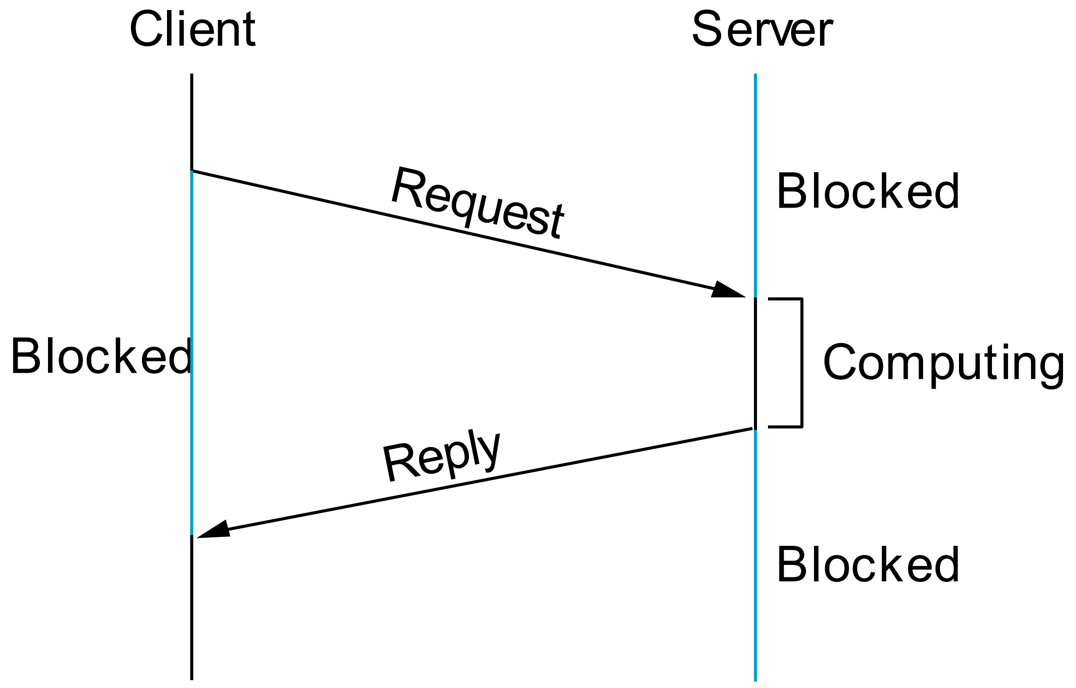
Remote Procedure Call

Outline

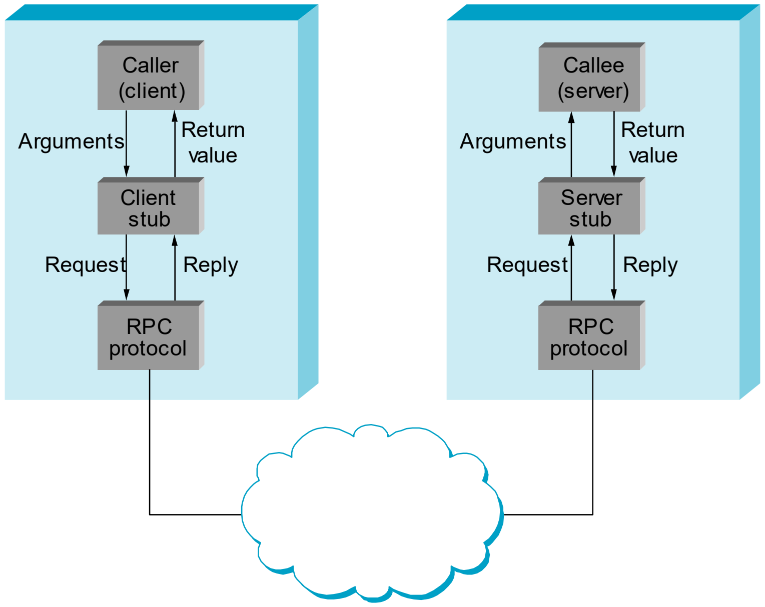
- Protocol Stack
- Presentation Formatting

