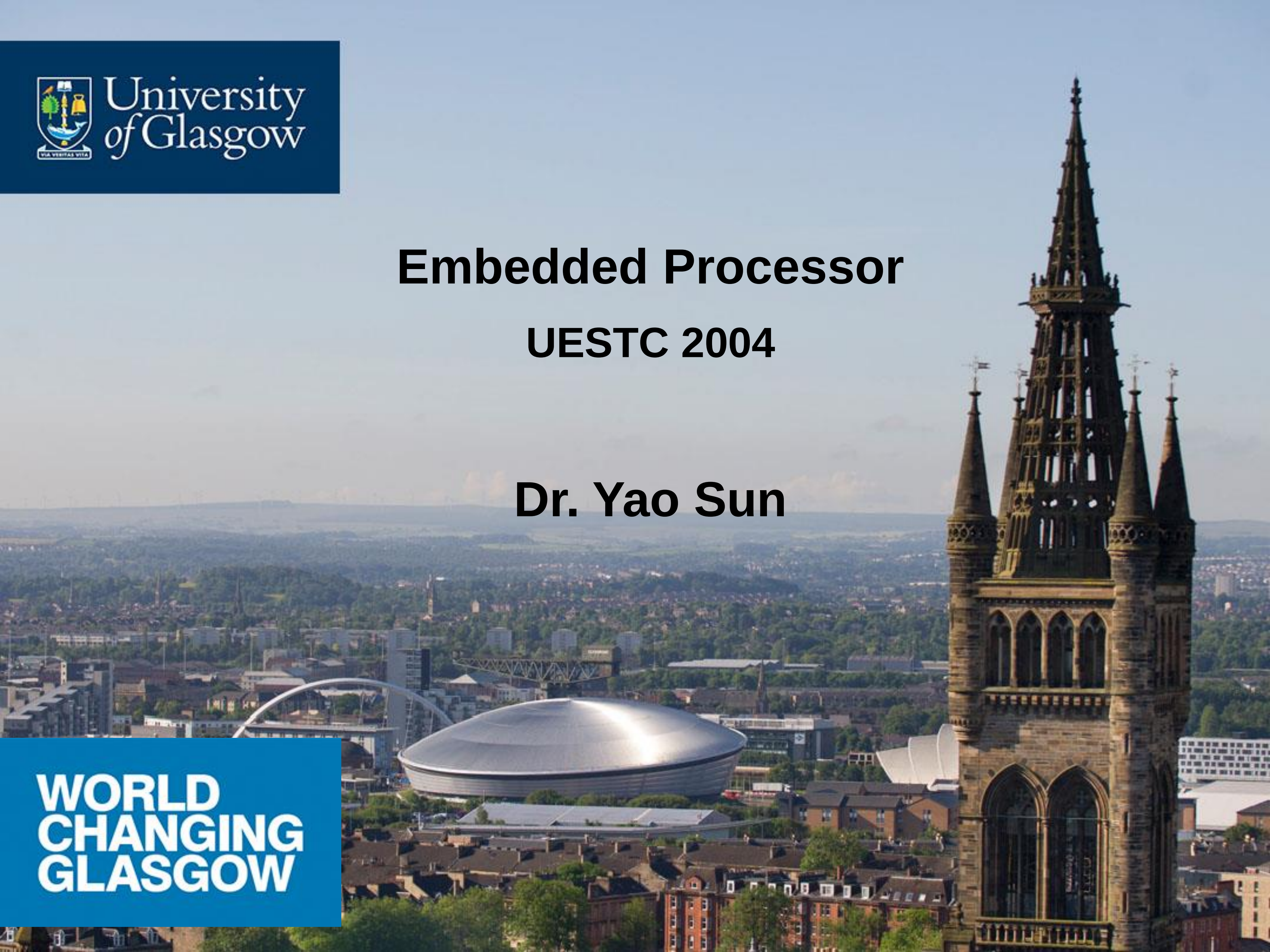


Embedded Processor

UESTC 2004

Dr. Yao Sun

Overview

Interrupt

Definition?

- **Definition:** An interrupt is the automatic transfer of software execution in response to a hardware event that is asynchronous with the current software execution.

