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Information technology — Radio frequency identification (RFID) for item management — Data protocol: application interface

Technologies de l'information — Identification par radiofréquence (RFID) pour la gestion d'objets — Protocole de données: interface d'application

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 15961 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

Introduction

The technology of Radio Frequency Identification (RFID) is based on non-contact electronic communication across an air interface. The structure of the bits stored on the memory of the RF tag is invisible and accessible between the RF tag and the interrogator only by the use of the appropriate air interface protocol, as specified in the appropriate part of ISO/IEC 18000. The transfer of data between the application and the interrogator in open systems requires data to be presented in a consistent manner on any RF tag that is part of that open system. Application commands from the application and responses from the interrogator also require being processed in a standard way. This is not only to allow equipment to be interoperable, but in the special case of data carrier, for the data to be encoded on the RF tag in one systems implementation for it to be read at a later time in a completely different and unknown systems implementation. The data bits stored on each RF tag must be formatted in such a way as to be reliably read at the point of use if the RF tag is to fulfil its basic objective. The integrity of this is achieved through the use of a data protocol as specified in this International Standard and ISO/IEC 15962.

Manufacturers of radio frequency identification equipment (interrogators, RF tags, etc) and the users of RFID technology require a publicly available data protocol for RFID for item management. This International Standard and ISO/IEC 15962 specify this data protocol, which is independent of any of the air interface standards defined in ISO/IEC 18000. As such, the data protocol is a consistent component in the RFID system that may independently evolve to include additional air interface protocols.

The transfer of data to and from the application, supported by appropriate application commands is the subject of this International Standard. The companion International Standard, ISO/IEC 15962, specifies the overall process and the methodologies developed to format the application data into a structure to store on the RF tag.

Information technology — Radio frequency identification (RFID) for item management — Data protocol: application interface

1 Scope

The data protocol used to exchange information in an RFID system for item management is specified in this International Standard and in ISO/IEC 15962. Both International Standards are required for a complete understanding of the data protocol in its entirety; but each focuses on one particular interface:

- This International Standard addresses the information interface with the application system.
- ISO/IEC 15962 deals with the processing of data and its presentation to the RF tag, and the initial processing of data captured from the RF tag.

This International Standard focuses on the interface between the application and the data protocol processor, and includes the specification of the transfer syntax and definition of application commands and responses. It allows data and commands to be specified in a standardised way, independent of the particular air interface of ISO/IEC 18000.

This International Standard

- provides guidelines on how data shall be presented as objects;
- defines the structure of object identifiers, based on ISO/IEC 9834-1;
- specifies the commands that are supported for transferring data between the application and the RF tag;
- specifies the responses that are supported for transferring data between the RF tag and the application;
- provides a formal description of all the processes using ASN.1, as specified in ISO/IEC 8824-1;
- specifies the transfer syntax, based on the Basic Encoding Rules of ISO/IEC 8825-1, for data to be transferred from and to the application.

It is expected that this International Standard will be used as a reference to develop software appropriate for particular applications, or for particular RF equipment.

NOTE Conventionally in International Standards, long numbers are separated by a space character as a "thousands separator". This convention has not been followed in this International Standard, because the arcs of an object identifier are defined by a space separator (according to ISO/IEC 8824 and ISO/IEC 8825). As the correct representation of these arcs is vital to this International Standard, all numeric values have no space separators except to denote a node between two arcs of an object identifier.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 8824-1, *Information technology — Abstract Syntax Notation One (ASN.1) — Specification of basic notation* (equivalent to ITU-T Recommendation X.680)

ISO/IEC 8825-1, *Information technology — ASN.1 encoding rules — Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER)* (equivalent to ITU-T Recommendation X.690)

ISO/IEC 9834-1, *Information technology — Open Systems Interconnection — Procedures for the operation of OSI Registration Authorities: General procedures* (equivalent to ITU-T Recommendation X.660)

ISO/IEC 15962:2004, *Information technology — Radio frequency identification (RFID) for item management — Data protocol: data encoding rules and logical memory functions*

ISO/IEC 18000 (all parts), *Information technology — Radio frequency identification for item management*

ISO/IEC 19762-1, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 1: General terms relating to AIDC*[1)]

ISO/IEC 19762-3, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 3: Radio frequency identification (RFID)*[1)]

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762-1, 19762-3 and the following apply.