RPC Timeline



RCP Components

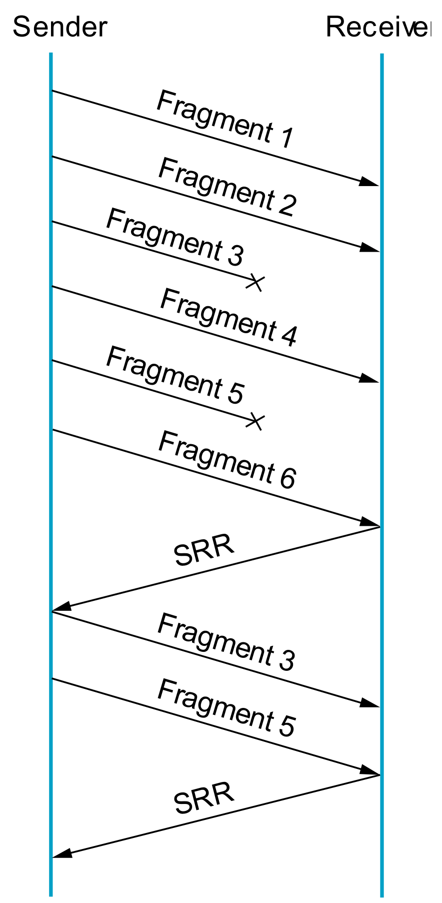
- Protocol Stack
  - BLAST: fragments and reassembles large messages
  - CHAN: synchronizes request and reply messages
  - SELECT: dispatches request to the correct process
- Stubs



Bulk Transfer (BLAST)

- Unlike AAL and IP, tries to recover from lost fragments

- Strategy
  - selective retransmission
  - aka partial acknowledgements



BLAST Details

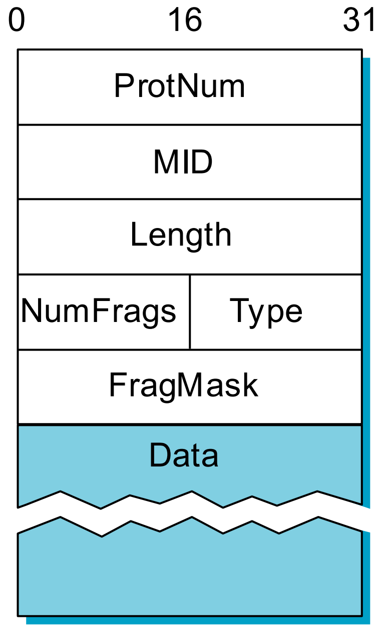
- Sender:
  - after sending all fragments, set timer DONE
  - if receive SRR, send missing fragments and reset DONE
  - if timer DONE expires, free fragments

BLAST Details (cont)

- Receiver:
  - when first fragments arrives, set timer LAST_FRAG
  - when all fragments present, reassemble and pass up
  - four exceptional conditions:
    - if last fragment arrives but message not complete
      - send SRR and set timer RETRY
    - if timer LAST_FRAG expires
      - send SRR and set timer RETRY
    - if timer RETRY expires for first or second time
      - send SRR and set timer RETRY
    - if timer RETRY expires a third time
      - give up and free partial message

BLAST Header Format

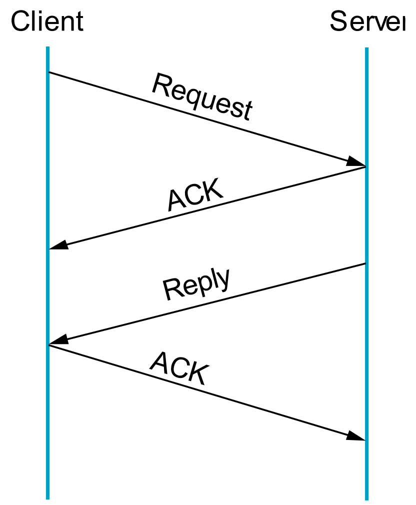
- MID must protect against wrap around
- TYPE = DATA or SRR
- NumFrags indicates number of fragments
- FragMask distinguishes among fragments
  - if Type=DATA, identifies this fragment
  - if Type=SRR, identifies missing fragments



