ASN.1

Communication between Heterogeneous Systems

Olivier Dubuisson

translated from French by Philippe Fouquart

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Communication between heterogeneous systems

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ASN.1 (Abstract Syntax Notation One) is an international standard which aims at specifying of data used in telecommunication protocols. It is a computing language that is both powerful and complex: it was designed for modeling efficiently communications between heterogeneous systems.

ASN.1 was in great need of a reference book, didactic as well as precise and Olivier Dubuisson's book meets these demands. The language is comprehensively described from its basic constructions to the latest additions to the notation. The description of each of these constructions is wholly accessible and accurate. Many case studies of real-world applications illustrate this presentation. The text also replaces the language in its historical background and describes the context in which it is used, both from the application viewpoint and from that of other specification standards which use or refer to ASN.1.

This book is written by an expert of ASN.1, of its syntax and semantics, and clearly constitutes a reference on the language. It is intended for those merely interested in finding a complete and reliable description of the language and for programmers or experts who may want to look up for the proper usage of some constructions. The tools available on the website associated with this book will prove useful to both the proficient and the beginner ASN.1 user.

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Chapter 7

Protocols specified in ASN.1

Contents

> What a tremendous advantage not to have done anything, but this should be enjoyed with moderation.
>
> Antoine Rivarol.

As a conclusion for this introductory part, we describe a few application domains of the ASN.1 notation. Though wordy it might seem, this chapter is not meant to be a comprehensive description of all the protocols specified with ASN.1 and many other application domains will undoubtedly emerge in the near future.

7.1 High-level layers of the OSI model

As we shall see on page 361, the Presentation Protocol Data Unit (PPDU, 6th layer) is specified with ASN.1 [ISO8823-1]. Some PPDUs (particularly those of connection denial and connection acceptance for Presentation) are described in the module `ISO-8823-PRESENTATION`. Each PPDV is transmitted afterwards as a parameter of a Session primitive (5th layer, see Figure 3.1 on page 18).

The Application layer (7th layer) is divided into service elements, that are standardized for being often used by communicating applications. The data transfer brought about by the service elements are necessarily specified in ASN.1. We can mention:

- the *Association Control Service Element* (ACSE, [ISO8650-1] standard), which manages the establishment and termination of the connections between two distant applications;
- the *Commitment, Concurrency, and Recovery* service element (CCR, [ISO9805-1] standard), which provides a number of cooperation and synchronization task functions in a distributed environment: it makes sure the operation left to a remote application (a database update, for instance) is executed properly, it ensures the information coherence when several processes are running in parallel and re-establishes a clean environment if errors or failures occur;
- the *Remote Operation Service Element* (ROSE, [ISO13712-1] standard): a very general client-server mecanism, which hides from the application programmer the existence of a communication between processes; it can ask the remote application to execute operations or to collect results and errors; each interface's operation is described with ASN.1 as an information object of the `OPERATION` class; ROSE provides a common and standardized method for carrying requests and answers laying by specific gaps in the APDU to be filled in dynamically during communication;
- the *Reliable Transfer Service Element* (RTSE, [ISO9066-2] standard) which can transfer safely and permanently APDUs by taking over the communication where the transfer was interrupted or warning off the sender that the transfer is not possible.

These generic service elements can then be combined more easily to build up applications for which data transfers are also specified in ASN.1 such as:

- the *File Transfer, Access, and Management service* (FTAM, [ISO8571-4] standard) for transferring files or programs between heterogeneous systems. It also provides an access to the files to read or write, to change the rights they have been attributed, or to change their size and content description (equivalent to the Unix `ftp`);
- the *Virtual Terminal service* (VT, ISO 9041 standard) for controlling a terminal that screen, keyboard and some peripheral like a printer for example, without the application knowing all the types of terminal which it may deal with (equivalent to the Unix `telnet`);
- the *Job Transfer and Manipulation service* (JTM, ISO 8832 standard) for executing data processing from a remote machine (a complex computation on a powerful computer for instance), supervising it and getting the results.

7.2 X.400 electronic mail system

E-mail is probably one of today's most famous information technology applications. It is therefore worthwhile describing what is meant by this expression. As exposed in our history review on page 60, it had a most important role for ASN.1 because the X.208 standard (ASN.1 first edition) directly resulted from the X.409:1984 notation, which had been designed for representing the various parts of an e-mail. Indeed, as the eighties saw the use of e-mail become more common, the CCITT was led to standardize an OSI-compliant e-mail service.