Overview

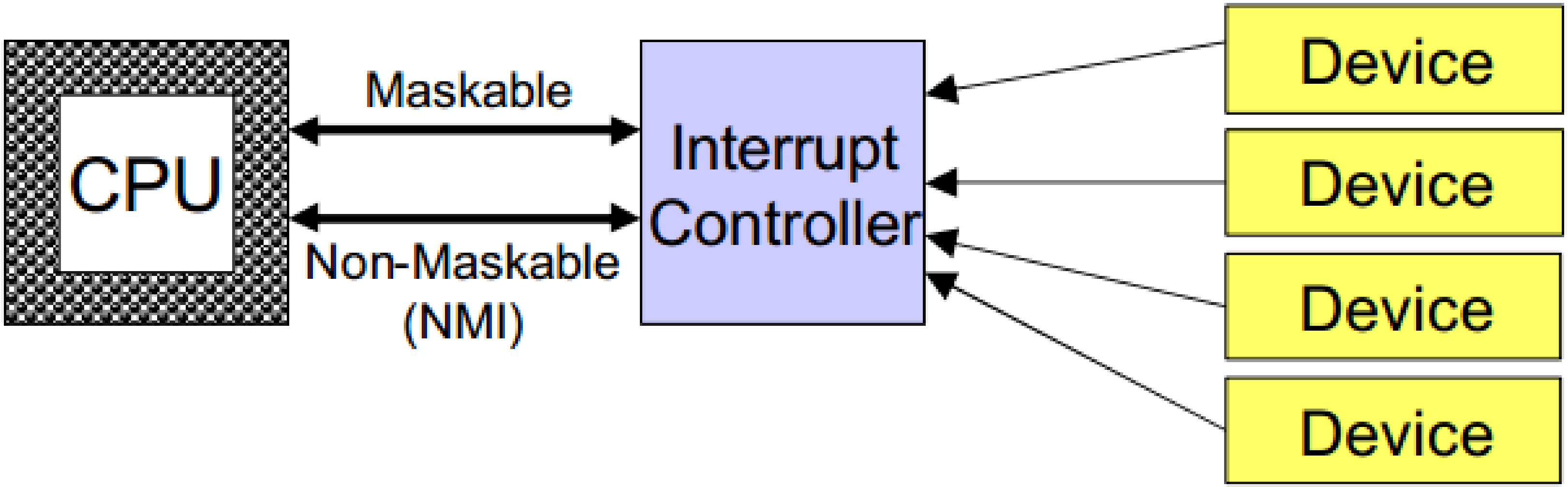


Figure Interrupt

The information should be exchanged between devices, controller and CPU.

HOW to exchange information? 🤔

BUS

BUS

- The basis of BUS
- UART Protocol
- I2C Protocol
- SPI Protocol

BUS

BUS

- ➢ The basis of BUS
- ➢ URAT Protocol
- ➢ I2C Protocol
- ➢ SPI Protocol

The Basis of BUS

Concept: A **bus** is simply a collection of wires carrying various data signals, addresses, and control signals (clock signals, requests, acknowledgements, data type, etc.) between all of the other major components on the embedded board, which include the I/O sub-systems, memory subsystem, and the master processor.

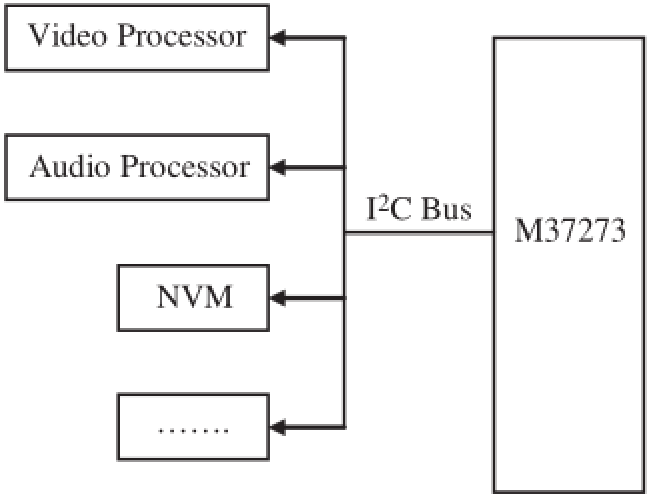
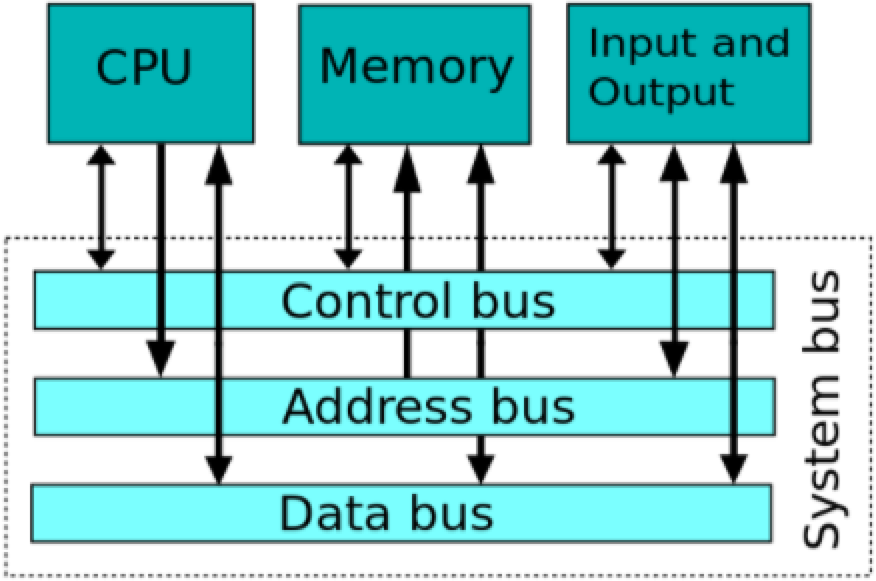


