Communication

Chirag Sangani

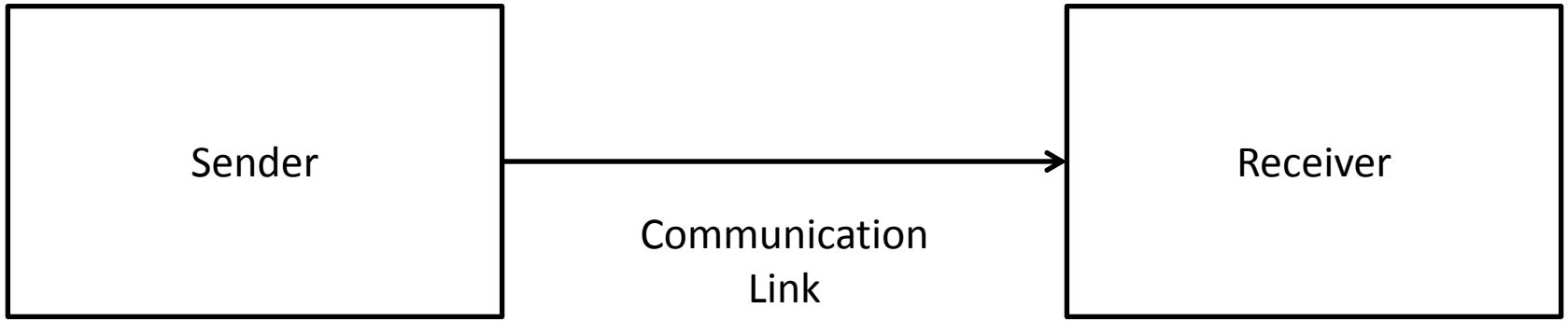
Scope of Communication

- Telephones and cell phones.
- Satellite networks.
- Radio and DTH services.
- Campus LAN and wireless.
- Internet.
- Intra-galactic communication.

Essentials of Communication

- The basic task: to convey a message (data) from one end to the other end.
- Sounds simple enough, however, there are a lot of assumptions that we're used to which need to be relooked at.
- The biggest assumption usually is that the message will reach the destination correctly.

Essentials of Communication



Assumptions in Communication

- The communication link exists.
- The communication link is sound.
- The sender and receiver are the correct nodes.
- The sender is sending the correct data.
- The receiver is able to correctly interpret the incoming data.

Protocols in Communication

- Assumptions in communication are harmful, yet important.
- To deal with these assumptions, we need an elaborate mechanism to ensure correctness of communication.
- These elaborate mechanisms have been codified and standardized as protocols.

Advantages of Protocols

- Standardized, so interoperability is ensured.
- Usually include error-detection and error-correction mechanisms.
- Are available as implemented chips that can be directly used.

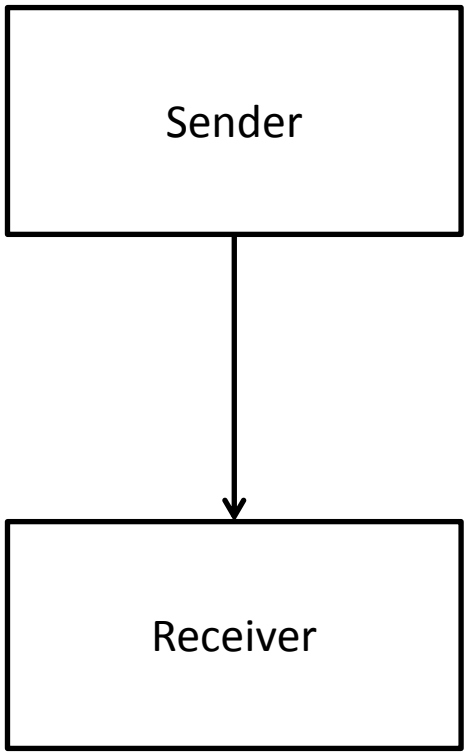
Types of Protocols

- There are different ways of categorizing protocols.
- Protocols can be categorized technically as serial mode transfer or parallel mode transfer.
- Protocols can also be categorized as asynchronous mode transfer or synchronous mode transfer.

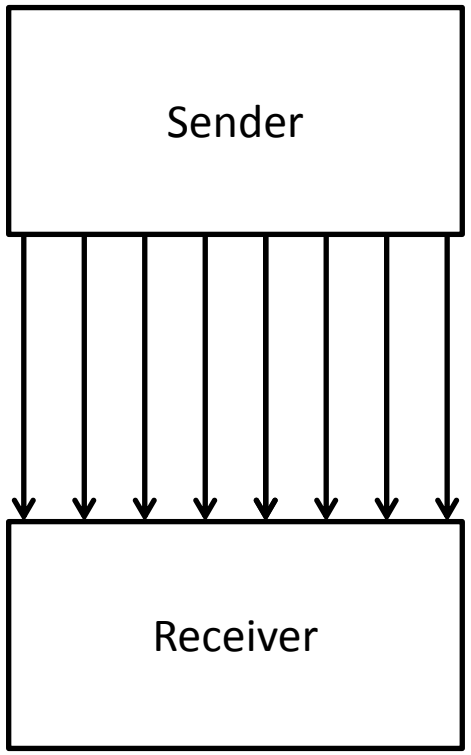
Serial and Parallel Mode

- Remember that we want to transfer data which, at its essence, is a binary number.
- We shall constrict ourselves to 8-bit binary numbers.
- Parallel protocols transfer 8 bits by 8 parallel wires.
- Serial protocols transfer 8 bits by using only one or two wires.