Today, the most industrialized countries have an e-mail public service that conforms to the X.400 standard service[1]. Such a service promotes the development of communicating applications particularly in office

[1]The equivalent ISO standard is called MOTIS (*Message Oriented Text Interchange System*) recorded as ISO 10021. Information about the X.400 standard services can be found at http://ftp.net-tel.co.uk/iso-iec-jtc1-sc33-wg1/ and http://www.alvestrand.no/x400/.

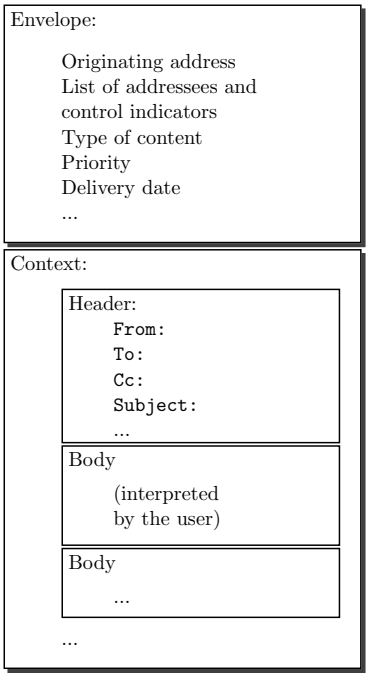

Figure 7.1: Structure of an X.400 message

automation and computerized documents (see Section 7.6 on page 88). The X.400 standards define the message format, given in Figure 7.1, and the exchange protocol but the message content is up to the user, and therefore outside the boundaries of the OSI world.

This standard series, which consists of about 5,000 lines of ASN.1 notations was completely rewritten to be compliant with all the functionalities of the ASN.1:1994 edition. The extract in Figure 7.2 on the next page is the ASN.1 definition (slightly simplified) of the envelope of message delivery according to Figure 7.1. The description of ASN.1 concepts in the previous chapter should be sufficient to make out the data types of this envelope.

Compared to the *Simple Mail Transfer Protocol* (SMTP), the e-mail protocol on the Internet, a BER-encoded X.400 message is more compact and offers more security since it is possible to ask for an acknowledgement of receipt and reading. On the other hand, SMTP fans may argue that BER encoding, which requires a decoder, is not as readable as the SMTP ASCII encoding, which transfer characters 'as is'.

```
MessageSubmissionArgument ::= SEQUENCE {
  envelope  MessageSubmissionEnvelope,
  content   Content }
MessageSubmissionEnvelope ::= SET {
  originator-name        OriginatorName,
  original-encoded-information-types
    OriginalEncodedInformationTypes OPTIONAL,
  content-type           ContentType,
  content-identifier     ContentIdentifier OPTIONAL,
  priority               Priority DEFAULT normal,
  per-message-indicators PerMessageIndicators
                               DEFAULT {},
  deferred-delivery-time [0] DeferredDeliveryTime
                               OPTIONAL,
  per-recipient-fields   [1] SEQUENCE
    SIZE (1..ub-recipients) OF
    PerRecipientMessageSubmissionFields }
```

Figure 7.2: An extract of ASN.1 for an X.400 message

7.3 X.500 Directory

The directory (ITU-T X.500 recommendation series or ISO 9594 standards)[2] is an international and distributed database that can store any kind of information about persons, organizations, communicating application entities, terminals, mailing lists, etc. It is often described in parallel with the X.400 e-mail because it provides an interactive search of subscriber addresses but also other items of information like phone number, address, favorite medium (e-mail, fax, phone...), photography, public key encoding...

The X.500 directory is a hierarchical database. Every node of this international tree is identified with a number of standardized or locally defined attributes; it can be referenced by a unique distinguished name, which locates it within the tree. Powerful search requests using pattern matching with the attributes' values enable to implement the directory with a user-friendly interface.

ASN.1 is fully used for the X.500 directory, particularly to specify the requests and the modification of the *Directory Access Protocol* (DAP) attributes. Figure 7.3 on page 85 defines the information object class `ATTRIBUTE` which allows a description of each attribute (data types,

[2] http://www.dante.net/np/ds/osi.html, http://www.cenorm.be/isss/Workshop/DIR/Default.htm

applicable comparison rules, usage) and the class `MATCHING-RULE`, which is used to define compatibility rules between attributes (for example, case-insensitive comparisons to differentiate names).