Figure. General Bus Structure

The Basis of BUS

Category:

- **Address Bus**
- **Data Bus (bidirectional)**
- **Control Bus**



There are three internal buses associated with processors: the **data bus, address bus, and control bus**. Together, these three make up the “system bus.”

The Basis of BUS

Parallel vs. Serial Communications

- Two communication schemes for Bus

  Parallel communications vs. Serial communications

- Parallel Communication

  When data is sent using parallel data transmission, multiple data bits are transmitted over multiple channels at the same time.

- Serial Communication

  Serial data transmission sends data bits one after another (in a specific order) over a single channel.

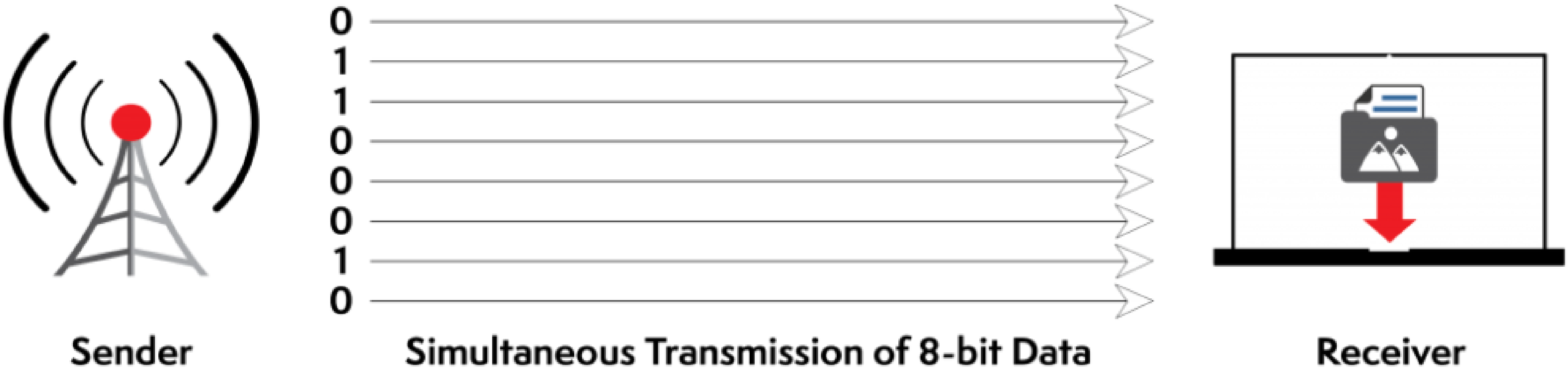
The Basis of BUS

Parallel vs. Serial Communications (cont’d)

An example of transmitting number 98

Parallel transmission

98 ⟶ 01100010



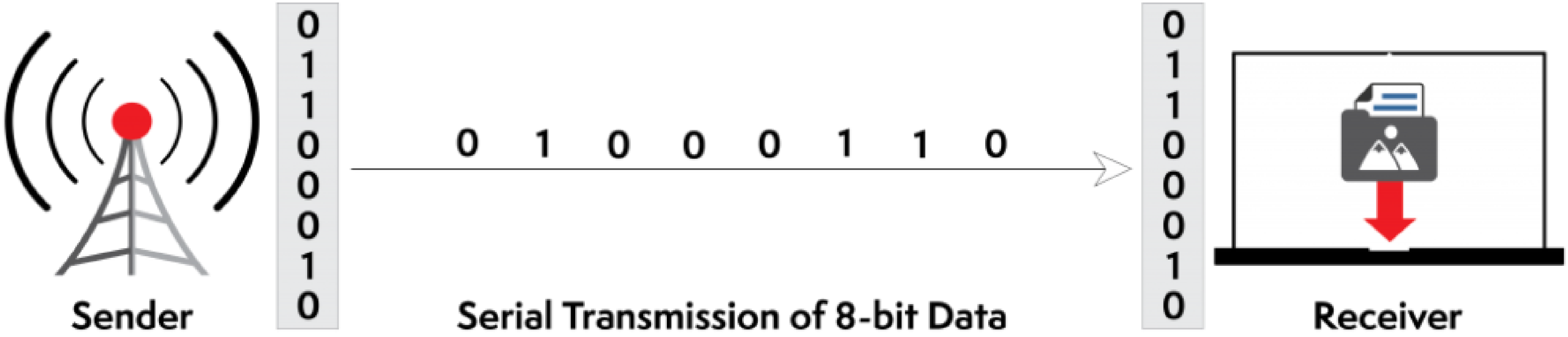
use high level to transmit 1 and low level 0