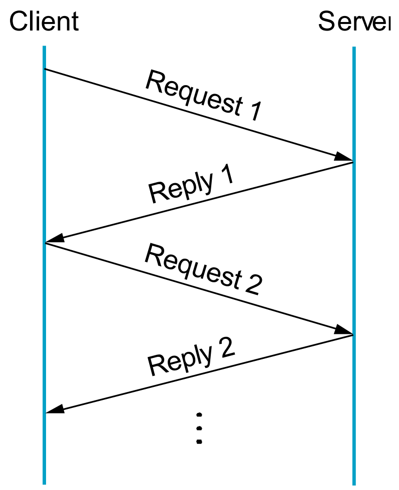
Request/Reply (CHAN)

- Guarantees message delivery
- Synchronizes client with server
- Supports *at-most-once* semantics

Simple case



Implicit Acks



CHAN Details

- Lost message (request, reply, or ACK)
  - set RETRANSMIT timer
  - use message id (MID) field to distinguish
- Slow (long running) server
  - client periodically sends “are you alive” probe, or
  - server periodically sends “I’m alive” notice
- Want to support multiple outstanding calls
  - use channel id (CID) field to distinguish
- Machines crash and reboot
  - use boot id (BID) field to distinguish

CHAN Header Format

```
typedef struct {
   u_short  Type;     /* REQ, REP, ACK, PROBE */
   u_short  CID;      /* unique channel id */
   int      MID;      /* unique message id */
   int      BID;      /* unique boot id */
   int      Length;   /* length of message */
   int      ProtNum;  /* high-level protocol */
} ChanHdr;


typedef struct {
   u_char    type;          /* CLIENT or SERVER */
   u_char    status;        /* BUSY or IDLE */
   int       retries;       /* number of retries */
   int       timeout;       /* timeout value */
   XkReturn  ret_val;       /* return value */
   Msg       *request;      /* request message */
   Msg       *reply;        /* reply message */
   Semaphore reply_sem;     /* client semaphore */
   int       mid;           /* message id */
   int       bid;           /* boot id */
} ChanState;
```

Synchronous vs Asynchronous Protocols

- Asynchronous interface

```
send(Protocol llp, Msg *message)
deliver(Protocol llp, Msg *message)
```

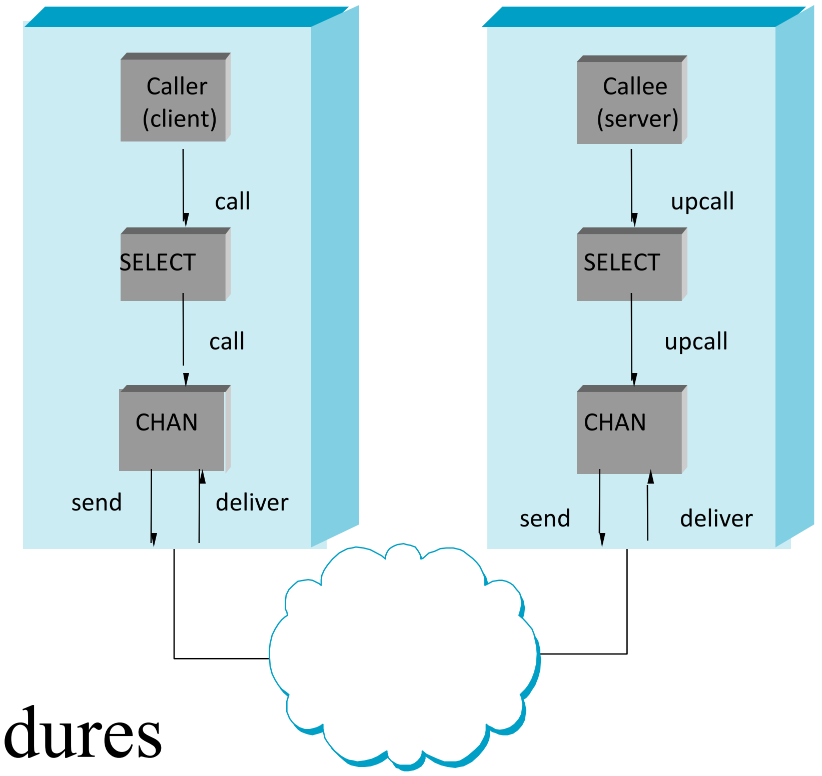
- Synchronous interface

```
call(Protocol llp, Msg *request, Msg *reply)
upcall(Protocol hlp, Msg *request, Msg *reply)
```

