Performance Comparison

- Bus Cycle Times
- Reaction Times / Determinism
- Implementations
Bus Cycle Time: Ethernet

- Ethernet Cycle Time is hardly predictable.
- Depends on software runtimes (UDP + TCP) and timing behavior of „Master“ (COTS Technology)
- 100 Mbit Switched Ethernet: almost independent of no. of nodes and of no. of bytes.

- Modbus TCP: Node Response within 10..20 ms, Cycle Times 40..60 ms
- Beckhoff ADS/UDP: Node Response within 1..4 ms, Cycle Times 15..25 ms
Bus Cycle Time: Profibus

- 12 MBaud, 2+2 Bytes
- 12 MBaud, 6+6 Bytes
- 12 MBaud, 20+20 Bytes
- 1,5 MBaud, 2+2 Bytes
- 1,5 MBaud, 6+6 Bytes
- 1,5 MBaud, 20+20 Bytes
- 500 kBaud, 2+2 Bytes
- 500 kBaud, 6+6 Bytes
- 500 kBaud, 20+20 Bytes

No of Nodes vs Cycle Time [ms]
Bus Cycle Time: DeviceNet

Graph showing the relationship between the number of nodes and cycle time for different baud rates and data sizes.
Bus Cycle Time: Sercos

- 16MBaud, 2+2Bytes
- 16MBaud, 6+6 Bytes
- 16MBaud, 20+20 Bytes
- 4MBaud, 2+2Bytes
- 4MBaud, 6+6 Bytes
- 4MBaud, 20+20Bytes
- 2MBaud, 2+2Bytes
- 2MBaud, 6+6 Bytes
- 2MBaud, 20+20Bytes

No of Slaves vs Cycle Time [ms]
**Reaction Time I**

Reaction to Digital Input

Typical for:
AllenBradley PLC / DeviceNet

**Scenario I:**
- Bus Cycle Time similar to Task Cycle Time
- Bus Cycle not synchronised with PLC Task
- Local I/O Cycle not synchronised with Bus Cycle

Diagram:

- **Signal in** (Worst case)
- **Signal in** (best case)
- **Signal out**

- $T_{mpd}$: Master Processing Delay
- $T_{I/O}$: Local I/O Update Time (Extension Bus)
Reaction Time II

Reaction to Digital Input

Scenario II:
- Bus Cycle Time shorter than Task Cycle Time
- Bus Cycle not synchronised with PLC Task
- Local I/O Cycle not synchronised with Bus Cycle

Typical for:
Siemens PLC / Profinet, AB / ControlNet

- **T_{mpd}:** Master Processing Delay
- **T_{I/O}:** Local I/O Update Time (Extension Bus)
Reaction Time III

Reaction to Digital Input

Typical for:
Siemens PLC / Profibus I/O (Beckhoff)

Scenario III:
- Bus Cycle Time **shorter** to Task Cycle Time
- Bus Cycle **not** synchronised with PLC Task
- Local I/O Cycle **synchronised** with Bus Cycle

**Typical for:**
Siemens PLC / Profibus I/O (Beckhoff)

**Scenario III:**
- Bus Cycle Time shorter to Task Cycle Time
- Bus Cycle not synchronised with PLC Task
- Local I/O Cycle synchronised with Bus Cycle

**Typical for:**
Siemens PLC / Profibus I/O (Beckhoff)

**Scenario III:**
- Bus Cycle Time shorter to Task Cycle Time
- Bus Cycle not synchronised with PLC Task
- Local I/O Cycle synchronised with Bus Cycle

**Typical for:**
Siemens PLC / Profibus I/O (Beckhoff)

**Scenario III:**
- Bus Cycle Time shorter to Task Cycle Time
- Bus Cycle not synchronised with PLC Task
- Local I/O Cycle synchronised with Bus Cycle

**Typical for:**
Siemens PLC / Profibus I/O (Beckhoff)
Scenario IV:
- Bus Cycle Time shorter than Task Cycle Time
- Bus Cycle synchronised with PLC Task
- Local I/O Cycle not synchronised with Bus Cycle

