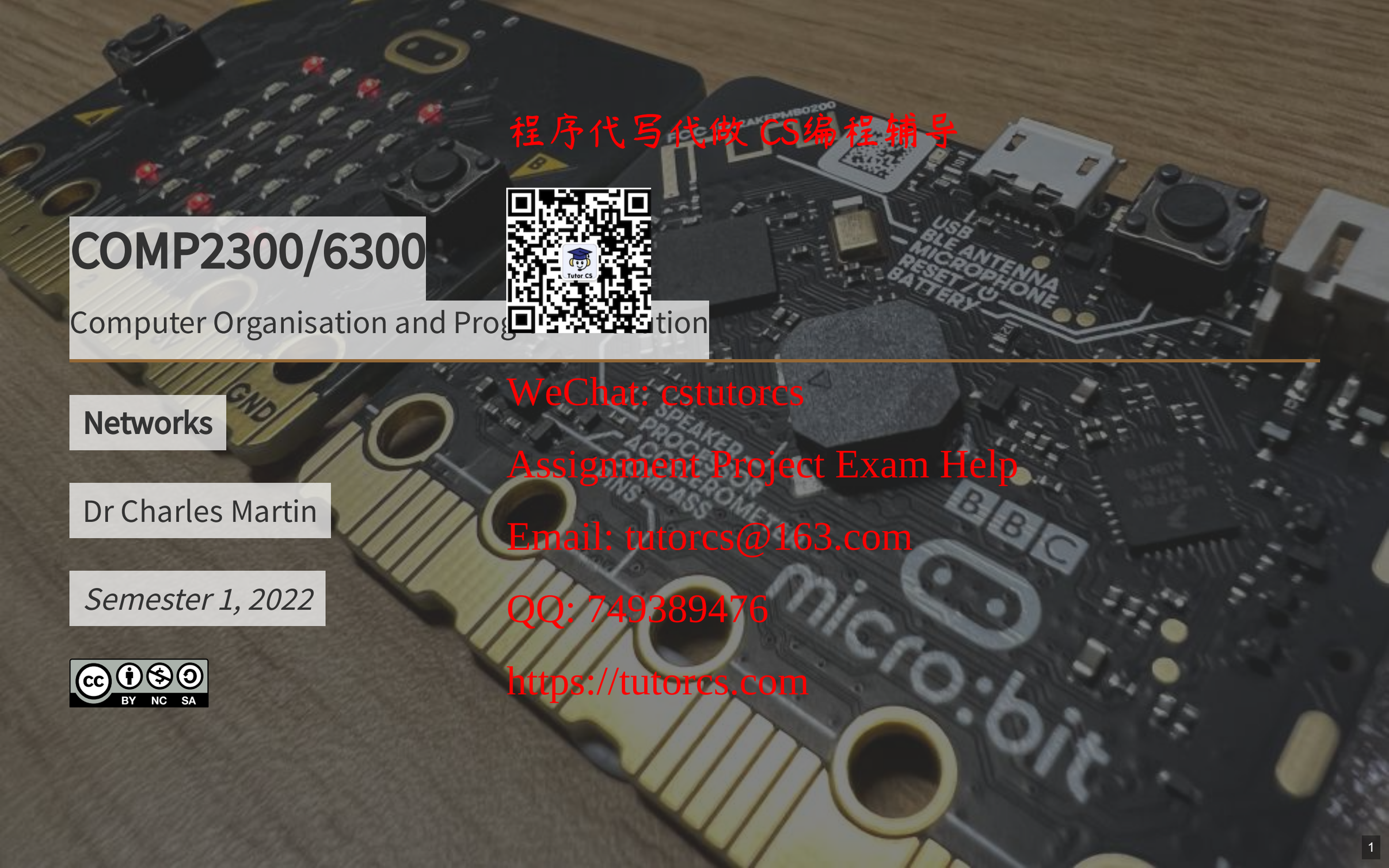


COMP2300/6300

Computer Organisation and Prog[illegible]tion

Networks

Dr Charles Martin

Semester 1, 2022

Week 9: Networks

Outline

- basic concepts
- MIDI and serial

- 7-layer OSI model
- Examples: standard protocols

Admin Time

Little wires!