Serial and Parallel Mode



Serial Mode



Parallel Mode

Advantages and Disadvantages

Serial Mode

- Advantages:
  - Reliable
  - Low-cost
  - Low-power
- Disadvantages:
  - Slow
  - Requires complex control

Parallel Mode

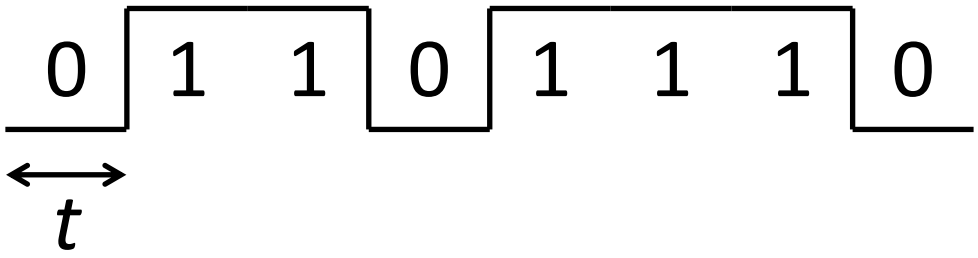
- Advantages:
  - Very fast
  - Simple to implement
- Disadvantages:
  - Unreliable
  - Short-range
  - Expensive
  - Draws more power

Synchronous and Asynchronous Mode

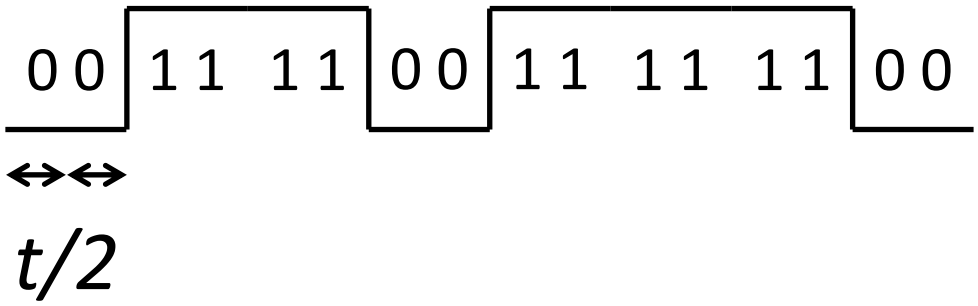
- Pertains to sender-receiver synchronization.
- Sender sends data at a certain speed. For flexibility, protocols allow for multiple speeds.
- If receiver does not know the speed or judges it incorrectly, errors may occur.

Perils of Desynchronization

Sender:

