abstract Syntax Notation One ASN.1

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Abstract Syntax Notation One

- Both the information and communications models need to be specified syntactically and semantically.
- This requires a language that specifies the management protocol in the application layer.
- This is where Abstract Syntax Notation One (ASN.1) plays a role.
- ASN.1 is actually more than a syntax; it's a language.
- Addresses both syntax and semantics
- Two type of syntax
  - Abstract syntax: set of rules that specify data type and structure for information storage
  - Transfer syntax: set of rules for communicating information between systems
- Makes application layer protocols independent of lower layer protocols.
- Can generate machine-readable code: Basic Encoding Rules (BER) is used in management modules.
- It is based on the Backus-Nauer Form (BNF)

Backus-Nauer Form (BNF)

- BNF constructs are developed from primitives.
  - *<name> ::= <definition>*
  - <name> is "entity"
  - ::= "defined as"
  - <definition> is "primitive"
- Example: Simple Arithmetic Expression entity (<SAE>) is constructed from the primitives <digit> and <op>
  - <digit> ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
  - <number> ::= <digit> | <digit><number>
  - <op> ::= + | - | x | /
  - <SAE> ::= <number>|<SAE>|<SAE><op><SAE>
- Example:
  - 9 is primitive 9
  - 19 is construct of 1 and 9
  - 619 is construct of 6 and 19

Simple Arithmetic Expression
<SAE> ::= <SAE><op><SAE>
Example: 13 x 2

Type and Value

- The format of each line is defined as an assignment
  - <BooleanType> ::= BOOLEAN
  - <BooleanValue> ::= TRUE | FALSE
- ASN.1 module is a group of assignments; for example:

```
person-name Person-Name::=
        {
        first     "John",
        middle    "I",
        last      "Smith"
        }
```

Data Type: Example 1

- Module name starts with capital letters
- Data types:
  - Primitives: NULL, GraphicString
  - Constructs
    - Alternatives : CHOICE
    - List maker: SET, SEQUENCE
    - Repetition: SET OF, SEQUENCE OF:

```
PersonnelRecord ::= SET
        {         Name,
         title      GraphicString,
         division   CHOICE {
            marketing      [0]   SEQUENCE
              {Sector,
               Country},
        research       [1]   CHOICE
              {product-based      [0]   NULL,
               basic              [1]   NULL},
        production         [2]   SEQUENCE
              {Product-line,
               Country }              }
etc.
```

Figure 3.13 ASN.1 Data Type Definition Example 1

Data Type: Example 2

A list of invoices.

```
Trade-message ::= SEQUENCE
     {invoice-no          INTEGER
      name                GraphicString,
      details         SEQUENCE OF
                          SEQUENCE
                {part-no         INTEGER
                 quantity        INTEGER},
      charge            REAL,
      authenticator         Security-Type}

Security-Type ::= SET
     {    …
          …
          …   }
```

Figure 3.14 ASN.1 Data Type Definition Example 2

ASN.1 Symbols

Symbol	Meaning
::=	Defined as
|	or, alternative, options of a list
-	Signed number
--	Following the symbol are comments
{}	Start and end of a list
[]	Start and end of a tag
()	Start and end of subtype
..	Range

MIB Definition Example

The terms DEFINITIONS, BEGIN, and END, are keywords. This statement means that the RFC1213-MIB Module is being defined

```
RFC1213-MIB DEFINITIONS ::= BEGIN
…
…
…
END
```

ASN.1 Data Type Conventions

Data Types	Convention	Example
Object name	Initial lowercase letter	sysDescr, etherStatsPkts
Application data type	Initial uppercase letter	Counter, IpAddress
Module	Initial uppercase letter	PersonnelRecord
Macro, MIB module	All uppercase letters	RMON-MIB
Keywords	All uppercase letters	INTEGER, BEGIN

Data Type: Structure & Tag

- We will now use the ASN.1 notation to define the various data types and apply them to describe objects of SMI and MIB.
- Data types are defined based on Structure and Tags
  - Structure defines how data type is built
  - Tag uniquely identifies the data type