Assignment 2 presubmission!

Midsem feedback: aiming for Monday 9/5

Quiz 2 opens next week!

Basic concepts

We want to communicate with others

What's so hard about this?

communication is easy if both ends of the communication can share memory/registers

e.g., function calls, shared global variables (in the `.data` section)

but most of the time that's not the case

Data Requires Difference

talk

on a wire carrying electrical sign 

ight difference look like? how many different ways could you achieve it?

Aspects of network communication

there are a few fundamental “dimensions” to a given communications network

- transmission medium
- communications protocol(s)
- topology

these are all (at least partially) orthogonal

What's a node?

the term **node** is used a lot when out networks

a node is anything which *commu* the network

- servers
- computers
- mobile phones
- IoT devices
- nanobots

Transmission medium

lots of options here:

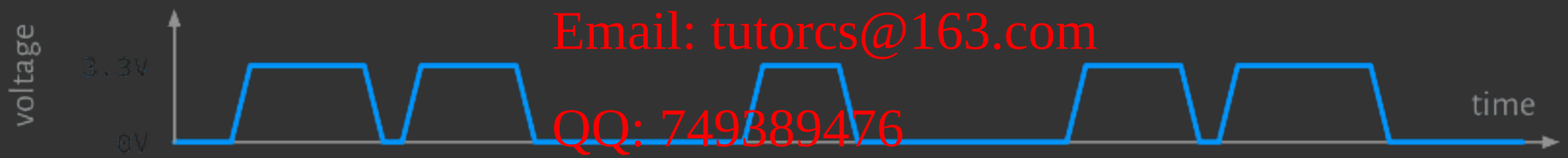
- electrical voltages on a wire (c ires)
- co-axial cable
- twisted-pair cable
- EM waves in the air
- light in an optic-fiber cable

(anything else?)

Physics refresher

In case you haven't studied phys

- a voltage is a *relative* measure
- the *ground* pins are the reference point on your microbit
- sometimes the *values* matter (low or high, `0` or `1`) and sometimes the *transitions* are most important (rising/falling edge triggers)



ReaccNet v1

can we communicate with reac

knock, knock!

who's there?

Communication protocol

a set of rules about what to "say" to understand the responses

in a computing context:

- how big are the messages?
- lsb first, or msb?
- is there metadata? how is it stored?

both sides must agree!

how are network "protocols" like *social* protocols? What happens when social protocols go wrong?

Circuit-switched networks

circuit-switched means nodes se[illegible] a dedicated connection (physical or logical)

example: phone lines in ye olden days—to **route** the phone call to the right place, the switchboard operator would literally make a physical connection between the caller & the receiver

Bell System international switchboard in 1943

Packet-switched networks

packet-switched means data tra ver the network is segmented into packets (or frames)

these packets contain both:

- a payload (*what* you want to send)

- an address (*who* you want to send it to)

these days, most network protocols are packet-switched

this allows different nodes to share the same physical connections (multiplexing)

ReaccNet v2

can we send a message in pack

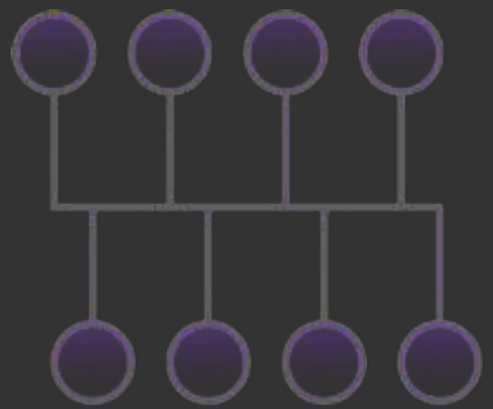
Directions of information flow

- **simplex** means information only flows one way: from sender to receiver
- **half-duplex** means information can flow both ways, but not at the same time
- **full-duplex** means information can flow both ways simultaneously

