Interface/Communications Protocols

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Steps for System Design

- Specification
- Partitioning
- Interface Specification
- Timing Design
  - Timing and sequencing of operations
- Module Design
- Performance Tuning

Specification

- A good specification should include
  - Overall description
    - What the system is, what is does, how it is used.
  - Inputs and outputs
    - Formats, range of values, timing, and protocols
  - States
    - User visible states, including registers, mode bits, and internal memories
  - Modes
  - Options
    - All notable features of the system
    - All interesting edge cases

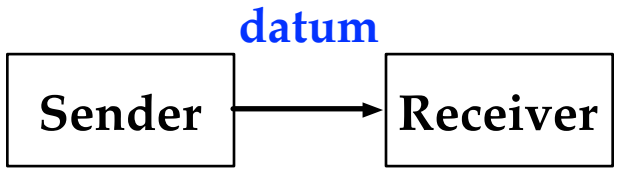
Interface Timing

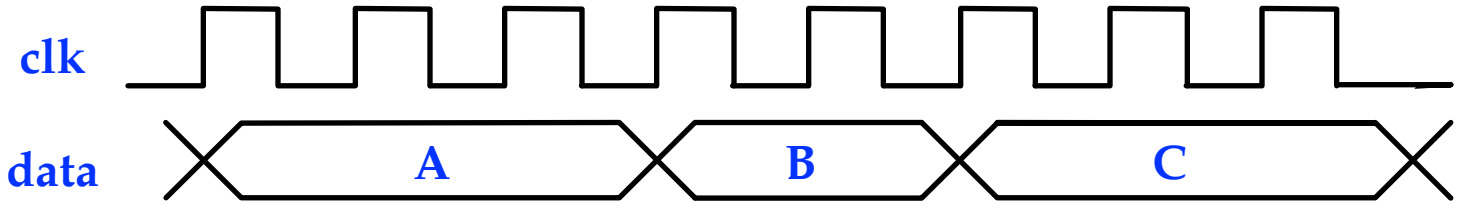
- Data transfer sequencing
  - When the data is valid from the source, and when the destination is ready to receive the data.
- Always valid timing
- Periodically valid signals
- Flow control

Always Valid Timing

- An always valid signal represents a value that can be dropped or duplicated.
- A static or constant signal is a special case.

