A short introduction to ASN.1 Encoding Control Notation (ECN)

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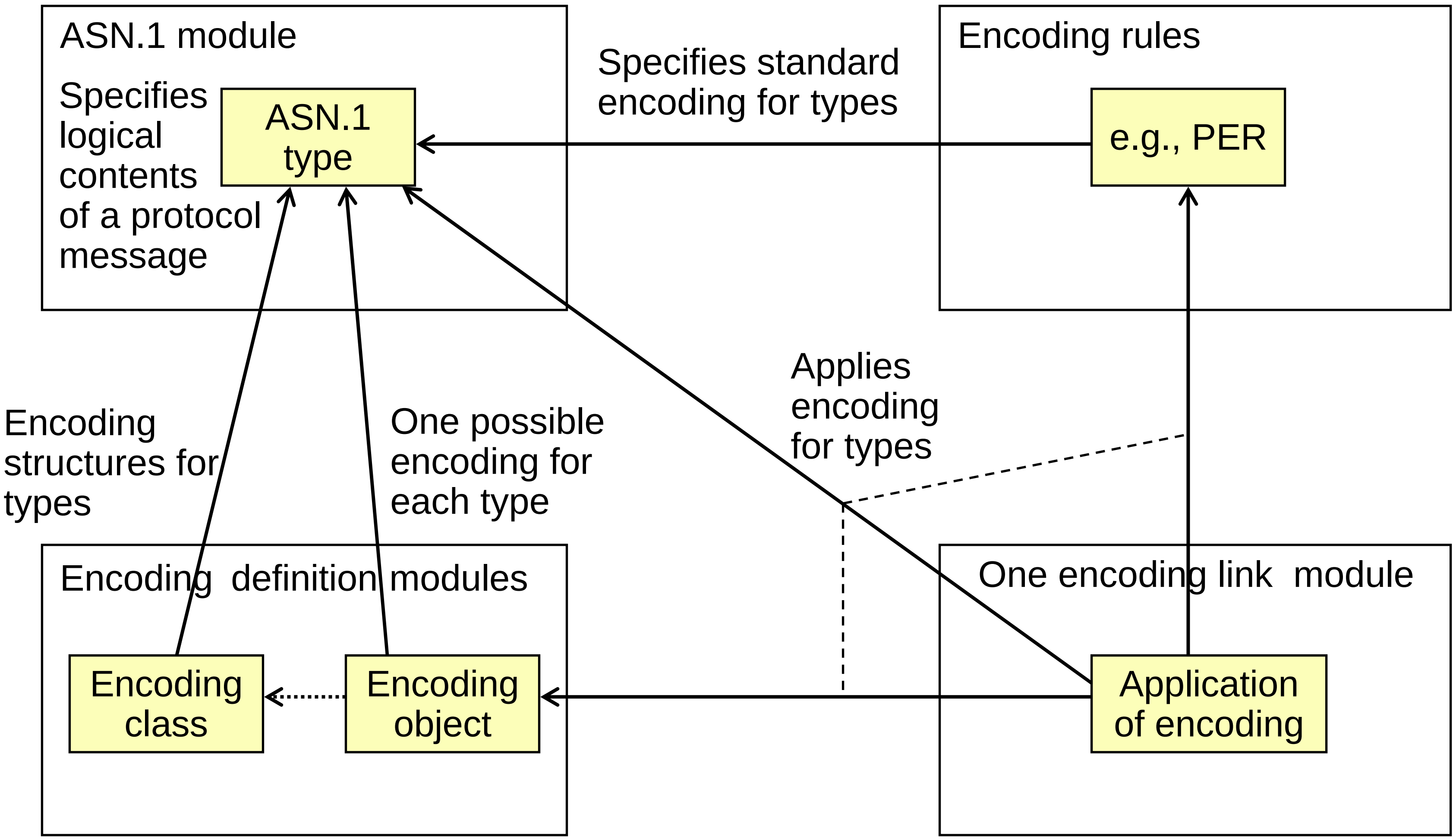
Contents

Introduction

- Purpose of the presentation
  - To give an overview of ASN.1 Encoding Control Notation (ECN)
  - To show how ECN can be used in different application areas

The Big Picture - ECN concepts



ASN.1 modules

- From ASN.1 point of view, ECN is transparent, no modifications in the ASN.1 specification.

```
Example-ASN1 DEFINITIONS AUTOMATIC TAGS ::=
BEGIN

MyType ::= INTEGER (0..7)

END
```