Of course, the class `MATCHING-RULE` only defines the comparison function interface, for their implementation is down to each provider of the directory service.

For a more thorough description of the directory, the reader can refer to [Cha96]. The information object classes `ATTRIBUTE` and `MATCHING-RULE` above mentioned are used in Chapter 15. Finally it is worthwhile mentionning that the ASN.1 specifications of the X.500 service protocols are being adapted for the Internet.

7.4 Multimedia environments

A growth industry because of the Web or digital phone networks, the multimedia applications also benefit from standards formalized in ASN.1. MHEG (*Multimedia and Hypermedia information coding Expert Group*[3], ISO 13522 standard) uses an object-oriented approach to describe the representation of multimedia and hypermedia information for exchanging it between applications (using the Distinguished Encoding Rules, DER).

Numerous application domains for the MHEG standard are being considered such as interactive digital TV programs, pay-per-view, simulation games, tele-teaching, tele-shopping and many other services where real-time transfer and a regular updating of many multimedia objects are necessary.

There are eight MHEG object classes that are defined both in ASN.1 and in SGML (*Standard Generalized Markup Language*). These classes can transparently exchange objects encoded in many different formats (JPEG, MPEG, text...), including all proprietary formats. The MHEG objects can be icons or buttons to trigger actions when clicked. They are independent from the applications as well as from presentation supports.

In the domain of videoconferencing, which annual growth is huge particularly because the productivity gains induced make it grow in popularity among businessmen, the ITU-T T.120[4] recommendation series describes a multithread architecture of data communication within

[3] http://www.fokus.gmd.de/ovma/mug/
[4] http://www.databeam.com/ccts/t120primer.html

```
ATTRIBUTE ::= CLASS {
  &derivation           ATTRIBUTE OPTIONAL,
  &Type                 OPTIONAL,
  &equality-match       MATCHING-RULE OPTIONAL,
  &ordering-match       MATCHING-RULE OPTIONAL,
  &substrings-match     MATCHING-RULE OPTIONAL,
  &single-valued        BOOLEAN DEFAULT FALSE,
  &collective           BOOLEAN DEFAULT FALSE,
  &no-user-modification BOOLEAN DEFAULT FALSE,
  &usage                Attribute-Usage
                          DEFAULT userApplications,
  &id                   OBJECT IDENTIFIER UNIQUE }
WITH SYNTAX {
  [SUBTYPE OF               &derivation]
  [WITH SYNTAX              &Type]
  [EQUALITY MATCHING RULE   &equality-match]
  [ORDERING MATCHING RULE   &ordering-match]
  [SUBSTRINGS MATCHING RULE &substrings-match]
  [SINGLE VALUE             &single-valued]
  [COLLECTIVE               &collective]
  [NO USER MODIFICATION     &no-user-modification]
  [USAGE                    &usage]
   ID                       &id }

Attribute ::= SEQUENCE {
  type   ATTRIBUTE.&id ({SupportedAttributes}),
  values SET SIZE (1..MAX) OF
    Attribute.&Type ({SupportedAttributes}{@type})}

MATCHING-RULE ::= CLASS {
  &AssertionType OPTIONAL,
  &id            OBJECT IDENTIFIER UNIQUE }
WITH SYNTAX {
  [SYNTAX        &AssertionType]
   ID            &id }

caseIgnoreSubstringsMatch MATCHING-RULE ::= {
  SYNTAX   SubstringAssertion
  ID       id-mr-caseIgnoreSubstringsMatch }

SubstringAssertion ::= SEQUENCE OF CHOICE {
  initial [0] DirectoryString {ub-match},
  any     [1] DirectoryString {ub-match},
  final   [2] DirectoryString {ub-match} }
ub-match INTEGER ::= 128
```

Figure 7.3: Two information object classes defined in the X.500 directory

the environment of a multimedia conference. It describes the establishment of phone meetings regardless of the underlying networks and the exchange of any format of information (binary files, fixed images, notes...) during the meeting. The data protocol is obviously specified in ASN.1 and the encoding compliant with the Packed Encoding Rules (PER).

Many other protocols in multimedia are specified with ASN.1. For example, audiovisual and multimedia systems (ITU-T H.200 series), videophone over RNIS (ITU-T H.320 recommendation), real-time multimedia communication over the Internet (ITU-T H.225, H.245, H.323 recommendation)[5] and fax over the Internet (ITU-T T.38 recommendation)[6] have been regularly mentioned in the press lately.

