Data Transmission (1)

• Communication: simple view
Data Transmission (2)

• Communication: detailed view

Sender → Encoding → Channel → Decoding → Receiver

Signal via Medium (e.g. sound by air)
Data Transmission (3)

• Data processing and data storage
Data Transmission (4)

• Data communication

Parallel communication

Serial communication
Data Transmission (5)

- Encoding example: ASCII code table

<table>
<thead>
<tr>
<th>ASCII</th>
<th>Lower Hex Digit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>NUL  SOH  STX  ETX  EOF  ENQ  ACK  BEL  BS  HT  LF  VT  FF  CR  SO  SI</td>
</tr>
<tr>
<td>1</td>
<td>DLE  DC1  DC2  DC3  DC4  NAK  SYN  ETB  CAN  EM  SUB  ESC  FS  GS  RS  US</td>
</tr>
<tr>
<td>2</td>
<td>!  &quot;  #  $  %  &amp;  '  (  )  *  +  ,  -  .  /</td>
</tr>
<tr>
<td>3</td>
<td>0  1  2  3  4  5  6  7  8  9  :  ;  &lt;  =  &gt;  ?</td>
</tr>
<tr>
<td>4</td>
<td>@  A  B  C  D  E  F  G  H  I  J  K  L  M  N  O</td>
</tr>
<tr>
<td>5</td>
<td>P  Q  R  S  T  U  V  W  X  Y  Z  [  \  ]  ^  _</td>
</tr>
<tr>
<td>6</td>
<td>`  a  b  c  d  e  f  g  h  i  j  k  l  m  n  o</td>
</tr>
<tr>
<td>7</td>
<td>p  q  r  s  t  u  v  w  x  y  z  {</td>
</tr>
</tbody>
</table>
Data Transmission (6)

• Serial communication is already quite old
  – Used to interconnect
    • Teletypewriters
    • Mainframe computers
    • Terminals
    • Printers
    • Etc.
Serial Ports (1)

• Serial Ports are used for serial communication
  – TXD: transmitted data
  – RXD: received data
  – GND: ground, electrical bonding
Serial Ports (2)

• How hosts communicate with each other
  – Point-to-point connection
    • UART
  – Serial buses
    • SPI
    • I²C
    • CAN
    • USB
Serial Ports (3)

- Clock drift may corrupt data

<table>
<thead>
<tr>
<th>Data</th>
<th>0</th>
<th>0</th>
<th>1</th>
<th>0</th>
<th>0</th>
<th>1</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clock A</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Signal</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Clock B</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Data seen by clock A: 8 Bits, 0010 0110, 26_{hex}
Data seen by clock B: 7 Bits, 001 0110, 16_{hex}
Serial Ports (4)

- Clocks must be synchronized
  - Synchronization bits (cf. UART)
  - Synchronization line (cf. I2C or SPI)