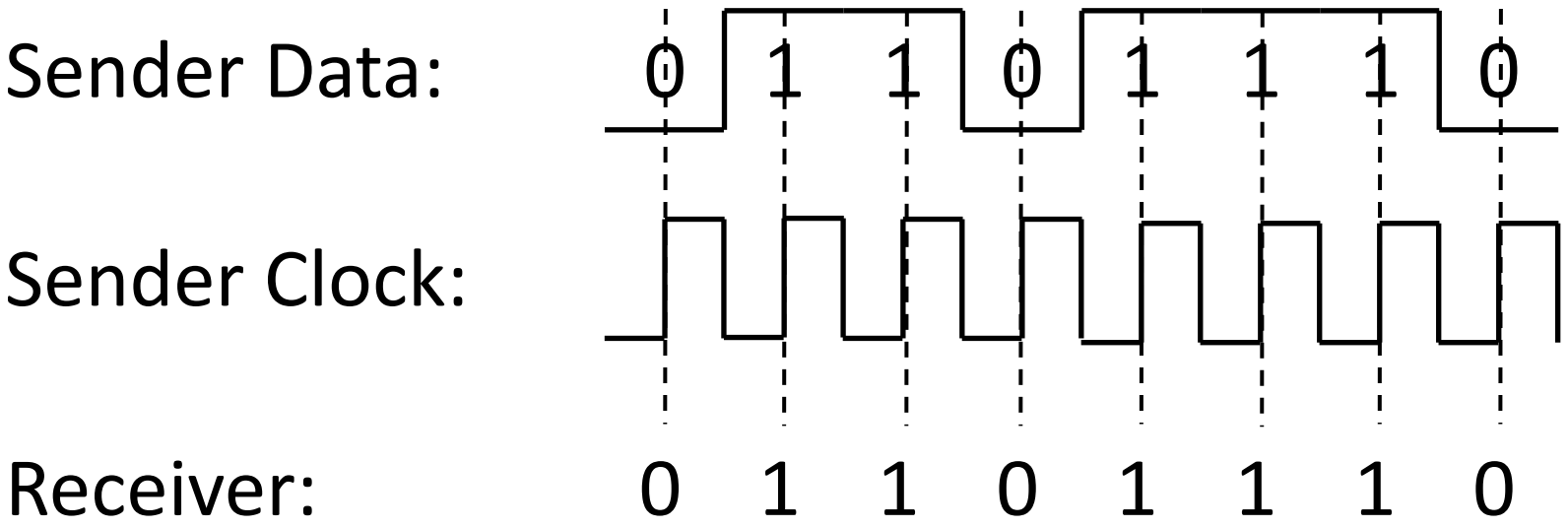


Receiver:



Synchronous Mode

- Sender sends a clock signal along with data: at every rising / falling edge of the clock, the data value is read by the receiver.



Asynchronous Mode

- There is no clock signal.
- The receiver and the sender communicate at a predetermined speed (bauds or bits per second).

Advantages and Disadvantages

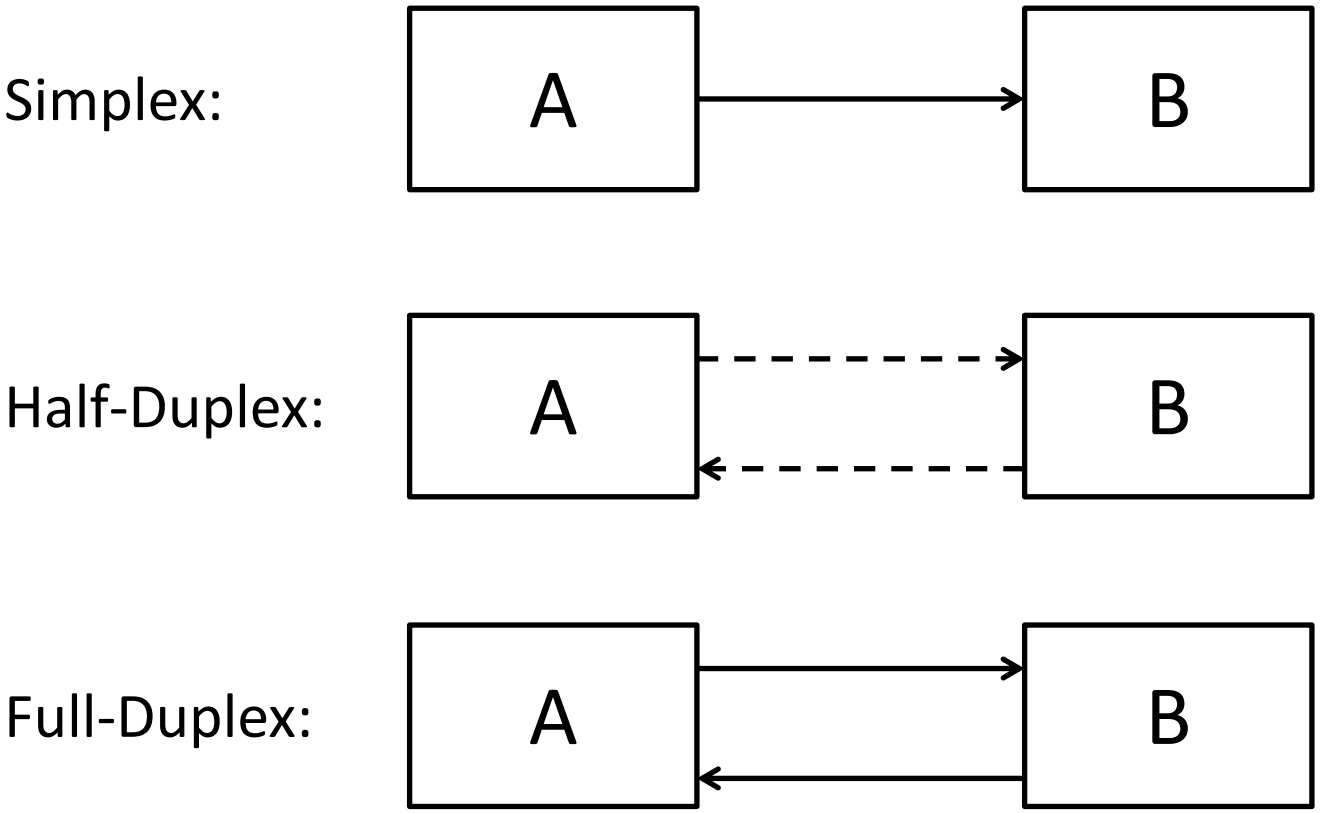
Asynchronous Mode

- Advantages:
  - Simple
  - Inexpensive
- Disadvantages:
  - High overhead
  - Error-prone