The Basis of BUS

Parallel vs. Serial Communications (cont’d)

Serial transmission

98 ⟶ 01100010

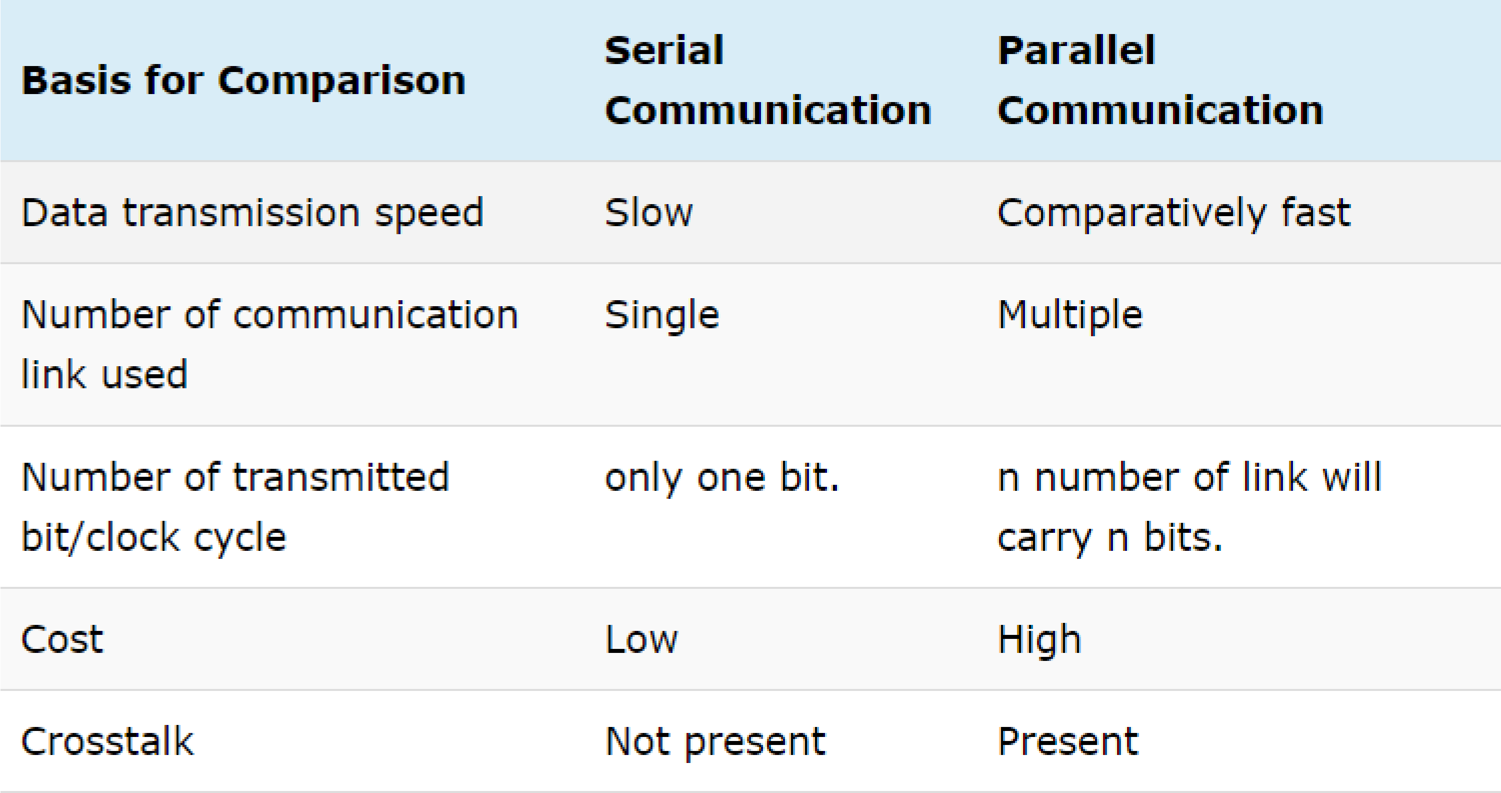


use high level to transmit 1 and low level 0

The Basis of BUS

Parallel vs. Serial Communications (cont’d)