- CHAN is a hybrid protocol
  - synchronous from above: **`call`**
  - asynchronous from below: **`deliver`**

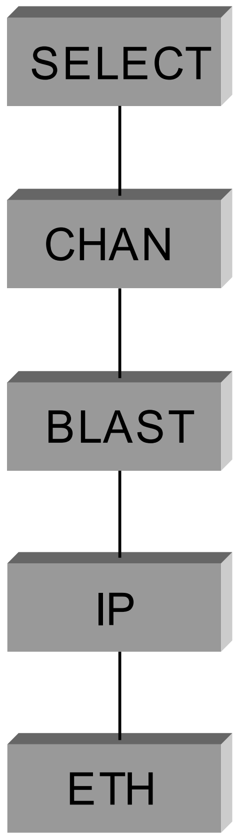
Dispatcher (SELECT)

- Dispatch to appropriate procedure
- Synchronous counterpart to UDP
- Implement concurrency (open multiple CHANs)



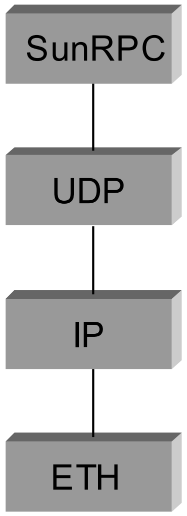
- Address Space for Procedures
  - flat: unique id for each possible procedure
  - hierarchical: program + procedure number

Simple RPC Stack



SunRPC

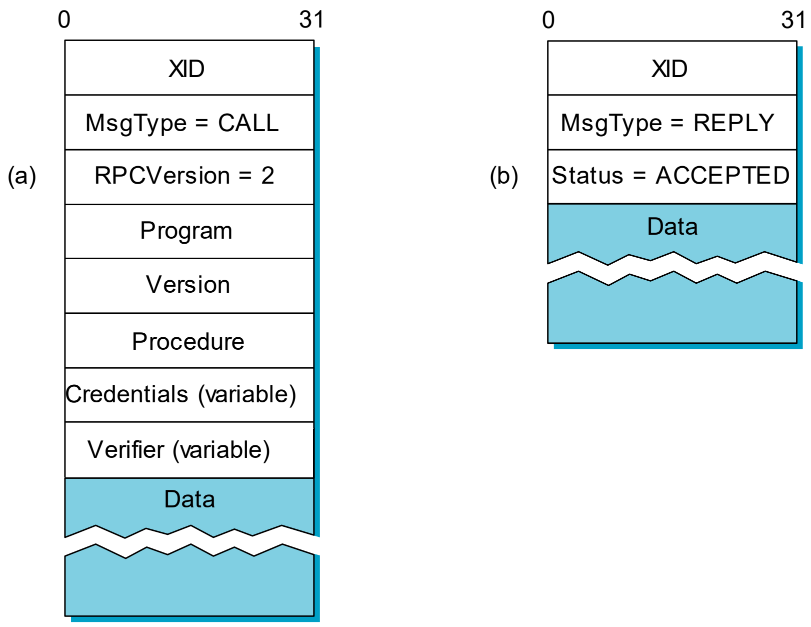
- IP implements BLAST-equivalent
  - except no selective retransmit
- SunRPC implements CHAN-equivalent
  - except not at-most-once