Synchronous Mode

- Advantages:
  - Efficient
  - Reliable
- Disadvantages:
  - Complicated
  - Expensive

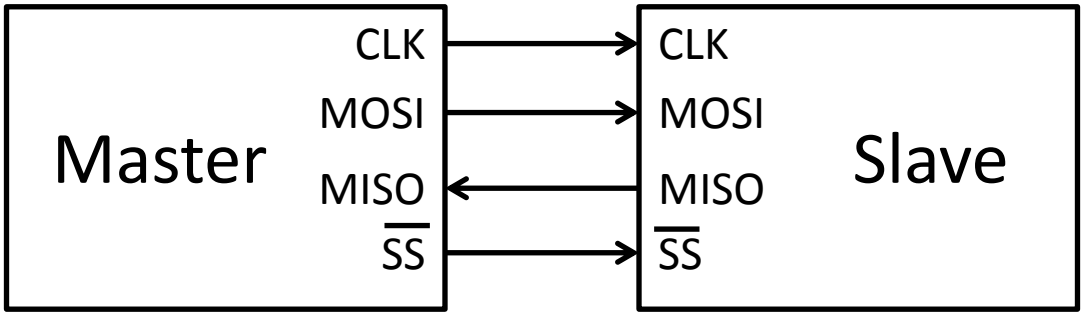
Transmission Modes



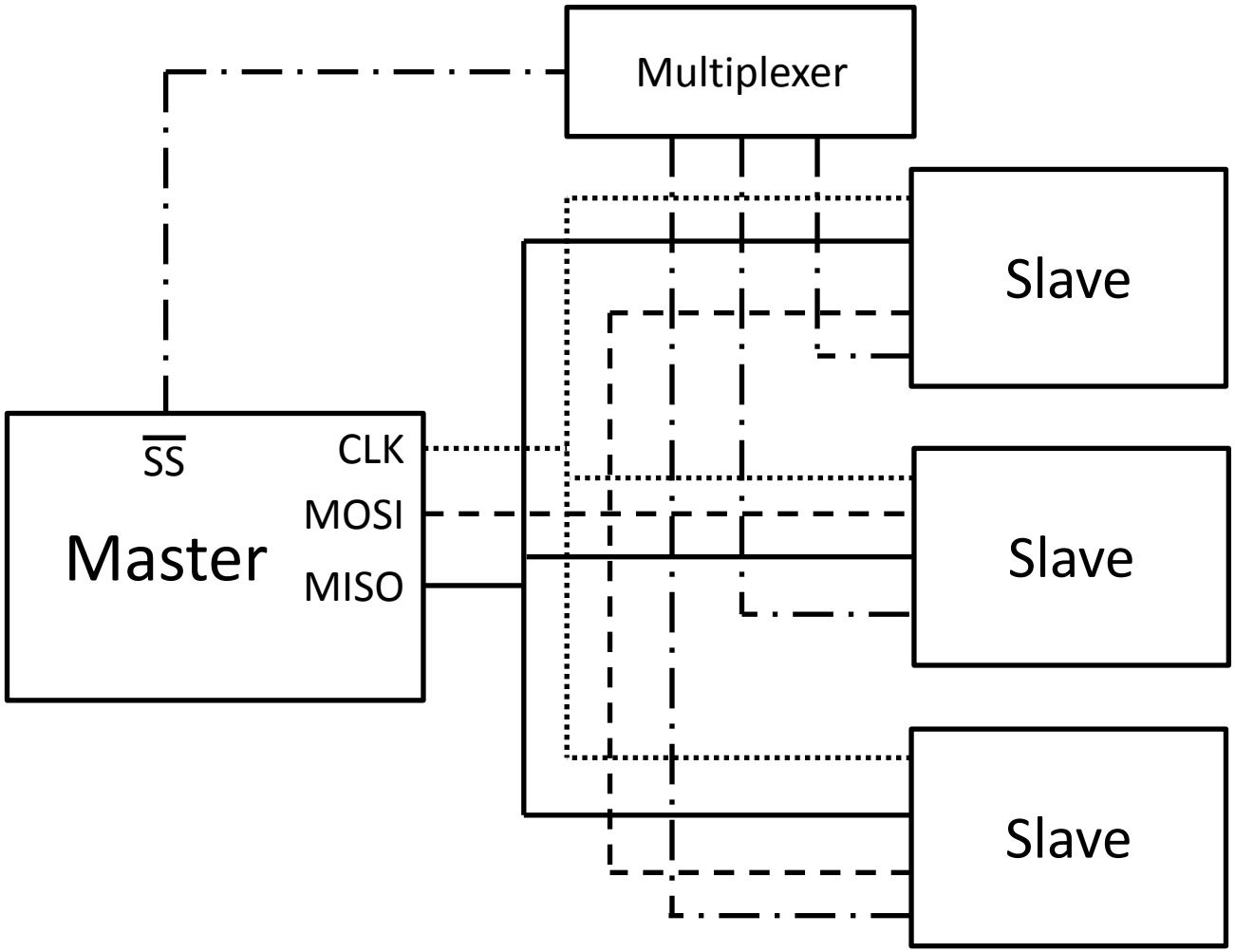
Serial Peripheral Interface (SPI)

- It is a serial, synchronous, full-duplex protocol.
- Sender and receiver follow a master-slave relationship.
- There may be multiple nodes in the network. One node is master, the rest are slaves.
- The slaves can communicate only with the master.
- Master decides when communication will occur.