NOTE: For terms defined below and in ISO/IEC 19762-1 or ISO/IEC 19762-3, the definitions given below apply.

3.1.1 Application command
The instruction issued from the application to the Data Protocol Processor in order to initiate an action or operation with the RF tag(s) via the interrogator.

3.1.2 Application memory
The area on the RF tag available for storing data written to it. Sometimes known as *user memory*.

3.1.3 Arc
A specific branch of an object identifier tree, with new arcs added as required to define a particular object. The top three arcs of all object identifiers compliant with ISO/IEC 9834-1 are defined in Annex A.

3.1.4 BER = Basic Encoding Rules
An ASN.1 encoding method.

3.1.5 Block
The minimum number of bytes on an RF tag that can be in a write transaction, or read transaction, across the air interface.

1) To be published.

3.1.6 Command / Response Unit
That part of the Data Protocol Processor that processes application commands and sends responses to control encoding, decoding, structuring of the Logical Memory and transfer to the Tag Driver.

3.1.7 Data carrier
A device or medium used to store data as a relay mechanism in an AIDC system, e.g. bar code, OCR character string, RF tag.

3.1.8 Data compaction
A mechanism, or algorithm, to process the original data so that it is represented efficiently in fewer octets in a data carrier than in the original presentation.

3.1.9 Data Compactor
The implementation of the data compaction process defined in ISO/IEC 15962.

3.1.10 Data Protocol Processor
The implementation of the processes defined in ISO/IEC 15962, including the Data Compactor, Formatter, Logical Memory, and Command / Response Unit.

3.1.11 Element name
A component of a Reference Type or enumerated list in ASN.1 syntax.

3.1.12 Formatter
The implementation of the data formatting process defined in ISO/IEC 15962.

3.1.13 Logical Memory
A software analogue on the Data Protocol Processor of the Logical Memory Map.

3.1.14 Logical Memory Map
An array of contiguous octets of memory on the RF tag, representing the application (or user) memory to be used exclusively for the encoding of objects, objectIds and their associated Precursor on the RF tag. The system information (see 7.1.2) shall be defined by different means, or stored in a separate area on the RF tag. This can be achieved by partitioning memory, partly for system information and mainly for the Logical Memory Map purpose.

3.1.15 Object
A well-defined piece of information, definition, or specification which requires a name in order to identify its use in an instance of communication.

3.1.16 Object identifier
A value (distinguishable from all other such values) which is associated with an object.

3.1.17 OBJECT IDENTIFIER type
A simple ASN.1 type whose distinguished values are the set of all object identifiers allocated in accordance with the rules of ISO/IEC 8824-1 (ITU-T X.680).

3.1.18 Octet
An ordered sequence of eight bits considered as a unit, equivalent to an 8-bit byte.

NOTE: The term is used in preference to "byte" in this International Standard and in the ASN.1 standards to avoid confusion in cases where there is a hardware association e.g. 7-bit byte, 16-bit byte.

3.1.19 RELATIVE-OID type
A particular object identifier where a common root-OID (for the first and subsequent arcs) is implied, and remaining arcs after the root-OID are defined by the RELATIVE-OID.

3.1.20 Response
The feedback received by the application from an application command sent to the Data Protocol Processor.

3.1.21 System information
Information held on the RF tag, or generated by unique features of the air interface, that specify Data Protocol parameters to establish the Logical Memory and other formatting rules.

3.1.22 Tag Driver
The implementation of the process to transfer data between the Data Protocol Processor and the RF tag.

3.1.23 Transfer syntax
The abstract syntax and concrete syntax used in the transfer of data between open systems.

NOTE: The term "transfer syntax" is sometimes used to mean encoding rules, and sometimes used to mean the representation of bits in data while in transit.

3.1.24 Type reference
A name, in ASN.1 syntax, associated uniquely with a characteristic e.g. ObjectId.

3.1.25 Unique item identifier
A code assigned to an item (for example a product, transport unit, returnable asset) that is unique within the domain and scope of a code system. When used with this Data Protocol, the particular ObjectId that defines the unique item identifier shall rely on the fact that each instance of its object shall be unique and unambiguous with all others related objects. As the object is unique, its use in the RF tag confers uniqueness to the RF tag itself.