- UDP + SunRPC implement SELECT-equivalent
  - UDP dispatches to program (ports bound to programs)
  - SunRPC dispatches to procedure within program

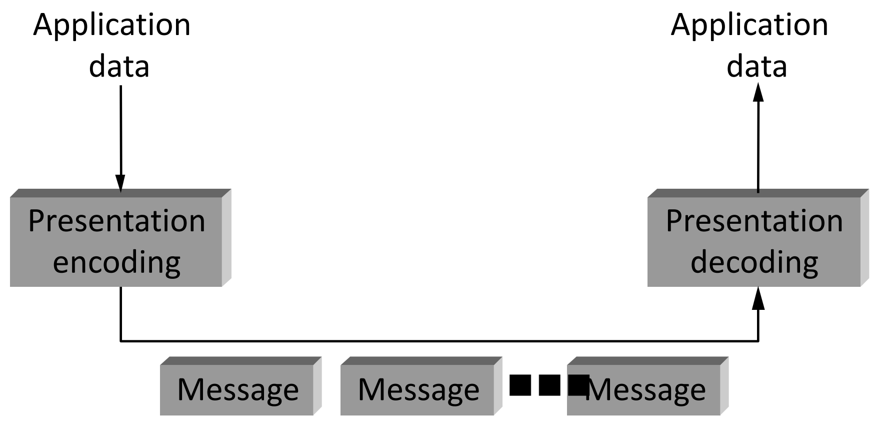
SunRPC Header Format

- XID (transaction id) is similar to CHAN's MID
- Server does not remember last XID it serviced
- Problem if client retransmits request while reply is in transit



Presentation Formatting

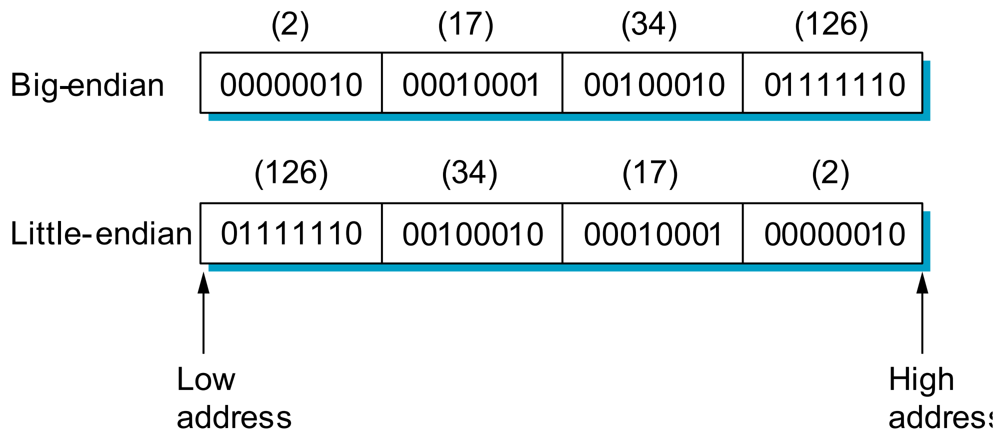
- Marshalling (encoding) application data into messages
- Unmarshalling (decoding) messages into application data



- Data types we consider
  - integers
  - floats
  - strings
  - arrays
  - structs
- Types of data we do not consider
  - images
  - video
  - multimedia documents