7.5 The Internet

In the booming Internet world (it is estimated that 25% of the telephone traffic have moved on the Internet by 2003), ASN.1 has appeared for quite a long time now in many *Requests For Comments*[7] (RFC) that specify the Net protocols. RFC 1189[8] (*The Common Information Services and Protocols for the Internet, CMOT and CMIP*) and RFC 1157[9] (*A Simple Network Management Protocol*, SNMP) for example are two alternative protocols allowing a network to control and evaluate the performance of a remote network element.

Unfortunately, in retaining its space of freedom, the *Internet Engineering Task Force* (IETF) has often let itself be entangled in liberal usages of ASN.1. The main critics about RFC are the following:

- the systematical use of `OCTET STRING` to modelize ill-known data or to avoid specifying too formally what they stand for;
- the definition of many macros and macro instances to represent semantic links instead of information object classes and information objects although no ASN.1 compiler properly takes into account

[5] http://www.openh323.org/standards.html, http://people.itu.int/~jonesp/iptel/

[6] http://www.dialogic.com/company/whitepap/4631web.htm

[7] It is a fast way of proposing new standards for the Internet and receive comments (http://www.rfc-editor.org/overview.html).

[8] http://www.faqs.org/rfcs/rfc1189.html

[9] http://www.faqs.org/rfcs/rfc1157.html, http://www.simple-times.org, http://www.snmp-products.com/REF/ref.html

the macro concept (on the other hand, no compiler of the public domain does with the information object class concept unfortunately);

- it does not clearly define the ASN.1 version it uses and mixes up ASN.1:1990 and ASN.1:1994 features, which can result in tricky compilations;
- the liberties they take with ASN.1 syntax and sometimes with the BER encodign rules: this disrecpect any compilation by commercial tools or any use of the generic encoder and decoder they produce. This often leads to hand-made specification implementation.

Two important projects have been recently specified with ASN.1 even though the Internet community is generally quite reserved about such specifications (mainly because they are tagged with the ISO and OSI labels!).

Since its creation in 1992, the ANSI Z39.50 protocol (ISO 10163-1 standard)[10] is specified in ASN.1 and encoded with BER. A variant protocol was used in the WAIS service (*Wide Area Information Server*) to make all kinds of information accessible on the Internet (library catalogs, directories, `ftp` archives, newsgroups, images, source codes, multimedia documents). It provides facilities for keyword search, for extending a search by including new criteria to be applied to the documents already found and for downloading selected documents. The Z39.50 protocol is mainly used in libraries and information centers because it is well-suited for the note formats they deal with. New encoding rules called XER (see Section 21.5 on page 458) are still under construction to promote the use of this protocol on the Web.

The authentication and distribution systems *Kerberos*[11] developed by the *Massachusetts Institute of Technology* (MIT) is a software designed for securing data exchanges within the network of a university or an organization. Since its fifth version, the data transfers are specified in ASN.1. Microsoft has already announced that this authentication system would be supported by *Windows NT 5*®.

Similarly the *Public Key Cryptography Standard* PKCS[12] no. 7 [RSA93] describes with ASN.1 the syntax of encrypted messages with

[10] http://mda00.jrc.it/z39.50/z39.50-asn1.html
[11] http://www.mit.edu/afs/athena/astaff/project/kerberos/www/
[12] http://www.rsa.com/rsalabs/pubs/PKCS/, http://www.rsa.com/rsa/developers/

digital signature encoded in BER. The standard was produced in 1991 jointly by a consortium of computer manufacturers and the MIT.

Finally, business and electronic transaction protocols described in Section 7.7 on the next page, as well as multimedia communications presented in the previous section, are now increasing on an unprecedented scale with the Internet.

7.6 Electronic Data Interchange Protocols (EDI)

The automation of exchange in the legal, economic and business domains now removes needless manual data capture. In order to take advantage of such practice, several standards offer information structures for the documents exchanged.

The *Office Document Architecture* or ODA proposes to transmit in the content of the e-mail the format tags in addition to the text itself so that the addressee could browse the document according to the representation required by the sender. It is particularly suited for office procedures such as word processing, archives and document exchanges.

Specified in ASN.1, the exchanged format called ODIF (*Office Document Interchange Format*, ISO 8613-5 standard or ITU-T T.415 recommendation), enables the transfer of the document description (letter, report, invoice...) and their content (text, graphs, images...) via an X.400 e-mail.