Encoding definition modules

- Encoding definition module contains
  - encoding classes
  - encoding objects
  - encoding object sets
- Encoding classes specify
  - encoding structure, i.e., what are the bitfields that an encoding of a type is composed of
- Encoding objects specify
  - how abstract values of a type are mapped to the bitfields
  - what are the relations between different bitfields, like length and presence determinant fields and determined fields
  - how the bitfields are encoded
- Encoding object sets are
  - collections of encoding objects to be applied to ASN.1 types

Encoding definition modules

```
Example-EDM ENCODING-DEFINITIONS ::=
BEGIN

IMPORTS
    #MyType                                       -- Implicit encoding class for an ASN.1
FROM Example-ASN1;                                -- type, #MyType ::= #INT (0..7)

MyEncodings #ENCODINGS ::= { myType-encoding }    -- Encoding object set with one object.

myType-encoding #MyType ::= {                     -- Encoding object which produces
    ENCODING {                                    -- the same encoding as PER would.
        ENCODING-SPACE
            SIZE            3
                MULTIPLE OF   bit
            ENCODING positive-int
    }
}
END
```

Encoding link modules

- Link modules specify how encoding objects are applied to ASN.1 types

```
Example-ELM LINK-DEFINITIONS ::=
BEGIN

IMPORTS
    #MyType              -- Implicit encoding class for an ASN.1 type
FROM Example-ASN1
    MyEncodings          -- Encoding object set containg an encoding object for #MyType
FROM Example-EDM;

ENCODE #MyType
    WITH                 MyEncodings                 -- MyEncodings is used for #MyType
    COMPLETED BY         PER-BASIC-UNALIGNED         -- The rest is encoded using PER

END
```

Application of ECN

- There are two main application areas for ECN:
  - Non-ASN.1 "legacy" protocols
  - Specialization of ASN.1 protocols

ECN and "legacy" protocols

- Context:
  - Protocol messages have originally been specified without ASN.1, e.g., as octet tables
- Problem:
  - Need for ASN.1 to express logical message contents, e.g., for test purposes
- Solution:
  - ECN can be used to fill the gap between message content definitions and message encoding
- Forces:
  - Separation of abstract message contents and auxiliary information
  - Specification of presence and length determinants
  - Complex message encoding => complex ECN

Hiperlan example

- Purpose of the example:
    - Show how messages that are originally specified using tables can be specified using ASN.1 and ECN

- Real-life Hiperlan protocol:
    - Existing ASN.1 definitions
    - Existing tables for message encoding
    - RLC-RADIO-HANDOVER-COMPLETE-ARG used as an example message

Hiperlan - Message table form

	8	7	6	5	4	3	2	1
Octet 1	Defined in DLC TS		MSB Sequence number					
Octet 2	Sequence number				MSB EXTENSION-TYPE			Future use
Octet 3	MSB RLC LCH PDU type							
Octet 4	Future use				mac-id-old			
Octet 5	mac-id-old				ap-id-old			
Octet 6	ap-id-old						net-id-old	
Octet 7	net-id-old							
Octet 8	mac-id-new							
Octet 9	cl-id							
Octet 10	Duc-ext-ind	cl-conn-attr-length(L)					# of DUC:s	
Octet 11	# of DUC:s(N)		Future use					
Octet 12	(DUC1) direction		dlcc-id					
	cl-connn-attr							
Octet(12+L)								
Octet Y	(DUC1-FW) allocation-type			Future use	cyclic-prefix	fec-used	ec-mode	
Octet ...	(DUC1-FW) arq-nr-of-retr				Future use	(DUC1-FW) arq-window-size		
	(DUC1-FW) fec				Future Use			
Octet ...	sch-per-nb-frames				lch-per-nb-frames			
Octet ...	nb-of-sch	phy-mode-sch			phy-mode-lch			
Octet ...	nb-of-lch							
Octet ...	min-nb-of-lch							
Octet X	(DUC1-BW) allocation-type			Future use	cyclic-prefix	fec-used	ec-mode	
Octet ...	(DUC1-BW) arq-nr-of-retr				Future use	(DUC1-BW) arq-window-size		
	(DUC1-BW) fec				Future Use			
Octet ...	sch-per-nb-frames				lch-per-nb-frames			
Octet ...	nb-of-sch	phy-mode-sch			phy-mode-lch			
Octet ...	nb-of-lch							
Octet ...	min-nb-of-lch							
Octet ...	Not used							
Octet ...								
Octet 51								