Difficulties

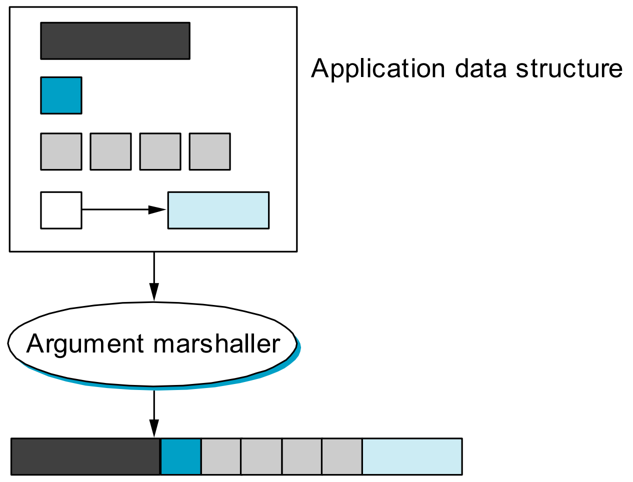
- Representation of base types
  - floating point: IEEE 754 versus non-standard
  - integer: big-endian versus little-endian (e.g., 34,677,374)



- Compiler layout of structures

Taxonomy

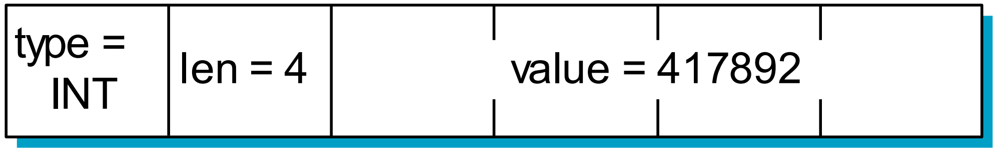
- Data types
  - base types (e.g., ints, floats); must convert
  - flat types (e.g., structures, arrays); must pack
  - complex types (e.g., pointers); must linearize



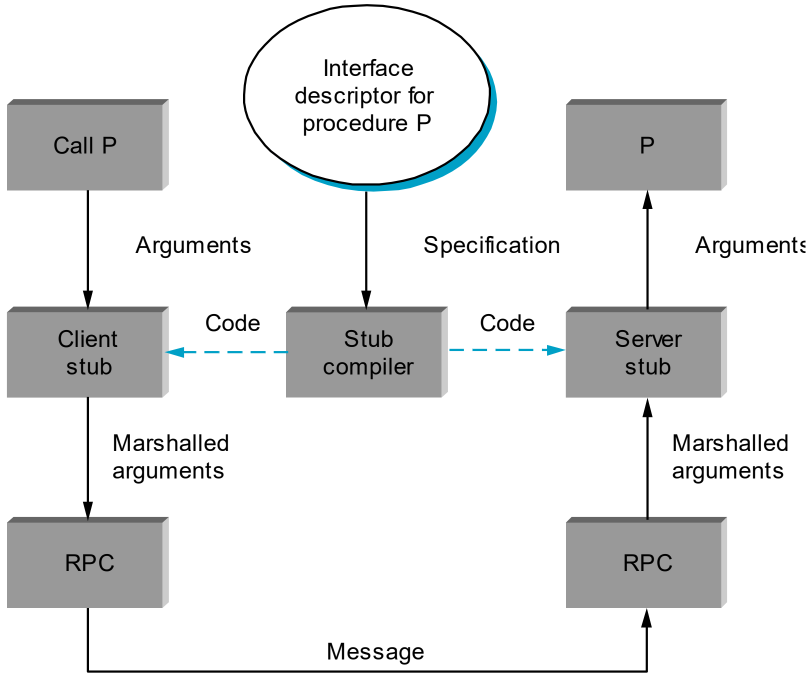
- Conversion Strategy
  - canonical intermediate form
  - receiver-makes-right (an *N* x *N* solution)

Taxonomy (cont)

- Tagged versus untagged data



- Stubs
  - compiled
  - interpreted



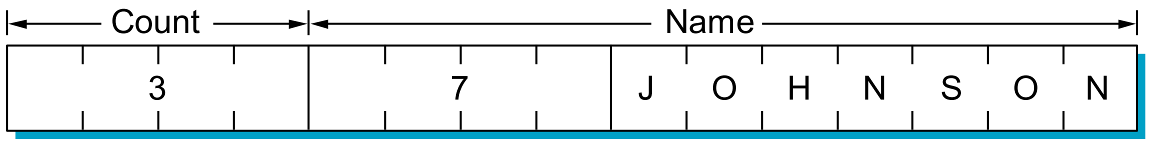
eXternal Data Representation (XDR)