SPI Schematics: Single Slave



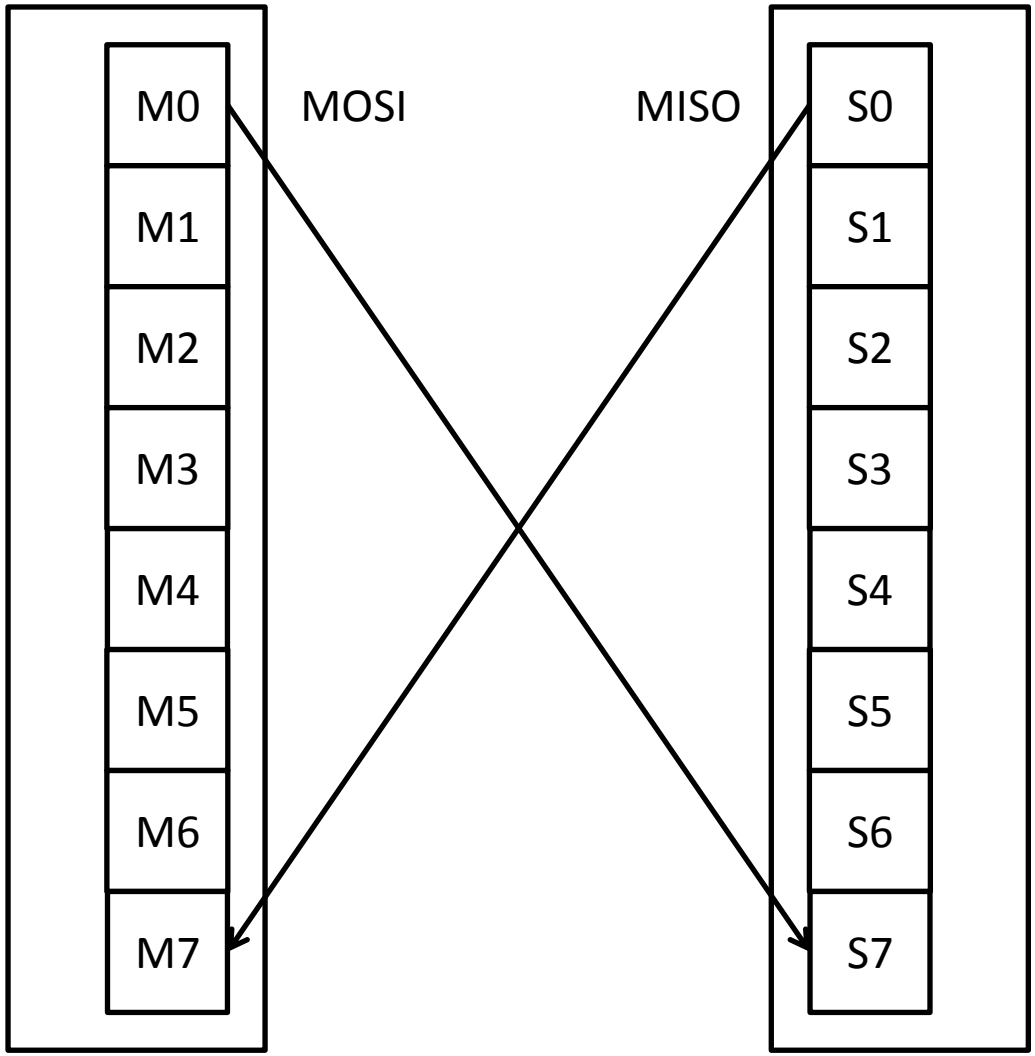
SPI Schematics: Multiple Slaves



Pins in SPI

- CLK is generated by Master.
- MOSI is Master Out Slave In: Data sent by Master to Slave.
- MISO is Master In Slave Out: Data sent by Slave to Master.
- $\overline{SS}$ is slave select: Slave communicates with Master only if this pin's value is set as LOW.