Padding bits

Octet-aligned fields

Length determinant field for several octet fields

Presence determinants

Hiperlan - ASN.1

- The ASN.1 definition for the RLC-RADIO-HANDOVER-COMPLETE-ARG message is simple

- Some determinant fields are visible in ASN.1:
  - cl-conn-attr-length, common length for all cl-conn-attr fields
  - fec-used presence determinant
- Some reserved values:
  - ALLOCATION-TYPE

- Otherwise the definitions are plain old ASN.1

⇒ ASN.1 definitions can be used as is after determinant fields have been removed

Hiperlan - ASN.1

```
RLC-RADIO-HANDOVER-COMPLETE-ARG ::= SEQUENCE {
    mac-id-old          MAC-ID,
    ap-id-old           AP-ID,
    net-id-old          NET-ID,
    mac-id-new          MAC-ID,
    cl-id               CL-ID,
    duc-ext-ind         DUC-EXT-IND,
    duc-descr-list      DUC-DESCR-LIST}
```

- There are additional requirements:
  - Every DUC-DESCR.cl-conn-attr in DUC-DESCR-LIST is of the same length.
  - This cannot be simply expressed formally in ASN.1 but will be enforced in the ECN specification.

```
DUC-DESCR-LIST ::= SEQUENCE (SIZE(1..cMAX-DESCR-LIST)) OF DUC-DESCR
```

Hiperlan - ECN

- Encoding structure
  - Insertion of padding bits

    aux-future-use

    aux-pad
  - Binding of determinant and determined fields

    cl-conn-attr-length

    fec-used
  - Space for reserved values

    allocation-type

    coder-type

    interleaver-type

Encoding structure for the message

- The encoding structure for RLC-RADIO-HANDOVER-COMPLETE-ARG has two additional fields:
  - "aux-future-use" for the reserved bits
  - "aux-cl-conn-attr-length" for length determinant for "duc-desc-list.*.cl-conn-attr"

```
#RLC-RADIO-HANDOVER-COMPLETE-ARG-struct ::= #CONCATENATION {
    aux-future-use              #PAD,                -- ** Inserted
    mac-id-old                  #MAC-ID,
    ap-id-old                   #AP-ID,
    net-id-old                  #NET-ID,
    mac-id-new                  #MAC-ID,
    cl-id                       #CL-ID,
    duc-ext-ind                 #DUC-EXT-IND,
    aux-cl-conn-attr-length     #INT(0..31),         -- ** Inserted
    duc-descr-list              #DUC-DESCR-LIST
}
```

Encoding object for the message

- Encoding object for #RLC-RADIO-HANDOVER-COMPLETE-ARG
  - maps fields to the fields of the encoding structure
  - specifies how padding is encoded
  - links the determinant field to the determined fields

```
rlc-radio-handover-complete-arg-encoding #RLC-RADIO-HANDOVER-COMPLETE-ARG ::= {
    USE             #RLC-RADIO-HANDOVER-COMPLETE-ARG-struct
    MAPPING         FIELDS
    WITH {
        ENCODE STRUCTURE {
                -- Components
                aux-future-use      reserved-bits-encoding{< 4 >},
                duc-descr-list      duc-descr-list-encoding{< aux-cl-conn-attr-length >}
                -- Structure
                STRUCTURED WITH per-sequence-encoding
        }
    }
}
```

Encoding object for one message field

- Encoding of the DUC-DESCR-LIST

```
duc-descr-list-encoding{< REFERENCE : aux-cl-conn-attr-length >} #DUC-DESCR-LIST ::= {
    ENCODE STRUCTURE {
        -- Components
        duc-descr-encoding{< aux-cl-conn-attr-length >}

        -- Structure
        STRUCTURED WITH per-sequence-of-encoding
    }
}
```

The length determinant for a sub-field is passed as an argument.

PER is used to construct the rest of the list encoding

Encoding object for list element

```
duc-descr-encoding{< REFERENCE : aux-cl-conn-attr-length >} #DUC-DESCR ::= {
    ENCODE STRUCTURE {
        -- Components
        cl-conn-attr        cl-conn-attr-encoding{< aux-cl-conn-attr-length >},
        forward-descr       USE-WITH OPTIONAL-ENCODING
                            -- simplex-forward, duplex, duplex-symetric
                            is-present-if{< direction, {0|1|3} >},
        backward-descr      USE-WITH OPTIONAL-ENCODING
                            -- simplex-backward, duplex
                            is-present-if{< direction, {1|2} > }
        -- Structure
        STRUCTURED WITH     octet-aligned-sequence-encoding
    }
WITH-PER-BASIC-UNALIGNED
}
```