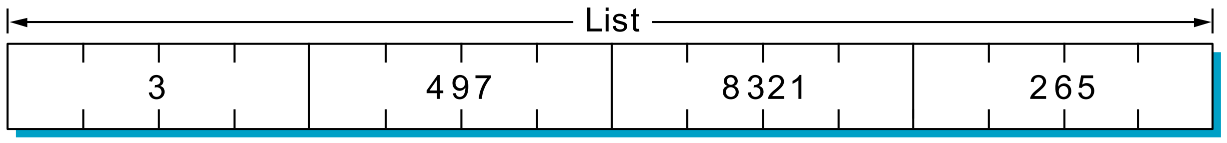
- Defined by Sun for use with SunRPC
- C type system (without function pointers)
- Canonical intermediate form
- Untagged (except array length)
- Compiled stubs

```
#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));
}
```

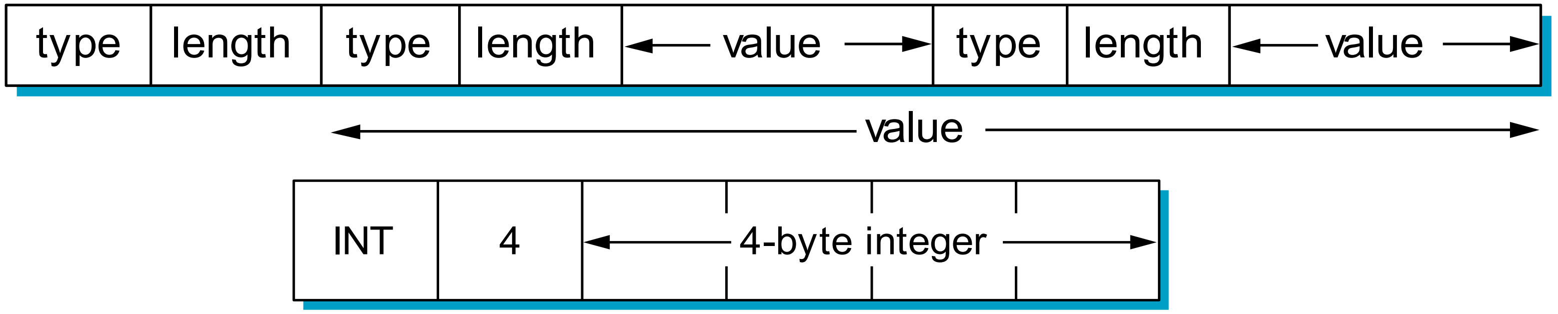




Abstract Syntax Notation One (ASN-1)

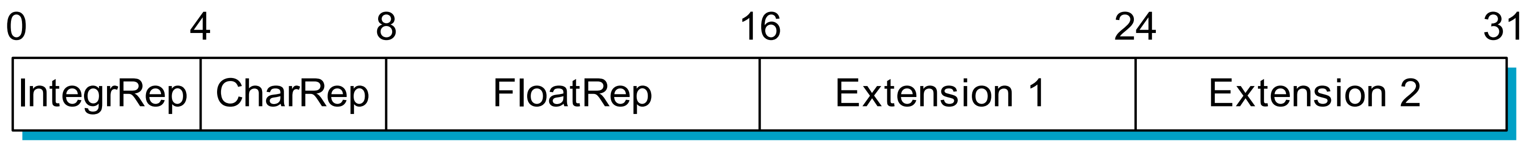
- An ISO standard
- Essentially the C type system
- Canonical intermediate form
- Tagged
- Compiled or interpretted stubs
- BER: Basic Encoding Rules

```
      (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


0
4
8
16
24
31
IntegrRep
CharRep
FloatRep
Extension 1
Extension 2