Recommendation ITU-T X.435 proposes an EDI e-mail system above the X.400 e-mail. It is aimed at users of the EDIFACT standard for business document exchange (see Section 24.5 on page 492) and other common EDI syntaxes.

The *Document Transfer And Manipulation* standard (DTAM, ITU-T T.431 recommendations) provides a service for processing, access, management and transfer of documents structured according to the ODA architecture when associating two applications. This service is general enough to cover a wide diversity of telematic application demands such as the group IV fax (ISDN transmission, 5 seconds per page, colour option) and videotext sytems. These two standards are specified in ASN.1.

7.7 Business and electronic transactions

Another one of today's booming area thanks to the generalization of the Internet at home or at work, is that of electronic business[13]. In this context, the transaction security must free up from the diversity of payment media, networks and softwares, and ASN.1 accedes to these requirements.

SET (*Secured Electronic Transaction*)[14] is a standard made up jointly by several american companies (*Mastercard*, *Visa*, *American Express*, *Netscape*, IBM...) in order to secure financial exchange on the Internet. It is based on the PKCS no. 7 standard of public encryption described on page 87 and on the procedure [X.509] for the directory seen in Section 7.3 on page 83. It provides the following services: confidentiality of the information to the transaction, integrity of the transferred data, authentication of the account owner and of the business party.

In order to benefit from the French specificity (France was the first country where the use of chip-based cards, opposed to magnetic track-based cards, were generalized) a national organization called *GIE Cartes Bancaires*[15], in charge of defining card specificities for that country, developed a promising standard, adapted from the SET standard and called C-SET[16] (*Chip-SET*). Also specified in ASN.1, it relies on the card itself to secure the transaction and therefore avoids exchanging authentication certificate.

In the USA, the ANSI X.9[17] committee, which numbers more than 300 members (banks, investors, software companies, associations) is responsible for developing national standards to facilitate financial operations: electronic payment on the Internet, secured service for on-line banks, business messages, fund transfers, etc. All the standards describing these data transfers are specified in ASN.1.

7.8 Use in the context of other formal notations

ASN.1 is the data typing language in three standard formal notations that will be described more thoroughly in Chapter 23.

[13] http://www.ecom.cmu.edu/resources/elibrary/epaylinks.shtml
[14] http://www.setco.org/set_specifications.html
[15] http://www.cartes-bancaires.com, http://www.visa.com/nt/ecomm/set/main.html
[16] http://www.europayfrance.fr/fr/commerce/secur.htm
[17] http://www.x9.org

The *Guidelines for the Definition of Managed Objects* (GDMO, [ISO10165-4] standard) are used to model system administration and technical management aspects as managed objects made of attributes (whose types are described in ASN.1) and actions that modify the attributes' values (the operation arguments and return values are also typed in ASN.1).

System or network management ensures a reliable and continuous functioning while optimizing the performance and make up for hardware failures. Every part of a computer or telecommunication network can be monitored: routers, queues, sensors, logs, software versions, clocks, accounts...

The *Common Management Information Protocol* (CMIP, [ISO9596-1] standard) in charge of the bi-directionnal dispatching of all the management information (the managed objects) between the manager and the agents is specified in ASN.1.

SDL (*Specification and Description Language*, ITU-T Z.100 recommendation) formalizes various concepts of telecommunication networks: signalling, switching network inter-operability, data processing, protocols... SDL is a very popular language and its scope of action goes beyond the telecommunication area.

It was at first related to the language *ACT ONE* for describing the data types handled by the specification but afterwards turned to ASN.1 to take over the task thereby making the development of a protocol easier: formalization, implementation, validation and tests. ASN.1 now tends to gradually take over *ACT ONE* more and more often.

TTCN (*Tree and Tabular Combined Notation*, ISO 9646 standard) is a test description language particularly convenient for protocol tests. It can describe a collection of abstract tests (regardless of the architecture) as PDUs or service primitives (see footnote 1 on page 22) without paying attention to the encoding. ASN.1 was included in TTCN in order to make it possible to describe test sequences for the application layer protocols; these sequences can be used even if the specification to be tested is not written in ASN.1.

7.9 Yet other application domains

We conclude this chapter with an enumeration *à la Prévert*[18] of other uses for ASN.1.

