# End-to-End Data

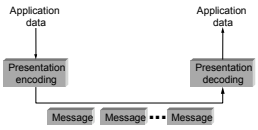
Outline

- Formatting
- Compression



# Presentation Formatting

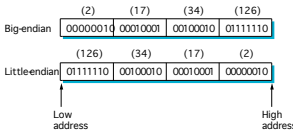
- Marshalling (encoding) application data into messages
- Unmarshalling (decoding) messages into application data






# Difficulties

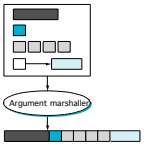
- Representation of base types
  - floating point: IEEE 754 versus non-standard
  - integer: big-endian versus little-endian (e.g., 34,677,374)




- Compiler layout of structures

# Taxonomy

- Data types
  - base types (e.g., ints, floats); must convert
  - flat types (e.g., structures, arrays); must pack
  - complex types (e.g., pointers); must linearize

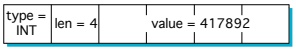



- Conversion Strategy
  - canonical intermediate form
  - receiver-makes-right (an *N* x *N* solution)

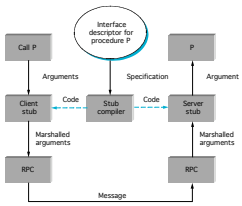


# Taxonomy (cont)

- Tagged versus untagged data




- Stubs
  - compiled
  - interpreted





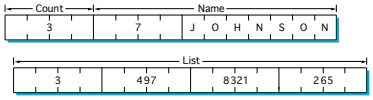

# eXternal Data Representation (XDR)

- Defined by Sun for use with SunRPC
- C type system (without function pointers)
- Canonical intermediate form
- Untagged (except array length)
- Compiled stubs

```
#define MAXNAME 256;
#define MAXLIST 100;

struct item {
   int     count;
   char    name[MAXNAME];
   int     list[MAXLIST];
};

bool_t
xdr_item(XDR *xdrs, struct item *ptr)
{
   return(xdr_int(xdrs, &ptr->count) &&
       xdr_string(xdrs, &ptr->name, MAXNAME) &&
       xdr_array(xdrs, &ptr->list, &ptr->count,
                 MAXLIST, sizeof(int), xdr_int));
}
```

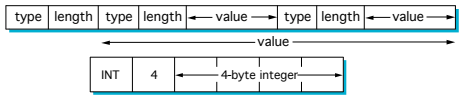





# Abstract Syntax Notation One (ASN.1)

- An ISO standard
- Essentially the C type system
- Canonical intermediate form
- Tagged
- Compiled or interpreted stubs
- BER: Basic Encoding Rules

**(tag, length, value)**

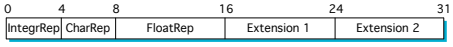





# Network Data Representation (NDR)

- Defined by DCE
- Essentially the C type system
- Receiver-makes-right (architecture tag)
- Individual data items untagged
- Compiled stubs from IDL
- 4-byte architecture tag

  - IntegerRep
    - 0 = big-endian
    - 1 = little-endian
  - CharRep
    - 0 = ASCII
    - 1 = EBCDIC
  - FloatRep
    - 0 = IEEE 754
    - 1 = VAX
    - 2 = Cray
    - 3 = IBM



## Markup Languages

- HyperText Markup Language (HTML)
- Extensible Markup Language (XML)

```
<?xml version="1.0"?>
<employee>
    <name>Spongebob Squarepants</name>
    <title>Frycook</title>
    <id>0123456</id>
    <hiredate>
        <day>1</day>
        <month>May</month>
        <year>1999</year>
    </hiredate>
</employee>
```