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$T_{mpd}$: Master Processing Delay
$T_{I/O}$: Local I/O Update Time (Extension Bus)
**Reaction Time V**

Reaction to Digital Input

**Scenario V:**
- Bus Cycle Time shorter than Task Cycle Time
- Bus Cycle synchronised with PLC Task
- Local I/O Cycle synchronised with Bus Cycle

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**Cycle**

- **$T_{mpd}$**

**TI/O**

- **Signal in** (Worst case)
- **Signal in** (Best case)

**Signal out**

- **$T_{I/O}$**: Master Processing Delay
- **$T_{I/O}$**: Local I/O Update Time (Extension Bus)
Scenario VI:
- Bus Cycle Time shorter than Task Cycle Time
- Bus Cycle synchronised with PLC Task
- Local I/O Cycle synchronised with Bus Cycle
- „Tuning“: Intermediate Bus Cycles introduced

**Reaction to Digital Input**

Possible with:
Beckhoff TwinCAT / Profibus / Sercos

Signal in
(Worst case)

Signal out

\[ T_{mpd} \]: Master Processing Delay

\[ T_{l/o} \]: Local I/O Update Time (Extension Bus)
Reaction Time VII

Reaction to Digital Input

Typical for:
Beckhoff TwinCAT / Profibus / Sercos

Scenario VII:
- Bus Cycle Time short, Several Task Cycle Times
- Bus Cycle synchronised with fastest PLC Task
- Local I/O Cycle synchronised with Bus Cycle

Signal in (Worst case)  Signal in (Best case)  Signal out

\( T_{mpd} \): Master Processing Delay
\( T_{I/O} \): Local I/O Update Time (Extension Bus)
Reaction Time VIII

Reaction to Digital Input

Typical for:
poor bus choice

Scenario VIII:
- Bus Cycle Time longer than Task Cycle Time
- Bus Cycle not synchronised with PLC Task
- Local I/O Cycle not synchronised with Bus Cycle

\[ T_{\text{mpd}} \] Master Processing Delay
\[ T_{\text{i/o}} \] Local I/O Update Time (Extension Bus)
Reaction Time: Conclusions

• Bus Cycle Time alone is no good performance indicator
• „Fast enough“ generally means: faster than PLC cycle
• Short Reaction Time is only one criteria – in many applications determinism is crucial
• Synchronisation improves determinism, not necessarily reaction time
• Some applications may require „tuning“
## Bus Performance Comparison: Implementations

<table>
<thead>
<tr>
<th>Fieldbus</th>
<th>Typical bus cycle time</th>
<th>Bus Coupler: K-Bus Synchronised with fieldbus?</th>
<th>Fieldbus Card: internal firmware cycle time</th>
<th>TwinCAT: card synchronised with TCAT task?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profibus</td>
<td>1-3 ms</td>
<td>Yes (optional)</td>
<td>~ 0,5 ms</td>
<td>yes</td>
</tr>
<tr>
<td>Devicenet</td>
<td>5-15 ms</td>
<td>no</td>
<td>~ 2 ms (COS: 0,2ms**)</td>
<td>No (COS: yes**)</td>
</tr>
<tr>
<td>Sercos</td>
<td>1-2 ms</td>
<td>yes</td>
<td>~ 0,2 ms</td>
<td>yes</td>
</tr>
<tr>
<td>CANopen</td>
<td>3-15 ms</td>
<td>No (in sync mode: yes#)</td>
<td>~ 0,5 ms</td>
<td>no</td>
</tr>
<tr>
<td>Lightbus</td>
<td>1-2 ms</td>
<td>yes</td>
<td>~ 0,2 ms</td>
<td>yes</td>
</tr>
<tr>
<td>Ethernet</td>
<td>15-100 ms</td>
<td>no</td>
<td>~ 5..15 ms</td>
<td>no</td>
</tr>
</tbody>
</table>

* Depends on bus traffic  ** not yet implemented  # form Firmware version C0