Length determinant is passed further down

Conditional fields

List elements are octet-aligned

Encoding object for a field in the list

- Finally the length determinant is passed to the encoding object that uses it as a length determinant for an octet string

```
cl-conn-attr-encoding{< REFERENCE : aux-cl-conn-attr-length >} #CL-CONN-ATTR ::= {
    REPETITION-ENCODING {
        REPETITION-SPACE
            DETERMINED BY asn1-field
            USING aux-cl-conn-attr-length
    }
}
```

Spare values

- Spare values can be expressed by reserving more encoding space for fields

```
allocation-type-encoding  #ALLOCATION-TYPE ::= fixed-length-int-encoding{< 3 >},
```

- Parameterized encoding object for fixed length integer fields
  - Two's complement, big-endian, size is "nbits"

```
fixed-length-int-encoding{< #CONDITIONAL-INT.&encoding-space-size : nbits >} #INT ::= {
    ENCODING { ENCODING-SPACE SIZE          nbits }
}
```

Collection of encodings

- Encoding definitions are collected as an encoding object set

```
Hiperlan-Encodings #ENCODINGS ::= {
    rlc-radio-handover-complete-arg-encoding        |
    duc-direction-descr-encoding                    |
    allocation-type-encoding                        |
    arq-data-encoding                               |
    fec-encoding                                    |
    fca-descr-encoding
}
```

Hiperlan - ELM

- Encodings are applied to top-level types in the ASN.1 module

```
Hiperlan-ELM LINK-DEFINITIONS ::=
BEGIN

IMPORTS
    #RLC-RADIO-HANDOVER-COMPLETE-ARG
FROM Hiperlan-ASN1
    Hiperlan-Encodings
FROM Hiperlan-EDM;

ENCODE #RLC-RADIO-HANDOVER-COMPLETE-ARG
    WITH            Hiperlan-Encodings
    COMPLETED BY    PER-BASIC-UNALIGNED

END
```

Hiperlan example summary

- Application of ASN.1 + ECN for Hiperlan is straightforward

- ASN.1 definitions shall contain only application-specific definitions
- Encoding structures contain also auxiliary fields like length and presence determinants
- Encoding objects
  - specify relations between determinant fields and determined fields
  - specify special encoding (octet-alignment, padding, spare bits)
- The encoding link module applies the encoding objects to the ASN.1 types

ECN and specialization

- Context:
  - Protocol messages are defined using ASN.1
  - Standard ASN.1 encoding rules (e.g., PER) are used to provide encoding for messages
- Problem:
  - Standard encoding rules do not provide all the needed properties for encoding
- Solution:
  - Use standard encoding rules for the majority of encodings
  - Use ECN to specialize encoding for wanted properties
- Forces:
  - A kind of specialization vs. a generic property

Specialization of CHOICE index encoding

- Context:
  - There is a top-level message container type which encapsulates specific messages and provides identification for them

```
Messages ::= CHOICE {
        a           MessageA,
        b           MessageB,
        c           MessageC
}
```

- Problem:
  - New messages are wanted to be added in the container.
  - Encoding for the new messages should be similar to the old messages, i.e., no extension container is needed.
  - The number of new messages is not limited
- Solution:
  - Encode CHOICE index using a Huffman-like encoding

Specialization of CHOICE index encoding

- The following encoding object specifies that the encoding structure for the Messages type consists of
  - an "aux-messageId" field, which is used as a message determinant
  - a "message" field, which contains the selected message

```
messages-encoding #Messages ::= {
    REPLACE     STRUCTURE
        WITH         #Messages-struct{< >}
        ENCODED BY   messages-struct-encoding{< >}
}

#Messages-struct{< #OriginalMessages >} ::= #SEQUENCE {
    aux-msgId        #MessageIdentifier,
    message          #OriginalMessages
}

#MessageIdentifier ::= #INT
```

Specialization of CHOICE index encoding

- The following encoding object specifies how the fields are encoded
  - "aux-msgId" field is encoded as an open-ended integer field
  - "aux-msgId" acts as a determinant for the "message" field

```
messages-struct-encoding{<#OriginalMessages>} #Messages-struct{<#OriginalMessages>} ::= {
    ENCODE STRUCTURE {
            aux-msgId           msgId-encoding,
            message             { ALTERNATIVE DETERMINED BY added-field USING aux-msgId }
    }
    WITH PER-BASIC-UNALIGNED
}

msgId-encoding #MessageIdentifier ::= {
    USE             #BITS
    MAPPING TO BITS {
            0 .. 2      TO  ‘000’B .. ‘010’B,       -- 0 - MessageA, 1 - MessageB, 2 - MessageC
            3           TO  ‘1’B                    -- 3 - Extensions, like 10000, 10001, 10010 etc
    }
    WITH self-delimiting-bits }
```