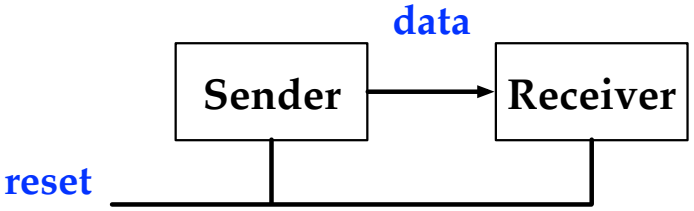
Ex: thermometer

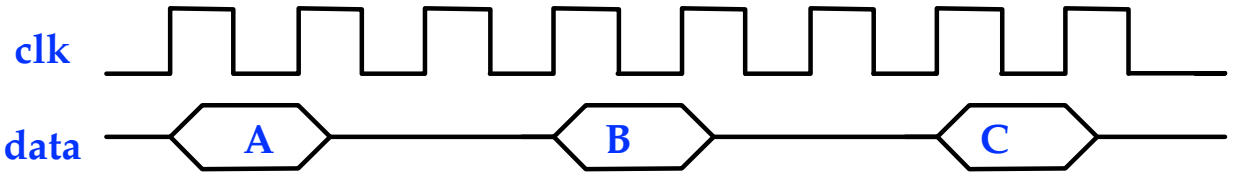




Periodically Valid Signals

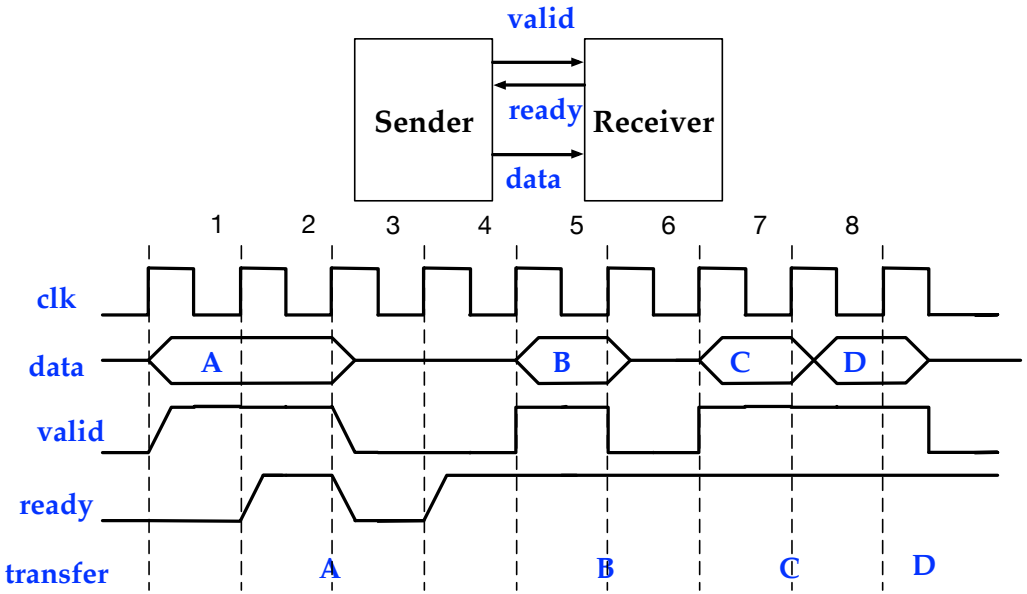
- A signal with *periodically valid timing* or *periodical timing* is valid once every *N* cycles.
  - Each value of a periodically valid signal represents a particular event, task, or token, and cannot be dropped or duplicated.
  - With periodically signaling, the sending and receiving modules must be synchronized.





Flow Control

- Use explicit sequencing signals: ***valid*** and ***ready***.
  - Data is only transferred when both ***valid*** and ***ready*** are asserted.
  - pull timing: transfers are controlled by the receiver ***ready***
  - push timing: transfers are controlled by the sender ***valid***
  - ***valid*** signal can be encoded in the data signal by using an unused or invalid data code to imply not valid.
  - FIFO: output is ***valid*** unless it is empty, input is ***ready*** unless it is full

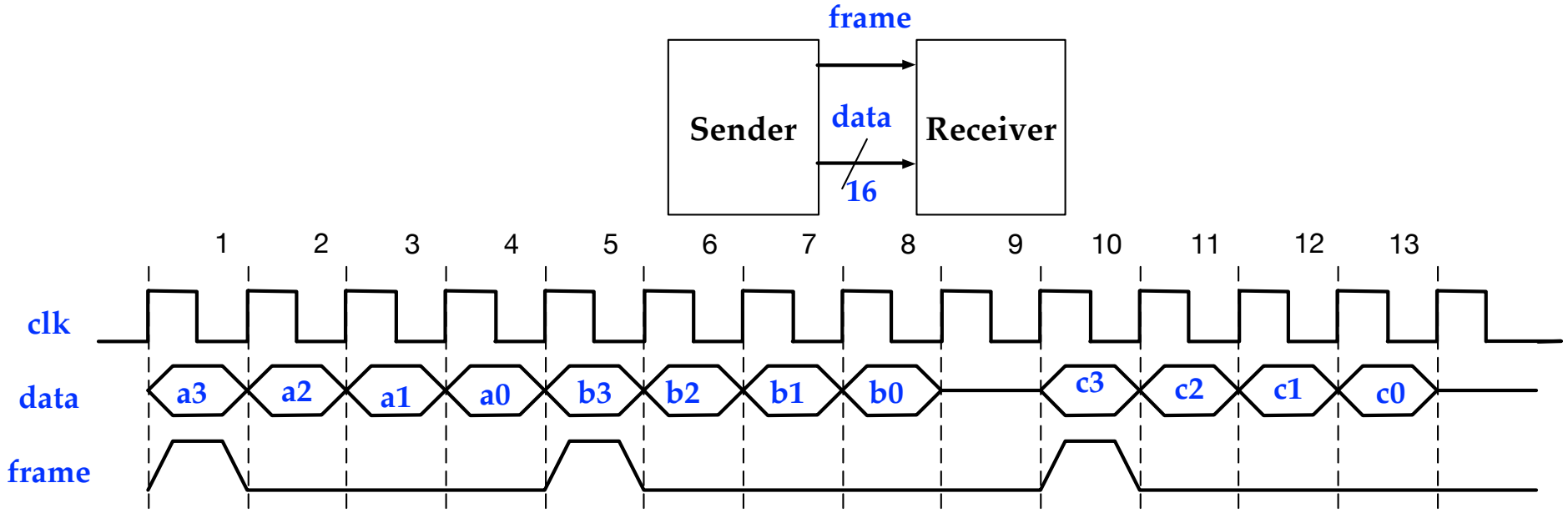


Interface Partitioning and Selection

- A common interface technique provides separate fields for ***control***, ***address***, and ***data***.
- The ***control*** and ***address*** fields are selection fields.
  - The control field selects the operations to be performed
  - The address field selects which location the operation is performed on.
- Both the data and selection fields are sequenced using the above-mentioned timing conventions.