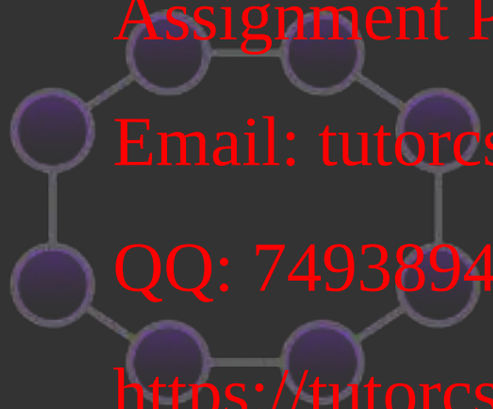
Topology

topology is the way that the nod[illegible]nected to one another (both physically and logically)

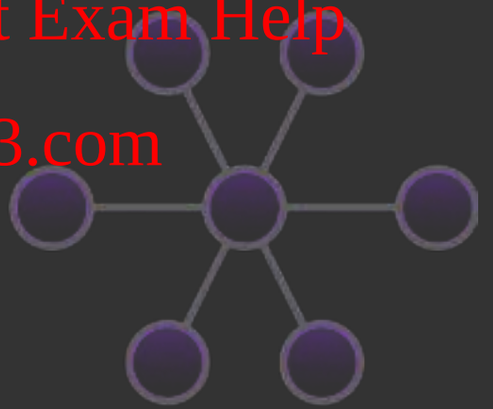
there are several different ways to connect the nodes together, what are the consequences of different topologies?



bus



ring



star

ReaccNet v3

how about sending a message t c node?

circuit-switched vs packet-switched?

Serial vs parallel

serial

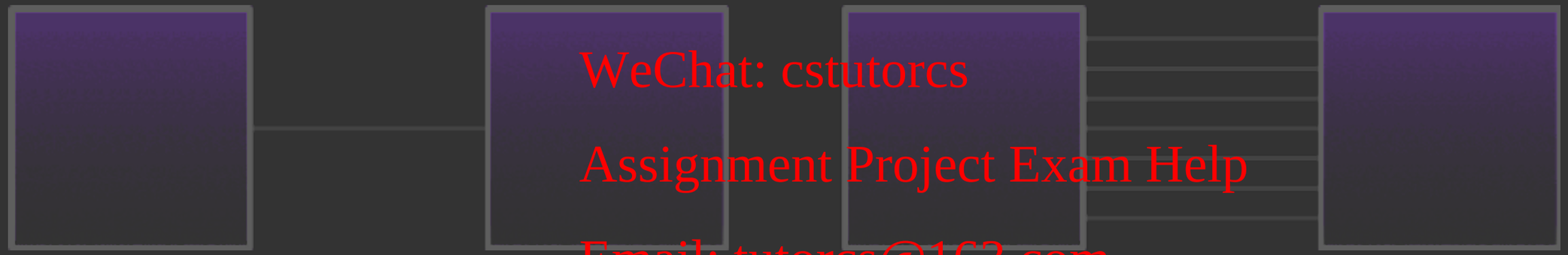
data is sent one-bit-at-a-time

fewer bits sent per signal, but si

llel

iple bits sent simultaneously (e.g. multiple wires)