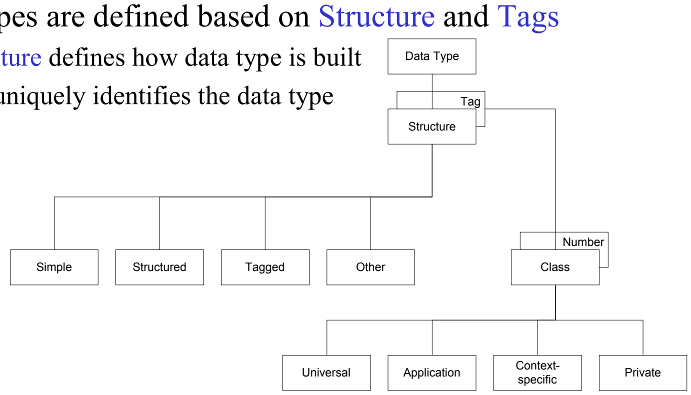


Figure 3.15 ASN.1 Data Type Structure and Tag

Structure

- Simple (values are specified directly)
  - PageNumber ::= INTEGER
  - ChapterNumber ::= INTEGER
- Structure / Construct (Contains other types)
  - BookPageNumber ::= SEQUENCE
    {ChapterNumber, Separator, PageNumber}
    Example: {1-1}
  - BookPages ::= SEQUENCE OF {BookPageNumbers}
    Example: {1-1, 2-3, 6-25}
- Tagged (Used primarily for efficiency)
  - Derived from another type; given a new ID
- Other types: (Data type that is not pre-defined)
  - values chosen from CHOICE and ANY types

Other Types

- CHOICE (No Data Types)

```
research Research ::= CHOICE
    {product-based   [0]    NULL,
     basic           [1]    NULL}
```

- CHOICE (Data Types)

```
research Research ::= CHOICE
    {product-based ProductType,
     basic    VisibleString}
    ProductType ::= VisibleString
```

- ANY (From the previous definitions)

```
Research ::= CHOICE
    {product-based ANY,
     basic    ANY}
```

Example of Sequence Structure

- Two ways to define all the pages of a book as a sequence of page numbers making certain that they are in order.

```
BookPages ::= SEQUENCE OF { BookPageNumber}
                        or
BookPages ::=
        SEQUENCE OF
        {
        SEQUENCE
          {ChapterNumber, Separator, PageNumber}
        }
```


Tag

- Tag uniquely identifies a data type. It is required for encoding the data types for communication.
- Every data type except CHOICE and ANY have data tags associated with them.
- Comprised of a class and tag number.
- Four Class types:
  - Universal – is the most common, like global variables in a software program.
  - Application - only in the application used, override universal.
  - Context-specific - specific context in application.
  - Private - used extensively by commercial vendors .

Tag	Type Name	Set of Values
Universal 1	BOOLEAN	TRUE or FALSE
Universal 2	INTEGER	0, Positive and negative numbers
Universal 3	BIT STRING	A string of binary digits or null set
Universal 4	OCTET STRING	A string of octets or null set
Universal 5	NULL	Null, single valued
Universal 6	OBJECT IDENTIFIER	Set of values associated with the object
Universal 7	Object description	Human readable text describing the object
Universal 8	EXTERNAL	The type is external to the standard
Universal 9	REAL	Real numbers, expressed in scientific notation Mantissa $\times$ base^{exponent}
Universal 10	ENUMERATED	Specified list of integers
Universal 11	ENCRYPTED	Encrypted information
Universal 12–15	Reserved for future use	
Universal 16	SEQUENCE and SEQUENCE OF	Ordered list of types
Universal 17	SET and SET OF	Unordered list of types
Universal 18	NumericString	Digits 0–9, space
Universal 19	PrintableString	Printable characters
Universal 20	TeletexString	Character set specified by CCITT Recommendation T.61

Context Specific Tag Example

```
PersonnelRecord ::= SET
        {       Name,
         title          GraphicString,
         division    CHOICE
            marketing            [0]   SEQUENCE
              {Sector,
               Country},
        research             [1]  CHOICE
              {product-based  [0]   NULL,
               basic              [1]   NULL},
        production         [2]  SEQUENCE
              {Product-line,
               Country      }              }
```

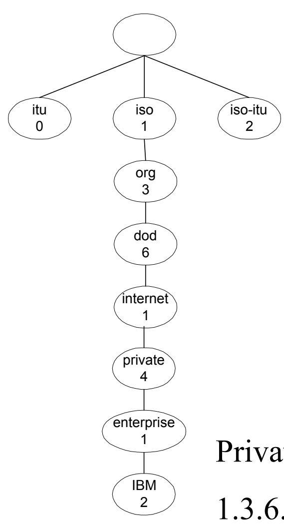
Figure 3.13 ASN.1 Data Type Definition Example 1

