Terminal Polling

Polling and addressing mechanisms
Simple error-control mechanisms
State-diagram descriptions
Frame formats
Transparency mechanisms
Retransmission strategies

Data-link control
<table>
<thead>
<tr>
<th>FEATURE</th>
<th>DDCMP</th>
<th>BISYNC</th>
<th>SDLC</th>
<th>ADCCP</th>
<th>HDLC</th>
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<tbody>
<tr>
<td>FULL DUPLEX</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
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<td>HALF DUPLEX</td>
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<tr>
<td>SERIAL</td>
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<tr>
<td>PARALLEL</td>
<td>YES</td>
<td>NO</td>
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<tr>
<td>DATA TRANSPARENCY</td>
<td>COUNT</td>
<td>CHARACTER STUFFING</td>
<td>BIT STUFFING</td>
<td>BIT STUFFING</td>
<td>BIT STUFFING</td>
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<tr>
<td>ASYNCHRONOUS OPERATION</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
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<tr>
<td>SYNCHRONOUS OPERATION</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>POINT-TO-POINT</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>MULTIPoint</td>
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<td>YES</td>
<td>YES</td>
<td>YES</td>
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<td>ERROR DETECTION (CRC)</td>
<td>CRC-16</td>
<td>CRC-16</td>
<td>CRC-CCITT</td>
<td>CRC-CCITT</td>
<td>CRC-CCITT</td>
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<tr>
<td>RETRANSMIT ERROR RECOVERY</td>
<td>YES</td>
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<td>YES</td>
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<td>YES</td>
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<td>BOOTSTRAPPING CAPABILITY</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
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</table>

BINARY SYNCHRONOUS COMMUNICATIONS BSC (IBM)

DIGITAL DATA COMMUNICATIONS MESSAGE DDCMP (DEC)

SYSTEMS NETWORK ARCHITECTURE SNA (IBM)

ANSII DATA COMMUNICATIONS CONTROL ADCCP (ANSI)

HIGH-LEVEL DATA LINK CONTROL HDLC (ISO)

LINK ACCESS PROTOCOL BALANCED LAPB (CCITT)
TECHNIQUES FOR ACHIEVING TRANSPARENCY

1. CHARACTER STUFFING (BISYNC)

   DLE STX ... DLE DLE ... DLE ETX
   DEFINE ENTER/transparency
   STUFFED BY TRANSMITTER
   REMOVED BY RECEIVER
   DATA
   DEFINE EXIT/transparency

2. BIT STUFFING (HDLC, ADCCP, SDLC)

   0 1 1 1 1 1 1 0
   FRAME
   STUFFED BY TRANSMITTER
   REMOVED BY RECEIVER

3. COUNT (UDCMP)

   HEADER
   COUNT
   DATA

   LENGTH OF DATA FIELD
DDCMP MESSAGE FORMAT

SDLC FRAME FORMAT

<table>
<thead>
<tr>
<th>(F)</th>
<th>(A)</th>
<th>(C)</th>
<th>(I)</th>
<th>(FCS)</th>
<th>(F)</th>
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<tbody>
<tr>
<td>OPENING FLAG</td>
<td>ADDRESS</td>
<td>CONTROL</td>
<td>INFORMATION</td>
<td>FRAME CHECK SEQUENCE</td>
<td>CLOSING FLAG</td>
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<tr>
<td>01111110</td>
<td>8 Bits</td>
<td>8 Bits</td>
<td>VARIABLE OR ABSENT</td>
<td>16 Bits</td>
<td>8 Bits</td>
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</table>

SPAN OF CRC AND ZERO INSERTION
**LOOP CONSIDERATIONS**

- All secondary stations are repeaters

- Loop controller initiates by transmitting
  - A. Specific poll to a unique secondary
  - B. An ORP (optional response poll) to a common loop address

- Loop controller transmits the GA (go ahead) signal

- Secondary captures loop by converting GA to a transmit frame

- Secondary releases loop by returning to repeater operation

**LOOP CAPTURE EXAMPLE**

- Input signal to A (ga pattern from primary) 011111111111

- Output signal from A (repeater - no capture) 011111111111

- Output signal from B (loop capture) 01111110xxxx011110 opening frame closing flag contents flag

- Output signal from B (loop release) 011111111111
PHYSICAL LEVEL X.21

LINK (FRAME) LEVEL X.25

NETWORK (PACKET) LEVEL X.25

ADDRESSING X.121

PACKET ASSEMBLY/DISASSEMBLY X.3, X.28, X.29

GATEWAYS X.75

TRANSPORT PROTOCOLS

SMART PADS

CCITT PROTOCOL SUMMARY
**X.25 Virtual-Circuit Interface**

- Between DCE and DTE (only)
- Transparent data
- Reliable transmission
  - Error detection and retransmission
  - Sequencing guaranteed
- Virtual call set-up and supervision
- Full-duplex data with end-end interrupt and reset
- Private Virtual Circuits
X.25 INTERFACE