3.2 Abbreviated terms

BER	Basic Encoding Rules (of ASN.1)
EAN.UCC	EAN International & Uniform Code Council, Inc
IATA	International Air Transport Association
UPU	Universal Postal Union

4 Protocol model

4.1 Overview

RFID supports bit encodation in the RF tag memory. Unlike other data carrier standards prepared by ISO/IEC JTC1 SC31 which require encodation schemes that are specific to the individual data carrier technology, ISO/IEC 18000 does not specify the interpretation of bits or octets encoded on the RF tag memory. However, as an RF tag is a relay in a communication system, each tag used for open systems item management needs to have data encoded in a consistent manner. The prime function of this International Standard is to specify a common interface between the application programs and the RF interrogator. The prime function of ISO/IEC 15962 is to specify the common encoding rules and logical memory functions.

RF tags utilise electronic memory, which is typically capable of increasing data capacity as new generations of product are introduced. Differences in data capacity of each RF tag type, whether similar or dissimilar, are recognised by the data protocol defined in these two International Standards.

Different application standards may have their own particular data sets or data dictionaries. Each major application standard for item management needs to have its data treated in an unambiguous manner, avoiding confusion with data from other applications and even with data from closed systems. The data protocol specified in these International Standards ensures the unambiguous identification of data.

4.2 Layered protocol

The protocol layers of an implementation of RFID for item management are illustrated schematically in Figure 1.

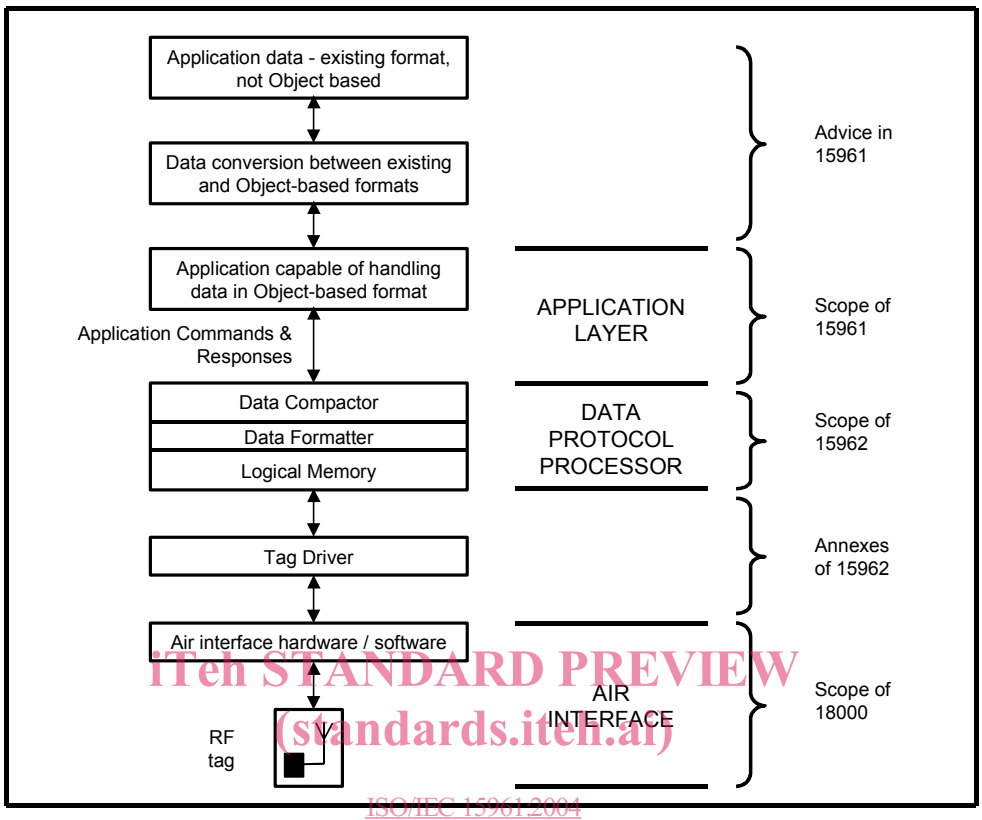

Figure 1 — Schematic of Protocol Layers for an Implementation of RFID for Item Management