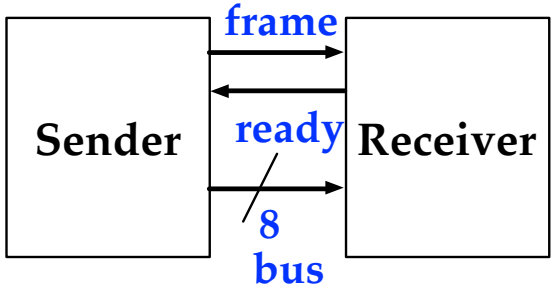
Serial and Packetized Interfaces

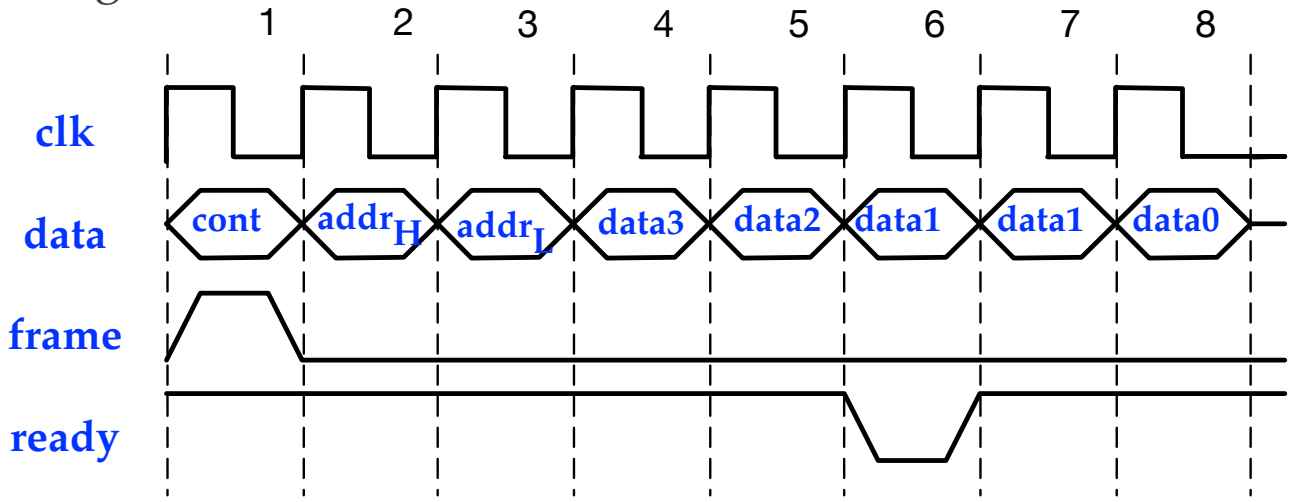
- The interface transfers 64-bit block of data once every four cycles.
  - Push timing: One-way flow control using ***frame*** (valid) signal
  - nested timing with push timing used at the frame level and periodically timing used at the cycle level.



Serial and Packetized Interfaces

- Memory and I/O interfaces often serialize the command, address, and data fields to transmit over a shared, narrow bus.
  - Cycle-valid/frame-ready flow control
- Serialized interfaces can be thought of as being ***packetized***.
  - Each item transmitted is a ***packet*** of information containing many fields and possibly of variable length





Serial and Packetized Interfaces

- Serialized vs. parallel interface
  - based on cost and performance
  - Pros of serialized interface: reduction of # of pins or wires
  - Cons of serialized interface: increase in latency and complexity of the serialization/de-serialization, and framing
- On-chips
  - cost of additional wires is small => parallel
- Off-chips
  - chip pins and system-level signals are expensive => serialized

Timing Tables

- Timing diagrams illustrate timing relationships for visualizing binary signals for a few cycles.
- For multi-bit signals with many more cycles => timing tables

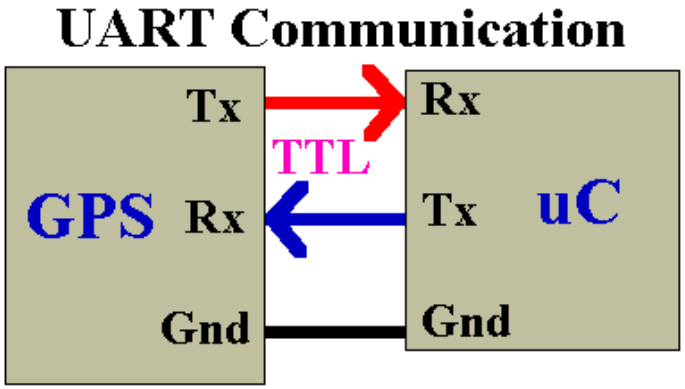
cycle	rst	ival	in	count	out	ov
0	1	x	x	x	x	x
1	0	1	A_0	0	00000000	0
2	0	1	A_1	1	0000000A_0	0
3	0	1	A_2	2	000000A_1A_0	0
…	0	1	A			0
8	0	1	A_7	7	0$A_6A_5A_4A_3A_2A_1A_0$	0
9	0	1	B_0	0	$A_7A_6A_5A_4A_3A_2A_1A_0$	1
10	0	0	x	1	$A_7A_6A_5A_4A_3A_2A_1B_0$	0
11	0	1	B_1	1	$A_7A_6A_5A_4A_3A_2A_1B_0$	0
12	0	1	B_2	2	$A_7A_6A_5A_4A_3A_2B_1B_0$	0
…	0	1	B			0
18	0	0	x	0	$B_7B_6B_5B_4B_3B_2B_1B_0$	1