Data Transfer in SPI



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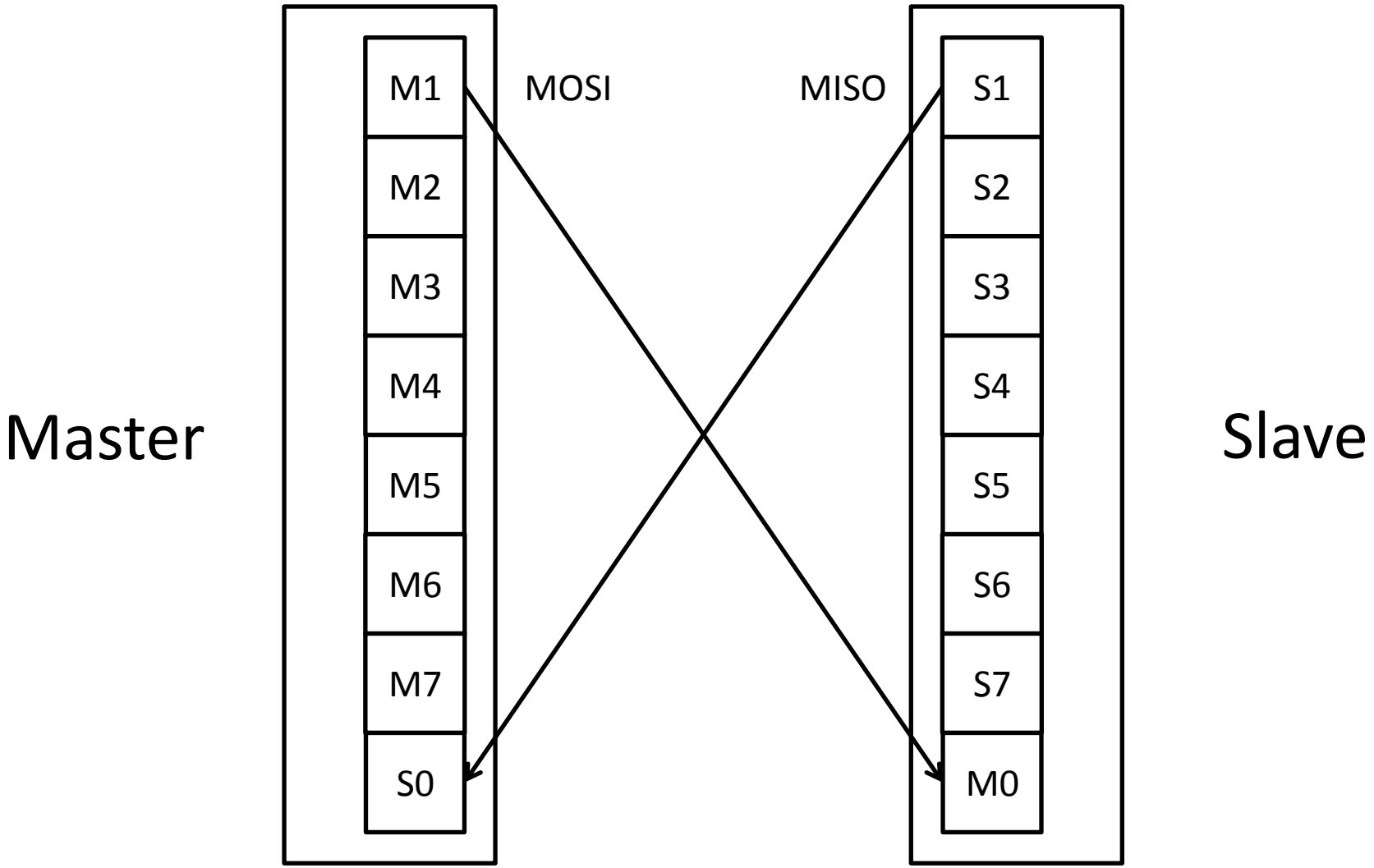