The data protocol specified in this International Standard is independent of the different RF tag technologies specified in ISO/IEC 18000, which is concerned with different air interface protocols that function between the interrogator and the RF tag. This independence is achieved by implementing the standards at different levels in the protocol hierarchy. The RFID data protocol defined in this International Standard is primarily concerned with the upper layers as described below:

Application layer - as defined in this International Standard

- The RFID data protocol specifies how data is presented as objects, each uniquely identified with an object identifier, which are meaningful to the application and can be encoded on the RF tag.
- This RFID data protocol defines application commands and responses so that application programs can specify what data to transfer to and from the RF tag and to append, update or delete data on the RF tag.
- This RFID data protocol also defines error messages as responses to the application.

The application interface of this RFID data protocol is based on ASN.1, which:

- provides a means of defining the protocol which is independent of the host application, operating system, and programming language and also independent of the specific command structures between the interrogator and tag driver.
- identifies any data object distinctly from all others using object identifiers, even to enable different data formats to be intermixed on the same RF tag.

- defines unambiguous commands and responses, so that they can be intermixed with data on the same wired or wireless network.

- provides the abstract syntax for defining the commands and responses in a structured and consistent and verifiable manner, and provides the transfer syntax that defines the byte stream transferred between the processes of this International Standard and those of ISO/IEC 15962.

- enables implementation in a variety of computer languages through the use of compilers, alternatively programs can be written from the specification. In either case there is a vital need for the transfer syntax to be fully consistent and compliant to function in open systems where the sender and recipient can be unknown to one another.

Data Protocol Processing - as defined in ISO/IEC 15962

- The RFID data protocol specifies how data is encoded, compacted and formatted on the RF tag and how this data is retrieved from the RF tag to be meaningful to the application.

- This RFID data protocol provides for a set of schemes that compact the data to make more use of the memory space.

- This RFID data protocol also supports various storage formats to enable efficient use of memory and efficient access procedures.

All these features are described and specified later in this International Standard and its companion standard. Figure 1, and the outline description above, applies to a general process. Different rules may apply to RF tags that are capable of executing commands (see 7.3.3 of ISO/IEC 15962).

This RFID data protocol specifies the application level communication and the RF tag interrogator level rules for data encoding, compaction and storage formats. This protocol may be implemented:

- on the same platform as the application.

- on a separate platform linked to the application platform e.g. linked via a serial link, LAN or internet connection.

- on an embedded platform e.g. in a bar code printer/RFID encoder, in a bar code/RFID scanner, or a dedicated RFID interrogator.

This RFID data protocol has been designed such that the actual platform on which it is implemented is transparent to the application. It is also independent of the programming language used by the application. If both standards are not implemented, care will need to be taken to maintain the functionality between the two standards. The compliance clauses of both standards address these points in greater detail.

The rules specified in these International Standards create a complete independence between the application and the technology of the air interface and RF tag. The type of RF tag used in an implementation can be changed without requiring the application to change.

4.3 Functional processes

There are various functional processes that need to take place to write data to an RF tag and to read data from it. Figure 2 shows a schematic of an implementation where the processing of the data protocol resides in the interrogator. This illustration is provided to help with the understanding of the processes, and although a typical implementation, many others are possibly compliant with this data protocol.