- Comparisons



Basis for Comparison	Serial Communication	Parallel Communication
Data transmission speed	Slow	Comparatively fast
Number of communication link used	Single	Multiple
Number of transmitted bit/clock cycle	only one bit.	n number of link will carry n bits.
Cost	Low	High
Crosstalk	Not present	Present

The Basis of BUS

Parallel vs. Serial Communications (cont'd)

Q: Which one is suitable for BUS system? 🤔

A: Serial Communication! 😎

fewer connections;
lower cost;
lower data amount in BUS

The Basis of BUS

Parallel vs. Serial Communications (cont'd)

Q: When is parallel transmission used to send data?

A: Parallel transmission is used when:

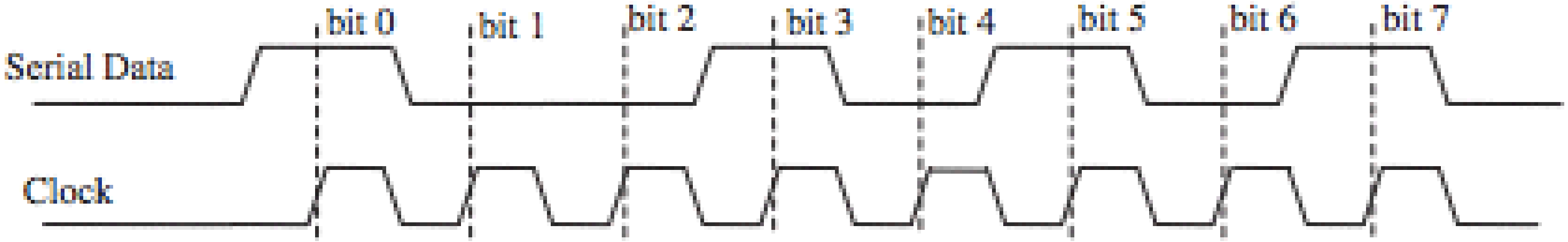
- a large amount of data is being sent;
- the data being sent is time-sensitive;
- and the data needs to be sent quickly.

Typical scenario: Video streaming

The Basis of BUS

Serial Communications

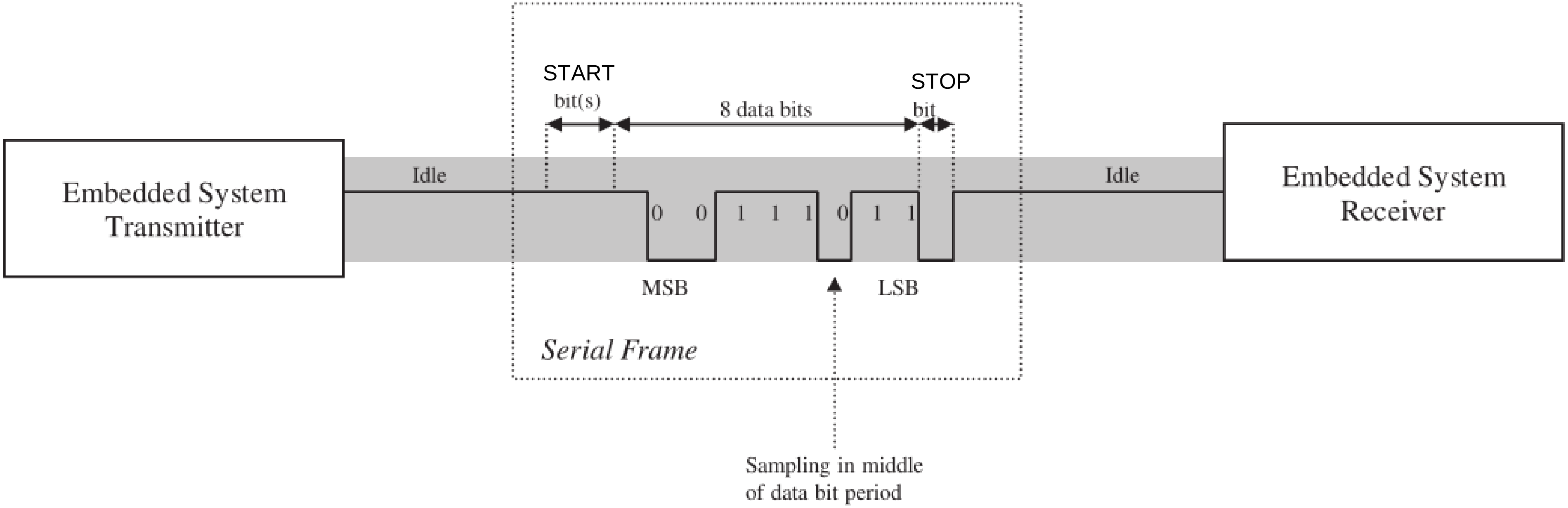
- Two classifications: synchronous and asynchronous
- Synchronous transmission:
  - Data bits are transmitted as a continuous stream in time with a master clock.
  - The data transmitter and receiver both operate using a synchronized clock frequency.