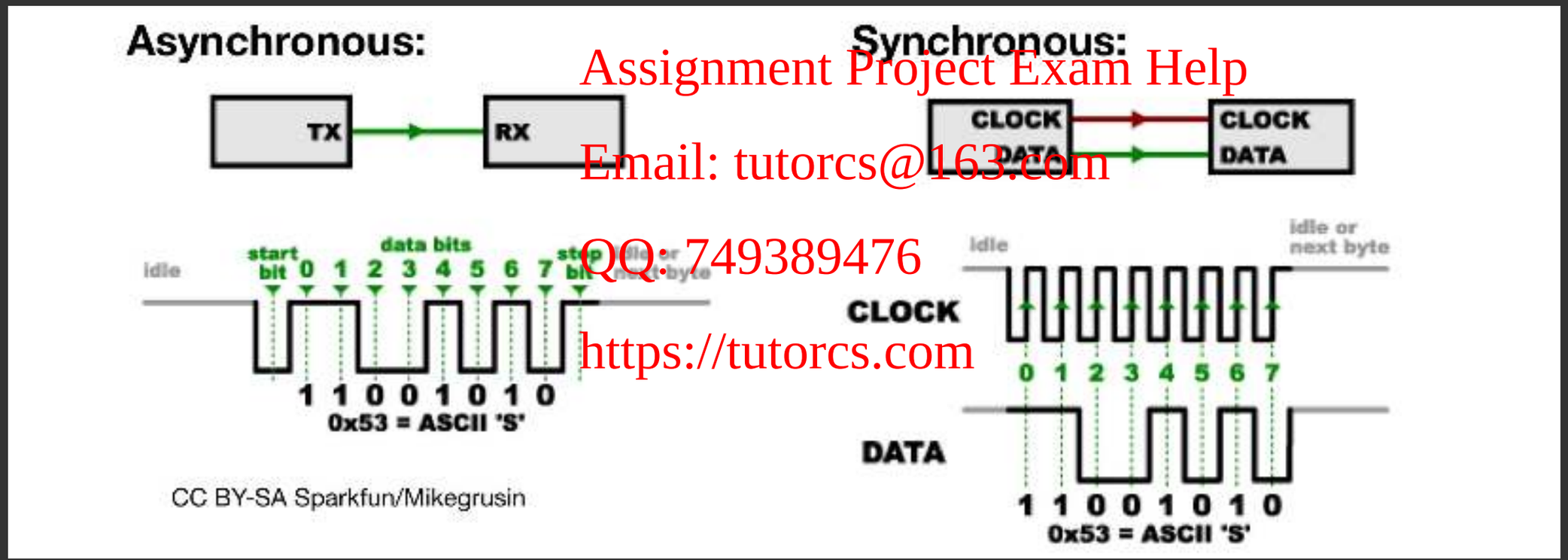
to keep all the connections in sync



Timing & synchronisation

There are two main approaches: [redacted]ous and asynchronous. (See **Sparkfun Serial Turorial**)

Within the world of *serial* connections this looks something like this:



Synchronous vs Asynchronous

Synchronous:

- need to have a *clock* line (extra
- simple to implement in hardware
- very widely used in simple devices, e.g., SD cards (can) use **SPI**

Asynchronous:

- transmitter and receiver both need a clock/timer and they need to pre-agree on the speed
- only need one wire (and ground) - useful for microbits!

Let's do some asynchronous data sending!

What do we have to do?

Decide on a *rate* of bits-per-second (baudrate)

Send a start bit (set GPIO low)

Send the 8 bits of a byte (changing GPIO)