PHYSICAL LINK
DCE(2-WAY SIMULTANEOUS)DTE

LEVEL 3

LEVEL 2

(LAPB)

ISO (HDLC)

(LAPB)

LEVEL 2

LEVEL 3

RELIABLE TRANSMISSION
(ERROR/FLOW CONTROL)

CONGESTION CONTROL
VIRTUAL CHANNEL
CALL SET-UP AND SUPERVISION
FLOW CONTROL AND WINDOW

<table>
<thead>
<tr>
<th>Packet No</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>0</th>
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<tbody>
<tr>
<td>Already Ack'ed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not yet Ack'ed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>May not be sent</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Window Size W**

In absence of optional user facility is common to all logical channels and agreed for a period of time between DTE and Administration. Does not exceed 7, or 127 when extended.

**P(R)**

A received P(R) becomes the lower window edge.
X.25 Level 3

- Up to 128 octets
- 12-bit logical channel number
- Window flow control (8 or 128 size)
- Virtual Call (VC) or Private Virtual Circuit (PVC)
- Interrupt control
- Reliability provided by Level 2
- Provisions for longer messages (multi-pkt) with re-assembly at receiver
- Provisions for qualified (multi-priority) msgs.
End-End Characteristics

**Call Setup**
- Call Req.
- Call Conn.
  - Clr. Req.
  - DCE Clr.
  - DTE Int.
  - DTE Int.Cfm.
  - DTE Data.
  - DCERR
  - DTE Data
  - DCERR

**Call Clear**
- Call Accept
  - Clr. Ind.
  - DCE Clr.
  - DCE Int.
  - DCE Int.Cfm.
  - DCE Data
  - DCE Data
  - DCE Data

**Interrupt**
- Data (D bit clear)
- Data (D bit set)
X.75 - "TERMINAL AND TRANSIT CALL CONTROL PROCEDURES AND DATA TRANSFER SYSTEM ON INTERNATIONAL CIRCUITS BETWEEN PACKET SWITCHED DATA NETWORKS"

- SYMMETRICAL VERSION OF X.25
- ALSO NETWORK-ORIENTED INFORMATION
- FIXED ROUTING BETWEEN NETWORKS PER VIRTUAL CALL
- INTERNATIONAL NUMBERING PLAN (X.121) USING 14 NUMERIC CHARACTERS

<table>
<thead>
<tr>
<th>3</th>
<th>1</th>
<th>10</th>
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<tbody>
<tr>
<td>DATA COUNTRY CODE</td>
<td>NETWORK DIGIT</td>
<td>NETWORK TERMINAL NUMBER</td>
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</table>

DATA NETWORK IDENTIFICATION CODE

STE: SIGNALLING TERMINAL EQUIPMENT (GATEWAY)
Retransmission Strategies

Stop and Wait

Go-back n

\[ \text{SN}_{\text{min}}, \text{SN}_{\text{max}} \]

1. \( \text{SN}_{\text{min}} = \text{SN}_{\text{max}} = 0 \)

2. Do 3, 4, 5 in order, but req. bounded delay between enabling condition and execution

3. If \( \text{SN}_{\text{max}} < \text{SN}_{\text{min}} + n \) and pkt ready,
   assign \( \text{SN}_{\text{max}} \) to it and incr. \( \text{SN}_{\text{max}} \)

4. If valid frame from B containing \( \text{RN} > \text{SN}_{\text{min}} \)
   set \( \text{SN}_{\text{min}} \) to \( \text{RN} \)

5. If \( \text{SN}_{\text{min}} < \text{SN}_{\text{max}} \) choose \( \text{SN}, \text{SN}_{\text{min}} \leq \text{SN} < \text{SN}_{\text{max}} \)
   and transmit \( \text{SN} \). We must retransmit this if not ack and \( \text{SN}_{\text{min}} \) does not change (lineweights)

Rev 1. Set \( \text{RN} = 0 \) and do 2, 3 forever

2. If error-free SN received, release pkt to upper layer and incr \( \text{RN} \)

3. At arbitrary times bounded for lineweights
   transm. frame w RN

(Usually transmits only when recv.)
17 March 2

Note that modulus m can be used, but m > n

Selective Repeat ARQ

$p = \text{prob err}$

$\beta = \# \text{frames delay}$

For good designs $p$ must be

Set ARQ: $\eta \leq 1 - p$

But for Set ARQ $m \geq 2n$

Works in the same way, but need send bitmap to say what frames beyond the RN.

Tricks - increase dupes after error

NB x.25, SRJ - repeat only one frame, but resume at F: window edge.

ARPANet inc

8 virtual channels that share phys. layer

each frame has addr + octet for & acus bits

 Saw for each v.c.

NB Memory - use Clark's reassembly alg.