## XML Schema

```
<?xml version="1.0"?>
<xs:schema xmlns=http://www.cs.princeton.edu/XMLSchema
    targetNamespace=http://www.cs.princeton.edu
    xmlns=http://www.cs.princeton.edu
    elementFormDefault="qualified">

    <xs:element name="employee">
        <xs:complexType>
        <xs:sequence>
        <xs:element name="name" type="xs:string"/>
        <xs:element name="title" type="xs:string"/>
        <xs:element name="id type="xs:string"/>
        <xs:element name="hiredate">
            <xs:complexType>
            <xs:sequence>
            <xs:element name="day" type="xs:integer"/>
            ...
```



## Compression Overview

- Encoding and Compression
  - Huffman codes
- Lossless
  - data received = data sent
  - used for executables, text files, numeric data
- Lossy
  - data received does not match data sent
  - used for images, video, audio

## Lossless Algorithms

- Run Length Encoding (RLE)
  - example: AAABBCDDDD encoding as 3A2B1C4D
  - good for scanned text (8-to-1 compression ratio)
  - can increase size for data with variation (e.g., some images)
- Differential Pulse Code Modulation (DPCM)
  - example AAABBCDDDD encoding as A0001123333
  - change reference symbol if delta becomes too large
  - works better than RLE for many digital images (1.5-to-1)



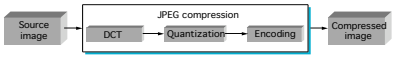
## Dictionary-Based Methods

- Build dictionary of common terms
  - variable length strings
- Transmit index into dictionary for each term
- Lempel-Ziv (LZ) is the best-known example
- Commonly achieve 2-to-1 ratio on text
- Variation of LZ used to compress GIF images
  - first reduce 24-bit color to 8-bit color
  - treat common sequence of pixels as terms in dictionary
  - can achieve 10-to-1 compression (less common)



## Image Compression

- JPEG: Joint Photographic Expert Group (ISO/ITU)
- Lossy still-image compression
- Three phase process



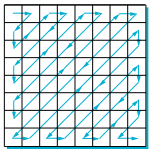

  - process in 8x8 block chunks (macro-block)
  - DCT: transforms signal from spatial domain into and equivalent signal in the frequency domain (loss-less)
  - apply a quantization to the results (lossy)
  - RLE-like encoding (loss-less)

# Quantization and Encoding

- Quantization Table

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 |
| 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 |
| 7 | 9 | 11 | 13 | 15 | 17 | 19 | 21 |
| 9 | 11 | 13 | 15 | 17 | 19 | 21 | 23 |
| 11 | 13 | 15 | 17 | 19 | 21 | 23 | 25 |
| 13 | 15 | 17 | 19 | 21 | 23 | 25 | 27 |
| 15 | 17 | 19 | 21 | 23 | 25 | 27 | 29 |
| 17 | 19 | 21 | 23 | 25 | 27 | 29 | 31 |

- Encoding Pattern





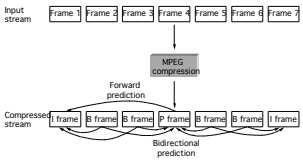
# MPEG

- Motion Picture Expert Group
- Lossy compression of video
- First approximation: JPEG on each frame
- Also remove inter-frame redundancy



# MPEG (cont)

- Frame types
  - I frames: intrapicture
  - P frames: predicted picture
  - B frames: bidirectional predicted picture




- Example sequence transmitted as I P B B I B B

## MPEG (cont)

- B and P frames
  - coordinate for the macroblock in the frame
  - motion vector relative to previous reference frame (B, P)
  - motion vector relative to subsequent reference frame (B)
  - delta for each pixel in the macro block
- Effectiveness
  - typically 90-to-1
  - as high as 150-to-1
  - 30-to-1 for I frames
  - P and B frames get another 3 to 5x



## MP3

- CD Quality
  - 44.1 kHz sampling rate
  - 2 x 44.1 x 1000 x 16 = 1.41 Mbps
  - 49/16 x 1.41 Mbps = 4.32 Mbps
- Strategy
  - split into some number of frequency bands
  - divide each subband into a sequence of blocks
  - encode each block using DCT + Quantization + Huffman
  - trick: how many bits assigned to each subband