The Basis of BUS

Serial Communications (cont’d)

- Synchronous transmission
- Asynchronous transmission:
  - Data bits can be sent at any point in time.
  - Stop bits and start bits are needed



The Basis of BUS

Serial Communications (cont’d)

- Comparisons

	Synchronous	Asynchronous
Transmission manner	Sends data in the form of blocks or frames	Sends 1 byte or character at a time
Synchronization	Present with the same clock pulse.	Absent
Gap between the data	Does not exist	Exist
Transmission Speed	Fast	Slow
Time Interval	Constant	Random
Cost	Expensive	Economical

BUS

BUS

- The basis of BUS
- UART Protocol
- I2C Protocol
- SPI Protocol

UART Protocol

What is UART?

- Universal Asynchronous Reception and Transmission (UART)
- Protocol for Asynchronous communication in BUS system
- TX: Transmitter
- RX: Receiver
- One connection for data transmission
- Frequently used in conjunction with the RS-232 standard

UART Protocol

How does UART work?

- How can the RX correctly understand the data without clock?
- Start bit — indicates the beginning of the data word
- Stop bit(s) — indicates the end of the data word
- Data length — how many bits does TX transmit
- Transmission speed (Baud rate) — the bit rate of the serial port (bits/second)
- Before sending, RX and TX should make an agreement on this parameters

UART Protocol

➢ How does UART work? (cont'd)