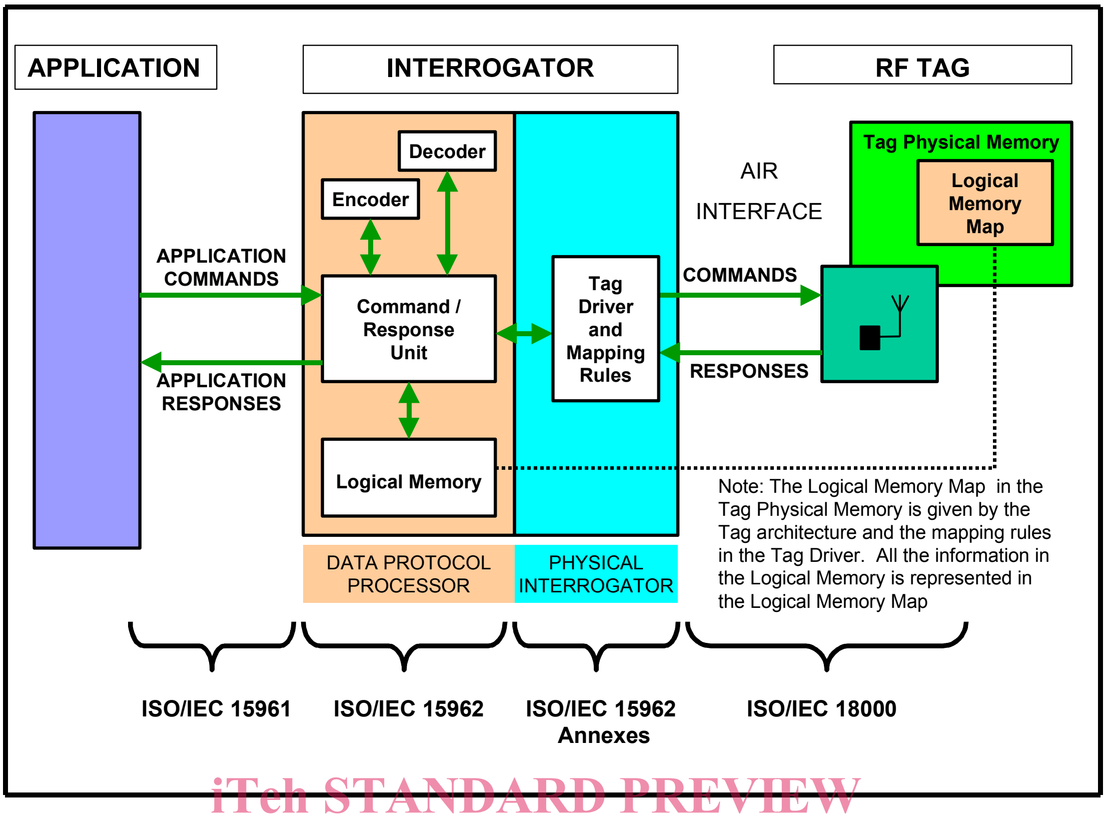

Figure 2 — Logical Functions and Interfaces

Application is the user application database and software.

The data flows between the application and the Data Protocol Processor are formatted according to this International Standard and are uncompacted. However, there are numerous established systems where data is formatted to be compliant, for example, with a bar code related syntax. It is therefore reasonable to insert interface modules in the data flow to convert from and to existing application formats.

NOTE: Careful consideration should be given to the extent that established systems need to be supported relative to the potential benefits to be gained from adopting the data protocol specified in this International Standard and ISO/IEC 15962. This is because this protocol has been developed around the features of RFID, such as selective read/write and the ability to lock data. Older protocols are unlikely to support such features.

Interrogator is the module in which all the basic processing of the data protocol takes place and there is an interface to the RF tag.

Data Protocol Processor provides all the processing, which is as specified in ISO/IEC 15962 and is required for handling application data. It consists of the following components, all of which are described more fully below: Command/Response Unit, Logical Memory, Encoder (which supports a Data Compactor and Formatter function) and Decoder (which supports the inverse functions of the Encoder). The Data Protocol Processor can physically reside anywhere between the application software and the tag driver but shall contain all the components.

Command/Response Unit for receiving the application commands from the application in a format specified in this International Standard, acting upon these commands where appropriate and converting to the specific RF tag lower level command codes.

EXAMPLE:

An application command of *write Data Object {name}* is application related. The data protocol recognises this and can format the data onto the Logical Memory in the Data Protocol Processor. The information from the particular RF tag is required to set the parameters of the Logical Memory Map (e.g. number of octets, whether a directory is in use, etc) on the RF Tag. The Tag Driver converts the application command into a tag-specific command.

It can be seen from this example that there is a distinct boundary between the Data Protocol Processor and the Tag Driver.

Logical Memory. This is an array of contiguous octets (or bytes) of memory acting as a common representation of the Logical Memory Map in the user memory of the RF tag to which the object identifiers and data objects are mapped in octets. The Logical Memory takes into account some parameters of the real RF tag, for example the block size, the number of blocks and the storage format. The Logical Memory ignores any detailed tag architecture.