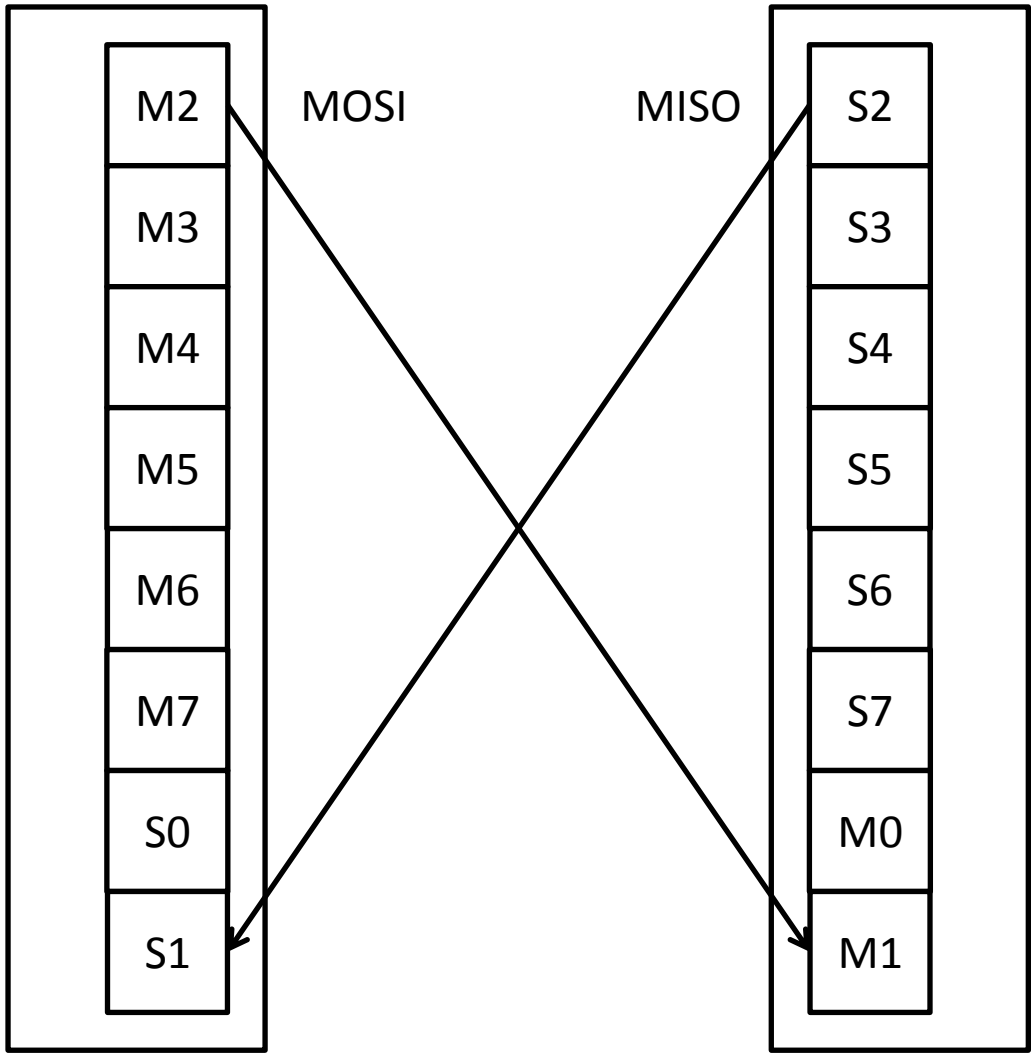
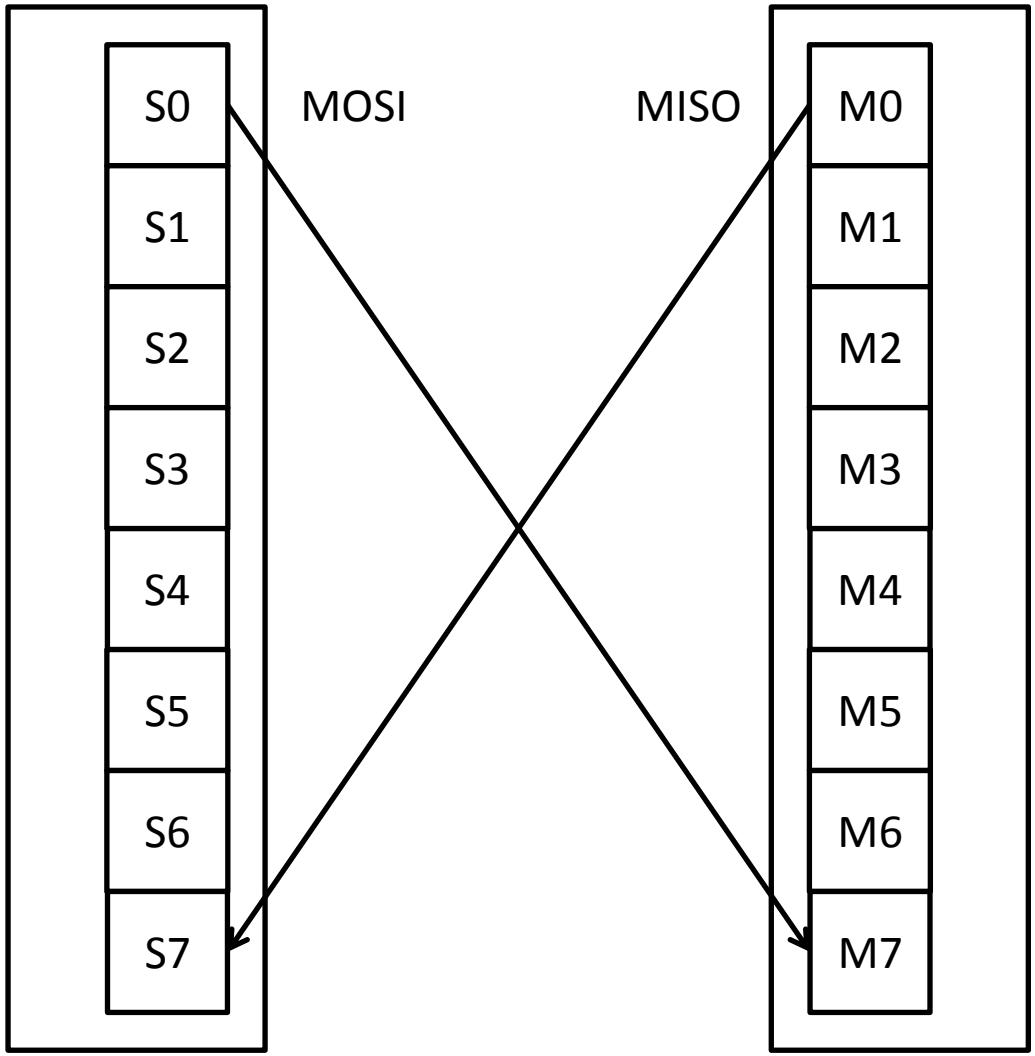