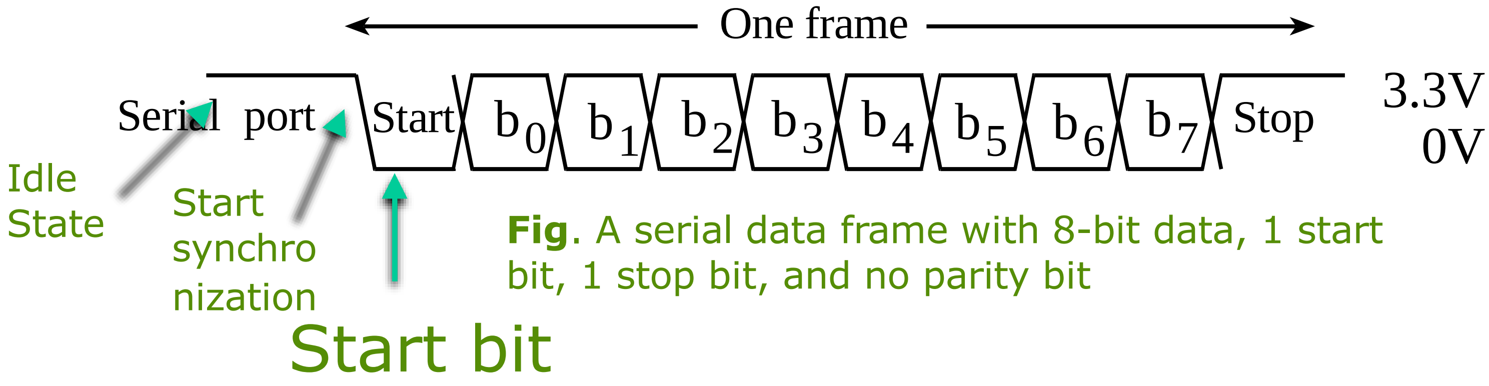


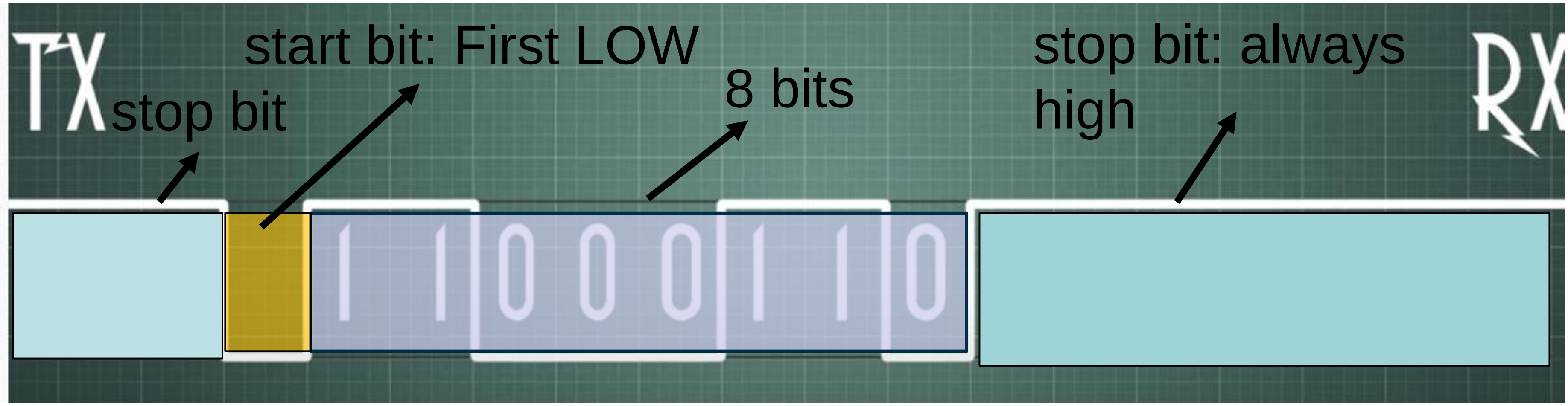
Fig. A serial data frame with 8-bit data, 1 start bit, 1 stop bit, and no parity bit

- The serial line is '1' when it is idle.
- The transmission starts with a start-bit, which is the first '0', followed by data-bits, and ends with stop-bits, which are '1'.
- The number of data-bits can be 5, 6, 7 or **8** (usually) bits

UART Protocol

- **How does UART work? (cont’d)**

Example: transmit number 198 by using UART protocol.



- Data length: 8 bits
- start and stop bit(s)

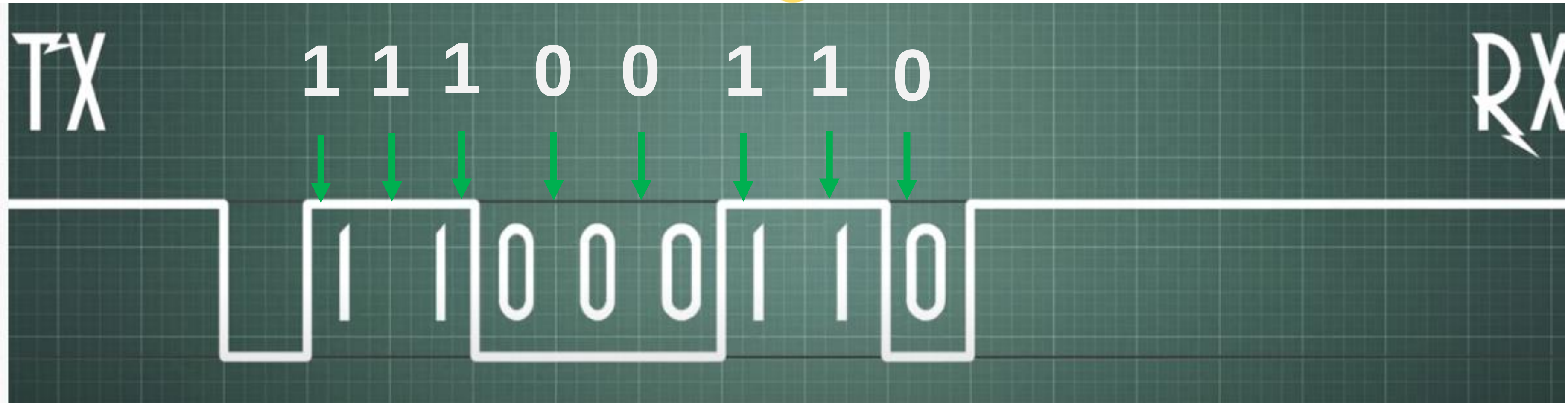
UART Protocol

How does UART work? (cont'd)

Example: transmit number 198 by using UART protocol.