The use of the Logical Memory means that an application can interface with an application-compliant RF tag, but that individual RF tags can have completely different memory capacities and architectures. This enables an implementation to benefit from new technological developments permitted within the framework of ISO/IEC 18000, such as larger capacity or faster access RF tags, without changing the application.

Encoder controls the process of writing data through the functional processes performed by the Data Compactor Module and Formatter Module.

Data Compactor provides the standard compaction rules to reduce the number of octets stored on the RF tag and transferred across the air interface. Numeric data, for example, is octet based to some coded character set for the application, but can be encoded in a compact form on the RF tag memory.

Formatter provides the processes to place the object identifier and object (data) into an appropriate and efficient format for storing on the Logical Memory.

NOTE: The physical mapping of bits to comply with the RF tag architecture is performed by the Tag Driver.

Decoder controls the process of reading and interpreting data through the functional processes performed by the Data De-compactor Module and De-formatter Module.

Tag Driver provides two main functions:

- It maps the contents of the Logical Memory to the Logical Memory Map of the RF tag in use.
- It provides facilities that accept the application commands of this data protocol, and converts them to a format that results in calls to command codes supported by the particular RF Tag. For example, an application command **write Data Object {name}** could result in the RF tag related command of write (block #, data).

The description of the tag driver for particular RF tags is provided in annexes of ISO/IEC 15962. For the purpose of ISO/IEC 15962, a tag driver is unique to a particular air interface type of RF tag as specified in the appropriate part of ISO/IEC 18000. This is a logical representation; physical implementation could combine features of different logical tag drivers. An interrogator may support one or many tag drivers.

RF Tag, although beyond the scope of these International Standards, is shown to complete the flow of data and commands.

Logical Memory Map represents all the data in the Logical Memory of the Data Protocol Processor converted (or mapped) to a location structure determined by the mapping rules in the Tag Driver and the architecture of the RF tag.

5 Data structure

5.1 Notation

5.1.1 The octet: the basic unit for 8-bit coding

This International Standard supports binary, 7-bit, 8-bit and user data that may exceed 8-bits per character. The common unit of coding is the octet (also known as the 8-bit byte). Binary data shall be padded with leading zero bits until the binary value is octet aligned; 7-bit data shall be represented as octets with bit 8 (see 5.1.2) set to a zero value. Data exceeding 8-bits shall be encoded in multiple octets.

An octet is represented as 2 hexadecimal characters with the values 0-9, A-F.

5.1.2 Bit ordering

Within each octet, the most significant bit is bit 8 and the least significant is bit 1. Accordingly, the weight allocated to each bit is:

Bit Value	bit 8	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1
Weight	128	64	32	16	8	4	2	1

5.1.3 Octet conversion

The 8-bit value is converted into the two hexadecimal characters with bit 8, bit 7, bit 6 and bit 5 having the weights 8, 4, 2 and 1 respectively to define the first hexadecimal character. Bit 4, bit 3, bit 2 and bit 1 retain the weights 8, 4, 2 and 1 respectively to define the second hexadecimal character.

5.2 Structure of the transfer between ISO/IEC 15961 and ISO/IEC 15962

All object identifiers, data, commands, and responses transferred between the application and the Data Protocol Processor shall be octet aligned. This simplifies the construction of the transfer and aids parsing the octets. It has no significance on the encoding efficiency on the RF tag itself, because the process by the Data Protocol Processor (as specified in ISO/IEC 15962) controls the final encodation.

6 Abstract and transfer syntax

ASN.1 defines:

- an **abstract syntax**, which is effectively a data definition language used to define repetitive and optional structures using a number of primitive data types. It is equivalent to high level programming languages, but is independent (hence "abstract") from any of these.
- a **transfer syntax** from which the encoding rules are derived. These rules determine the bit pattern representation during the transfer of data structures created using the abstract syntax.

6.1 Abstract syntax

The abstract syntax for this International Standard shall be ASN.1 as defined in ISO/IEC 8824-1. The notation shall be as specified in that standard.

The syntax required for RFID for item management are specified in Clause 7.