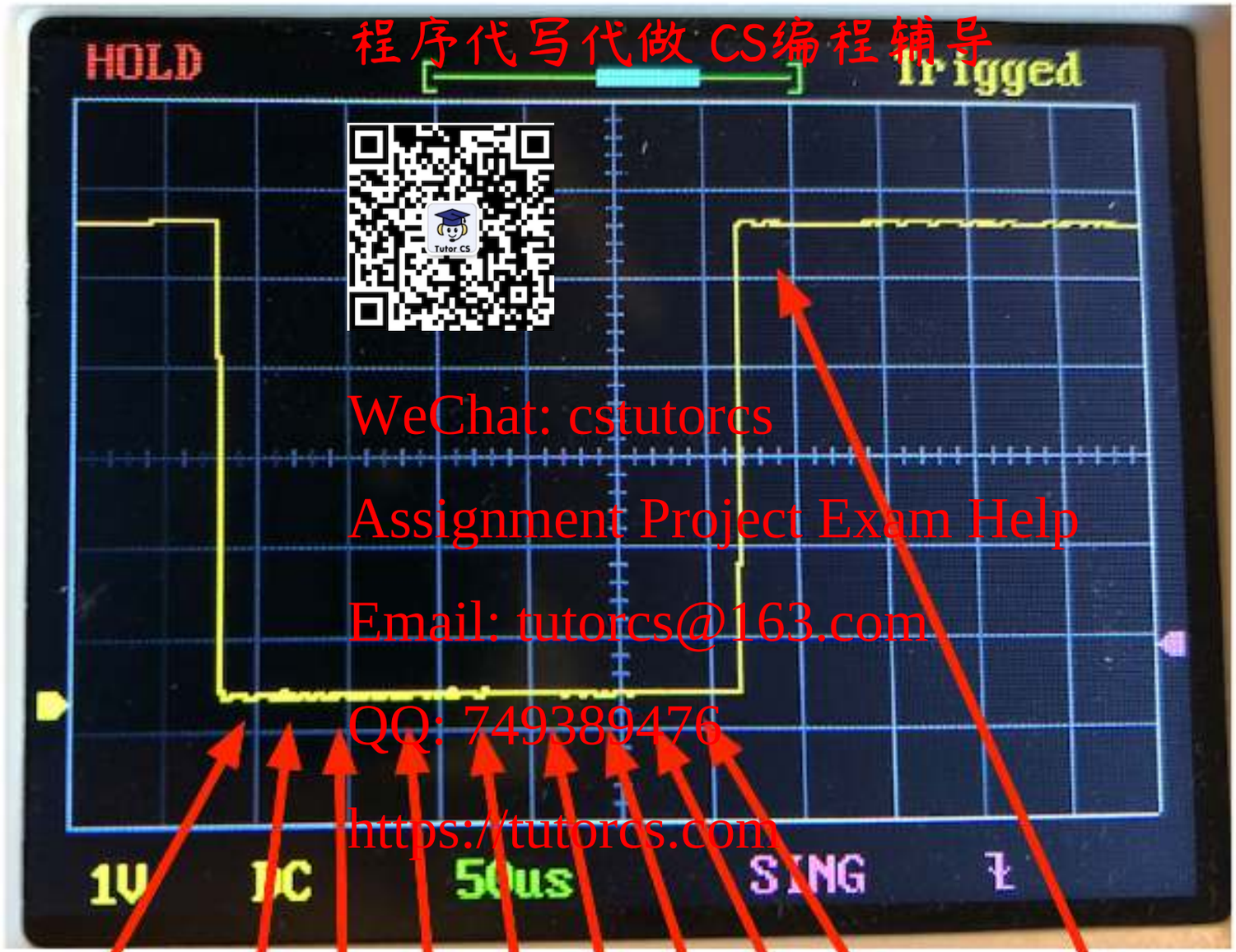
Send a stop bit (set GPIO high)

Not too hard, but we'll need an oscilloscope to see what we are doing!