The forthcoming *Aeronautical Telecommunication Network* (ATN), which should be operational in Europe around 2005, will be based on OSI protocols. The information exchanged between planes and ground control systems will be specified in ASN.1 and encoded in PER.

In the telecommunication domain, ASN.1 is essential although all the branches have not adopted it yet. It is indeed used for mobile phones (with the *Mobile Application Part* or MAP protocol for the GSM networks, or the third generation mobiles conform to the UMTS[19] standard), the free phone numbers, the *Integrated Services Digital Network* (ISDN), the intelligent networks (the *Intelligent Network Application Protocol*, also called INAP, whose second capability set (CS2) contains more than 250 pages of ASN.1 assignments and uses the X.500 directory definition), the *Signalling System No. 7* (SS7) between switches (signalling is an area where the use of ASN.1 should be generalized)...

The duality telephony/information technology, which allows communication between a phone system (such as a *Private Automatic Branch eXchange*, PABX) with computing applications, is undergoing radical changes, particularly in phone exchange centers whose productivity is tremendously improved or in office automation where it can integrate in a more homogeneous way all the computing services and products. The *Computer Supported Telecommunications Applications* (CSTA[20]) standards specify the structure of the message exchanged between equipments and computing applications in ASN.1 using a BER encoding.

The MMS (*Manufacturing Message Specification*, ISO 9506 standard) allows to control manufacturing without having to care about the potential heterogeneity of equipments: robots, digitally controlled machine tool, bespoke programmed automaton. It is used in exchanges for selling or buying electricity in real time, for controls of paper mills, for car assembly lines and for chemical or food factories.

[18] Other enumerations can be found at http://www.oss.com/rstand.htm, http://www.inria.fr/rodeo/personnel/hoschka/baosmsg.txt and http://www.inria.fr/rodeo/personnel/hoschka/ralphmsg.txt.

[19] http://www.umts-forum.org/, http://www.3gpp.org/

[20] http://www.etsi.org/brochures/stateart/huff.htm

The market of telematics applied to transport information and control systems[21] will be booming for the next twenty years. The progress of navigation systems by satellite, of digital cartography and mobile telecommunications may enable optimizing the management of taxi or public transport vehicle fleets and smooth the road traffic with intelligent signals and information transmission to individual navigation systems. Some protocols of the intelligent transport domain are specified in ASN.1 and encoded in PER (see Section 21.3 on page 456).

The Radio-Frequency IDentification (or RFID[22]) is implemented in numerous industrial sectors (person or vehicle identification, stock management...). The electronic tags are made of miniaturized radio transmitters that can be accessed from a few centimeters to several meters far or through obstacles (thereby forbidding barcodes for instance). The PER encoding seems to be an excellent answer to bandwidth problems frequently encountered in this area.

In the USA, the *National Center for Biotechnology Information* (NCBI) created *GenBank*[23], a database featuring around four million DNA sequences (DesoxyriboNucleic Acid). Everyday the american center gives and receives DNA sequences from its European and Japanese counterparts[24]. The *National Library of Medicine* also designed four databases (*Unified Medical Language System*, UMLS[25]) whose exchange format are specified in ASN.1. They describe scientific papers among other things.

The ISO/CEI 7816-4 standard[26] use a BER encoding for exchanging data with integrated circuit(s) cards with contacts; one of today's application domain is the Social Security electronic card. The european project Netlink on interworking social security card systems relies on ASN.1 for describing the card's data structures. The technical committee TC 251[27] in charge of Health Informatics at the European Committee for Standardization (CEN) published the ENV 12018 standard on "Identification, administrative, and common clinical data structure

[21] Some elements of information can be found at http://www.iso.ch/meme/TC204.html or http://www.nawgits.com/icdn.html.
[22] http://www.aimglobal.org/technologies/rfid/resources/papers/rfid_basics_primer.html
[23] http://www.ncbi.nlm.nih.gov/Web/Genbank/index.html
[24] ftp://ncbi.nlm.nih.gov/mmdb/specdocs/ncbi.asn
[25] http://www.nlm.nih.gov/research/umls/
[26] http://www.iso.ch/cate/d14738.html
[27] http://www.centc251.org/

for Intermittently Connected Devices used in healthcare" for which the data structures are described in ASN.1.

It is now up to the reader[28] to add on to the list other original applications of ASN.1 and even correct some inaccuracies in those already in this chapter.

[28] By sending an e-mail to asn1@rd.francetelecom.fr.