ASN.1 Module SNMP MIB Example

Address translation table.

```
IpNetMediaEntry ::=SEQUENCE{
        ipNetToMediaIfIndex          INTEGER,
        ipNetToMediaPhysAddress      PhysAddress,
        ipNetToMediaNetAddress       IpAddress,
        ipNetToMediaType             INTEGER}
```


Object Names and SMI Object Tree



- In a MIB there is an identifier for each occurrence of an object.

internet OBJECT IDENTIFIER ::=
{ISO(1) ORG(3) DOD(6) INTERNET(1)}

Private type identifier for IBM

1.3.6.1.4.1.2

Walkthrough Example

Description of a Personal Record

Name:	John P Smith
Title:	Director
Employee Number	51
Date of Hire:	17 September 1971
Name of Spouse;	Mary T Smith
Number of Children	2
Child Information	
Name	Ralph T Smith
Date of Birth	11 November 1957
Child Information	
Name	Susan B Jones
Date of Birth	17 July 1959

Walkthrough Example (…)

ASN.1 description of the record structure

```
PersonnelRecord ::= [APPLICATION 0] IMPLICIT SET {
        Name,
        title [0] VisibleString,
        number EmployeeNumber,
        dateOfHire [1] Date,
        nameOfSpouse [2] Name,
        children [3] IMPLICIT SEQUENCE OF ChildInformation DEFAULT { } }
ChildInformation ::= SET {
        Name,
        dateOfBirth [0] Date }
Name ::= [APPLICATION 1] IMPLICIT SEQUENCE {
        givenName VisibleString,
        initial VisibleString,
        familyName VisibleString }

EmployeeNumber ::= [APPLICATION 2] IMPLICIT INTEGER

Date ::=  [APPLICATION 3] IMPLICIT VisibleString -- YYYYMMDD
```

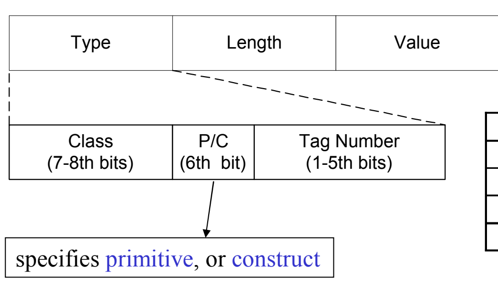
Walkthrough Example (…)

ASN.1 Description of a Record Value

{{ givenName “John”, initial “T”, familyName “Smith”},
title “Director”
number 51
dateOfHire “19710917”
nameOfSpouse { givenName “Mary”, initial “T”, familyName “Smith”},
children
{{{ givenName “Ralph”, initial “T”, familyName “Smith”},
dateOfBirth “19571111”},
{{ givenName “Susan”, initial “B”, familyName “Jones”},
dateOfBirth “19590717”}}}

TLV Encoding

- In ASN.1 ASCII text data is encoded into a bit-oriented data representation called TLV (Type, Length, and Value).
- TLV type, length, and value are components of the structure.



Class	8^{th} bit	7^{th} bit
Universal	0	0
Application	0	1
Context-specific	1	0
Private	1	1

ASN.1 Macro

- ASN.1 allows extensions to define new data types and values through a Macro definition.
- They also facilitate grouping of instances of an object.

```
<macroname> MACRO ::=
BEGIN
    TYPE NOTATION ::=  <syntaxOfNewType>
    VALUE NOTATION ::= <syntaxOfNewValue>
    <auxiliaryAssignments>
END
```


Macro Example

From ITU-T X.219:

```
ERROR  MACRO  ::=
  BEGIN
   TYPE NOTATION    ::=    Parameter
   VALUE NOTATION   ::=    value (VALUE CHOICE
                          { localValue   INTEGER,
                            globalValue  OBJECT IDENTIFIER
                          })
   Parameter       ::=   ``PARAMETER" NamedType | empty
   NamedType       ::=    identifier type  |  type
  END
```

Usage:

```
BadQueueName   ERROR
               PARAMETER   QueueName
                ::= 0
```