Can RX now receive the data correctly? NO 😭

Why? 😨

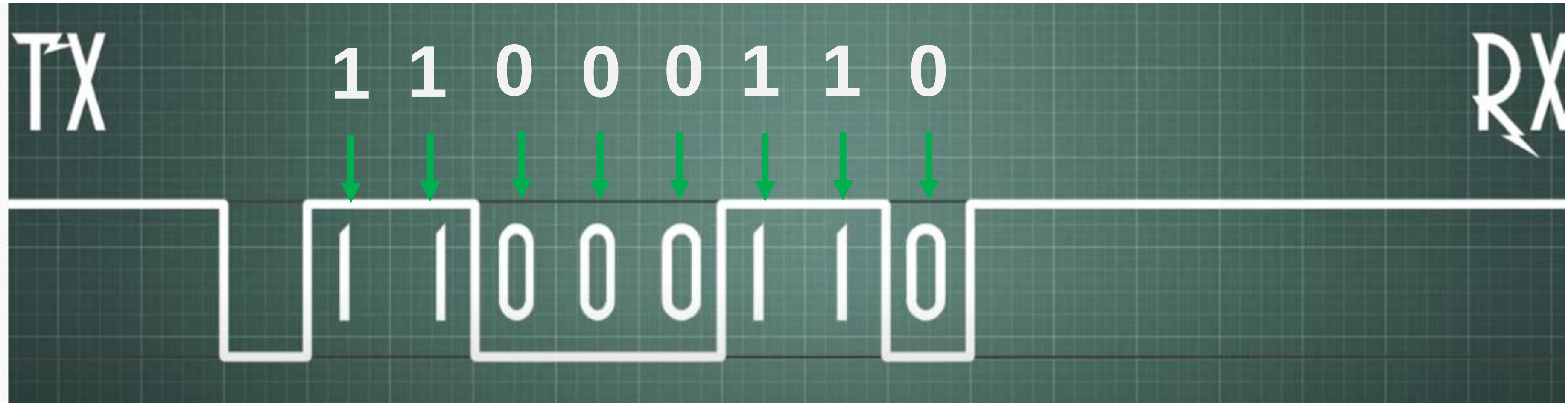


- Data length: 8 bits
- start and stop bit(s)
- Transmission speed

UART Protocol

How does UART work? (cont'd)

Example: transmit number 198 by using UART protocol.



- Data length: 8 bits
- start and stop bit(s)
- Transmission speed

UART Protocol

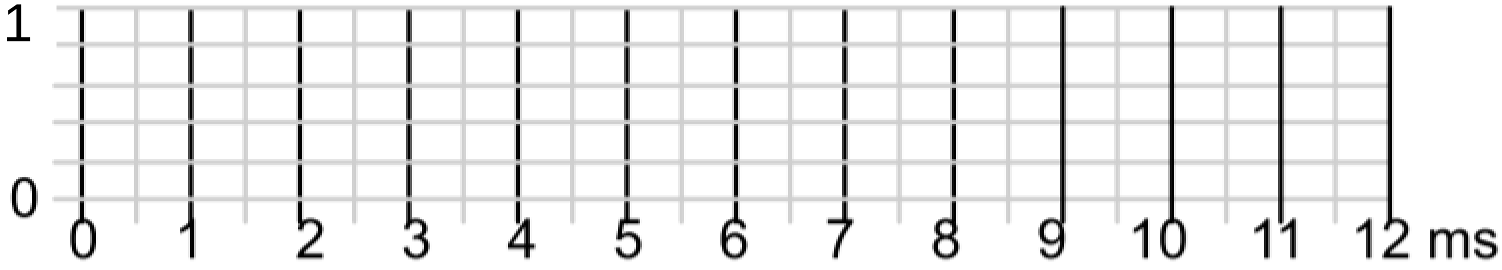
- **Pros and Cons**
  - Advantages
    - ✓ Simple to operate, well documented as it is a widely used method with a lot of resources online
    - ✓ No clock needed
    - ✓ Parity bit to allow for error checking
  - Disadvantages:
    - ✓ Cannot use for multiple masters and slaves system
    - ✓ Baud rates of each UART must be within 10% of each other to prevent data loss.
    - ✓ Low speed

QUIZ

1. Spend 5 mins to look at quiz, then finish the feedback first.
2. Quiz
3. Tutorial for answers
4. Finish another feedback after tutorial

QUIZ

1. Why cannot the program (showed last week) work correctly when we insert a very large number?
2. There are three categories of bus according to the function perspective. List the three categories and indicate which one is bidirectional.
3. What parameters should be agreed on between TX and RX for UART protocol?
4. Assuming the baud rate is 1000 bits/sec, draw the timing diagram as the data $0x27_{(16)}$ is transmitted via UART protocol. Make the frame start at time = 2 ms.



University of Glasgow

THANKS !

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