Length determinant for SEQUENCEs

- Context:
  - There is a group of SEQUENCE types which need to be extensible

```
MessageA ::= SEQUENCE {
        -- Whatever
        extensions        MessageA-Extensions    OPTIONAL
}

MessageA-Extensions ::= SEQUENCE {          -- Extensible
}
```

- Problem:
  - The size of the encoding needs to be smaller than in case of normal PER extensibility

- Solution:
  - Introduce a length determinant for the selected SEQUENCE types
  - Length of encoding of extensions is delimited by the SEQUENCE length determinant

Length determinant for SEQUENCEs

- The following generic encoding structure is used as a replacement structure for extensible SEQUENCEs

```
#Sequence-with-length-determinant ::= #SEQUENCE
```

- The following

```
sequence-with-length-determinant-encoding #Sequence-with-length-determinant ::= {
    REPLACE STRUCTURE
        WITH          Seq-with-length-struct{< >}
        ENCODEB BY    seq-with-length-struct-encoding{< >}
}

#Seq-with-length-struct{< #OrigSequence >} ::= #SEQUENCE {
    aux-length    #INT (0..512),
    seq           #OrigSequence
}
```

Length determinant for SEQUENCEs

- The following parameterized encoding object specifies that
  - the "aux-length" field is used as a length determinant for the "seq" field
  - length of "seq" field is measured in bits
  - otherwise the normal PER rules are used

```
seq-with-length-struct-encoding{< #OrigSeq >} #Seq-with-length-struct{< #OrigSeq >} ::= {
    ENCODE STRUCTURE {
        -- aux-length as in PER
        seq     {
                ENCODING SPACE
                    SIZE            variable-with-determinant
                            MULTIPLE OF   bit
                    DETERMINED BY added-field
                    USING  aux-length
        }
    }
    WITH PER-BASIC-UNALIGNED
}
```

Length determinant for SEQUENCEs

- The generic encoding structure and encoding object are applied for selected SEQUENCE types as follows:

```
RENAMES #SEQUENCE
        AS #Sequence-with-length-determinant
        IN #MessageA-Extensions, #MessageB-Extensions, #MessageC-Extensions
FROM Example-ASN1;
```

- As a result the property of length determined encoding is associated with the selected SEQUENCE types

Extension of value sets of INTEGER types

- Context:
  - There are integer types which need to have limited extensibility
  - The maximum number of extensions can be predicted
  - It is specified what to do when a spare value is received

  -- Used range in version 1 is 1..224, values 225-256 are spare values.

  -- If a spare value is received, then the following error procedure shall be initiated...

  ExtensibleInteger ::= INTEGER (1..256)

- Problem:
  - Minimize the encoding size
  - Make sure that senders do not send spare values

Ignore spare values

- The following encoding object specifies that
  - it is not allowed to send spare values but it is allowed to receive them

```
extensibleInteger-encoding #ExtensibleInteger::= {
  ENCODE-DECODE {
        USE         #INT (1..224)       -- no padding bits needed
        MAPPING     ORDERED VALUES
        WITH        per-int-encoding
  }
  DECODE-AS-IF      per-int-encoding
}

per-int-encoding #INTEGER ::= {
  ENCODE WITH PER-BASIC-UNALIGNED
}
```

Encoding object set

- Collect encoding objects in one encoding object set

```
MyEncodings #ENCODINGS ::= {
    messages-encoding                                  |
    sequence-with-length-determinant-encoding          |
    extensibleInteger-encoding
}
```

Encoding link module

```
Example-ELM LINK-DEFNITIONS ::=
BEGIN

IMPORTS
    #Messages,                              -- Implicit encoding classes
    #ExtensibleInteger
FROM Example-ASN1
    #MessageA-Extensions,                   -- Explicitly renamed encoding classes
    #MessageB-Extensions,
    #MessageC-Extensions,
    MyEncodings                             -- Encoding object set
FROM Example-EDM;

ENCODE #Messages, #ExtensibleInteger,
    #MessageA-Extensions, #MessageB-Extensions, #MessageC-Extensions
    WITH MyEncodings
    COMPLETED BY PER-BASIC-UNALIGNED

END
```

ECN Presentation Summary

- The basic concepts of ECN are fairly simple

- Application area and wanted encoding features affect a lot of how ECN can be applied
  - Multiple ways to achieve the same goal
  - What is specified in ASN.1 and what in ECN
  - Generic ECN vs. specific ECN