De-serializer:

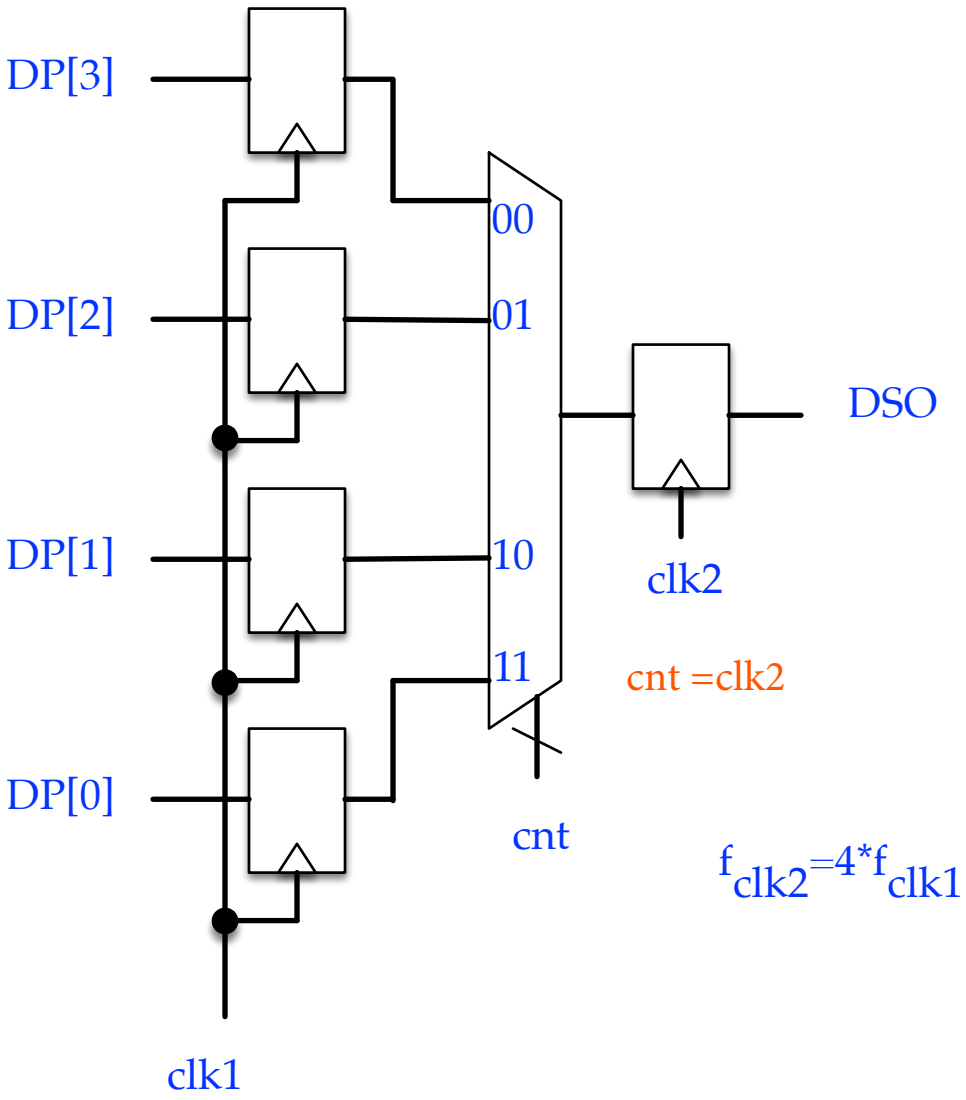
1. Convert a 1-bit wide data input to 8-bit wide data output
2. Both input and output use push flow control
3. The output is not valid until 8 valid inputs have been received.

UART
(Universal Asynchronous Receiver / Transmitter)

- serial-to-parallel conversion: peripheral to CPU
- parallel-to-serial conversion: CPU to peripheral
- RS232, RS485
- Baud rate



Parallel-to-Serial Conversion



Serial-to-Parallel Conversion

$f_{clk2}=4*f_{clk1}$