Data Link Control

Frame synchronization

Flow control

Error control

Addressing

Control and data on same link

Link management
Flow Control

Stop-and-wait flow control

\[ U = \frac{1}{1 + 2a} \]

\[ a = \frac{\text{Propagation time}}{\text{Transmission time}} \]

Sliding-window flow control

\[ U = \begin{cases} 
\frac{1}{N} & N > 2a + 1 \\
\frac{N}{2a+1} & N < 2a + 1 
\end{cases} \]
Error Detection

Parity check

Cyclic Redundancy Check (CRC)

- All single-bit errors.
- All double-bit errors.
- Any odd number of errors.
- Any burst error for which the length of the burst is less than the length of the divisor polynomial.
- Most larger burst errors.
Error Control

Stop-and-wait ARQ

\[ U = \frac{1 - p}{1 + 2a} \]

Co-back-N ARQ

\[ U = \begin{cases} 
\frac{1-p}{1+2ap} & \text{N} > 2a + 1 \\
\frac{N(1-p)}{(2a+1)(1-p+Np)} & \text{N} < 2a + 1
\end{cases} \]

Selective-reject ARQ

\[ U = \begin{cases} 
\frac{1-p}{N(1-p)} & \text{N} > 2a + 1 \\
\frac{1-p}{2a+1} & \text{N} < 2a + 1
\end{cases} \]
Data Link Control Protocols

Binary Synchronous Communication (BSC)

Synchronous data Link Control (SDLC)

High-Level Data Link Control (HDLC)
High-Level Data Link Control (HDLC)

Primary station

Secondary station

Combined station

Unbalanced configuration

Balanced configuration

Normal response mode (NRM)

Asynchronous balanced mode (ABM)

Asynchronous response mode (ARM)
Data Link Control Protocols

Logical Link Control

Link Access Procedure, Balanced (LAPB)

Link Access Procedure, D-Channel (LAPD)

Link Access Procedure for Modems (LAPM)
Data Link Control Protocols

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<tr>
<th>Protocol</th>
<th>Size</th>
<th>Error Detection</th>
<th>Retransmission</th>
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<tr>
<td>xmodem</td>
<td>132</td>
<td>8-bit Checksum</td>
<td>Stop-and wait ARQ</td>
</tr>
<tr>
<td>xmodem-crc</td>
<td>132</td>
<td>8-bit CRC</td>
<td>Stop-and wait ARQ</td>
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<tr>
<td>xmodem-1k</td>
<td>1028</td>
<td>8-bit CRC</td>
<td>Stop-and wait ARQ</td>
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<tr>
<td>ymodem</td>
<td>1029</td>
<td>16-bit CRC</td>
<td>Stop-and wait ARQ</td>
</tr>
<tr>
<td>zmodem</td>
<td>*</td>
<td>32-bit CRC</td>
<td>Continuous ARQ</td>
</tr>
<tr>
<td>kermit</td>
<td>*</td>
<td>24-bit CRC</td>
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## Data Link Control Protocols

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