Data Transfer in SPI



Data Transfer in SPI



SPI Code

Master

```
char A = spi('c');
lcd_putchar(A);
```

Slave

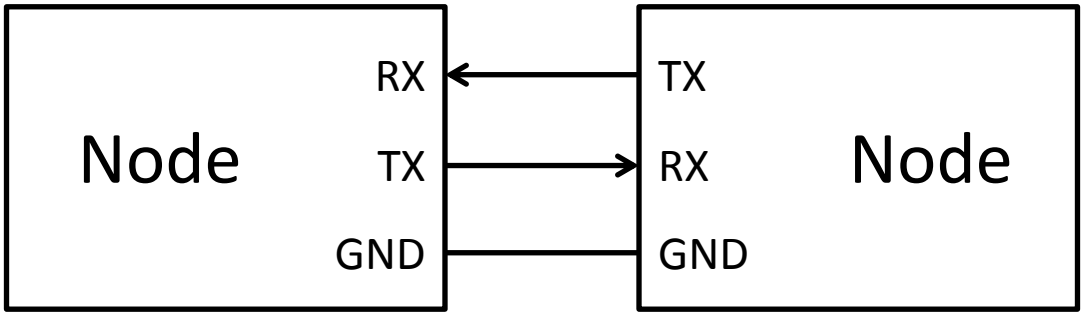
```
char B = spi('1');
```

This code will display '1' on the LCD.

Universal Asynchronous Receiver – Transmitter (UART)

- UART is a simple half-duplex, asynchronous, serial protocol.
- Simple communication between two equivalent nodes.
- Any node can initiate communication.
- Since connection is half-duplex, the two lanes of communication are completely independent.

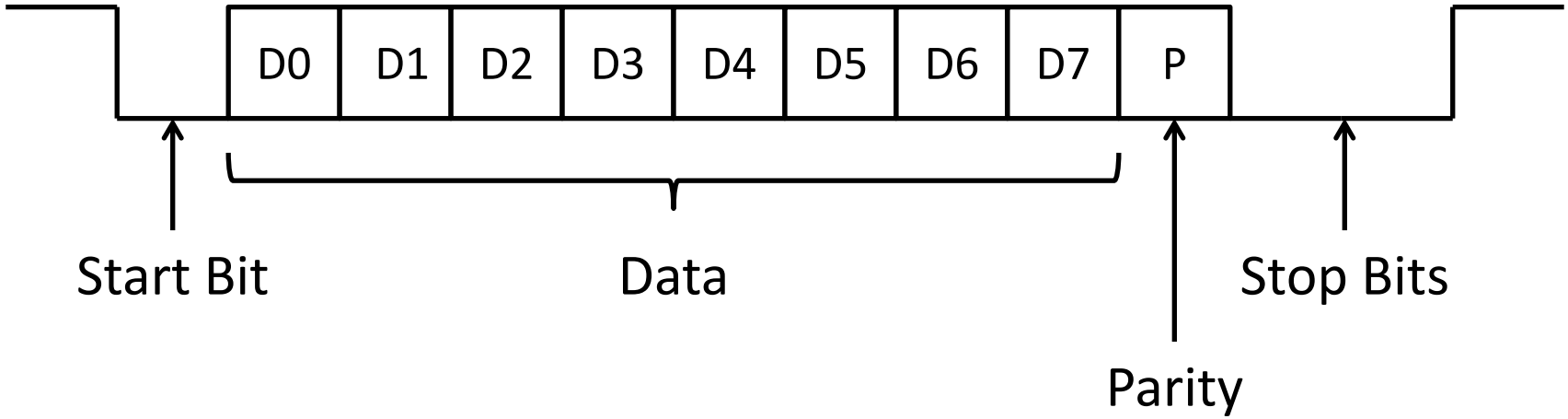
UART schematics



UART Characteristics

- The speed of communication (measured in bauds) is predetermined on both ends.
- A general rule of thumb is to use 9600 bauds for wired communication.
- UART implements error-detection in the form of parity bit.

UART Packet Structure



Parity Bit

- Parity bit is HIGH when number of 1's in the Data is odd.
- Respectively, it is LOW when number of 1's in the Data is even.

UART Code

Node A

```
putchar('a');
/*    Transmit the
*     character 'a'
*/
```

Node B

```
char B = getchar();
/*    getchar() waits
*     for transmission
*/
lcd_putchar(B);
```

This code will display 'a' on the LCD.

Thank you.