Serial Experiments Charles
Let’s have a look at some bytes
程序代写代做 CS编程辅导
WeChat: cstutorcs
Assignment Project Exam Help
Email: tutorcs@163.com
QQ: 749389476
https://tutorcs.com
KORG
volca fm
DIGITAL FM SYNTHESIZER
Running
Trigged
V/DIV
SEC/DIV
TRIGGER
OK
ADJ

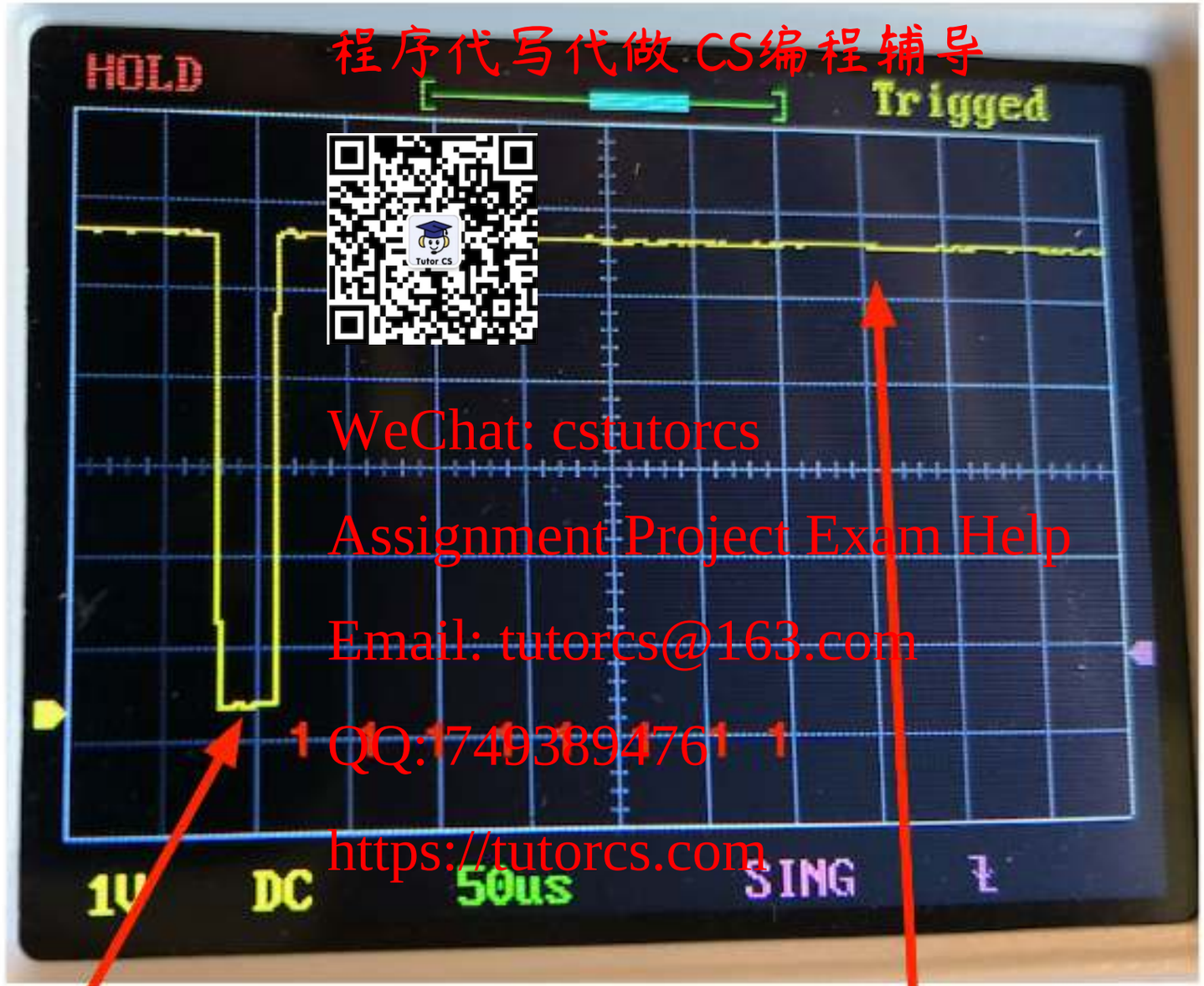
0x00

0x00



0xFF

0xFF

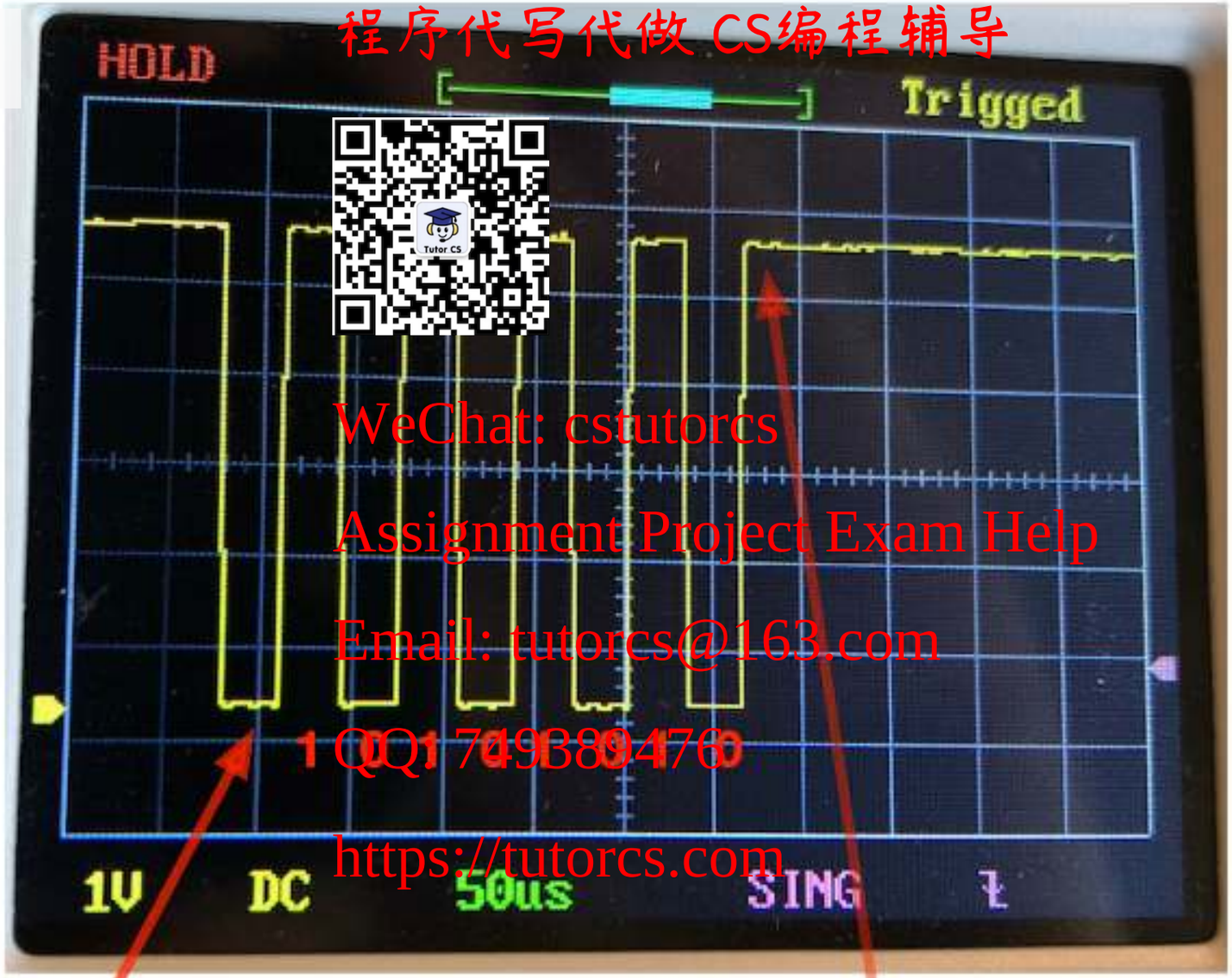


Start bit

Stop bit

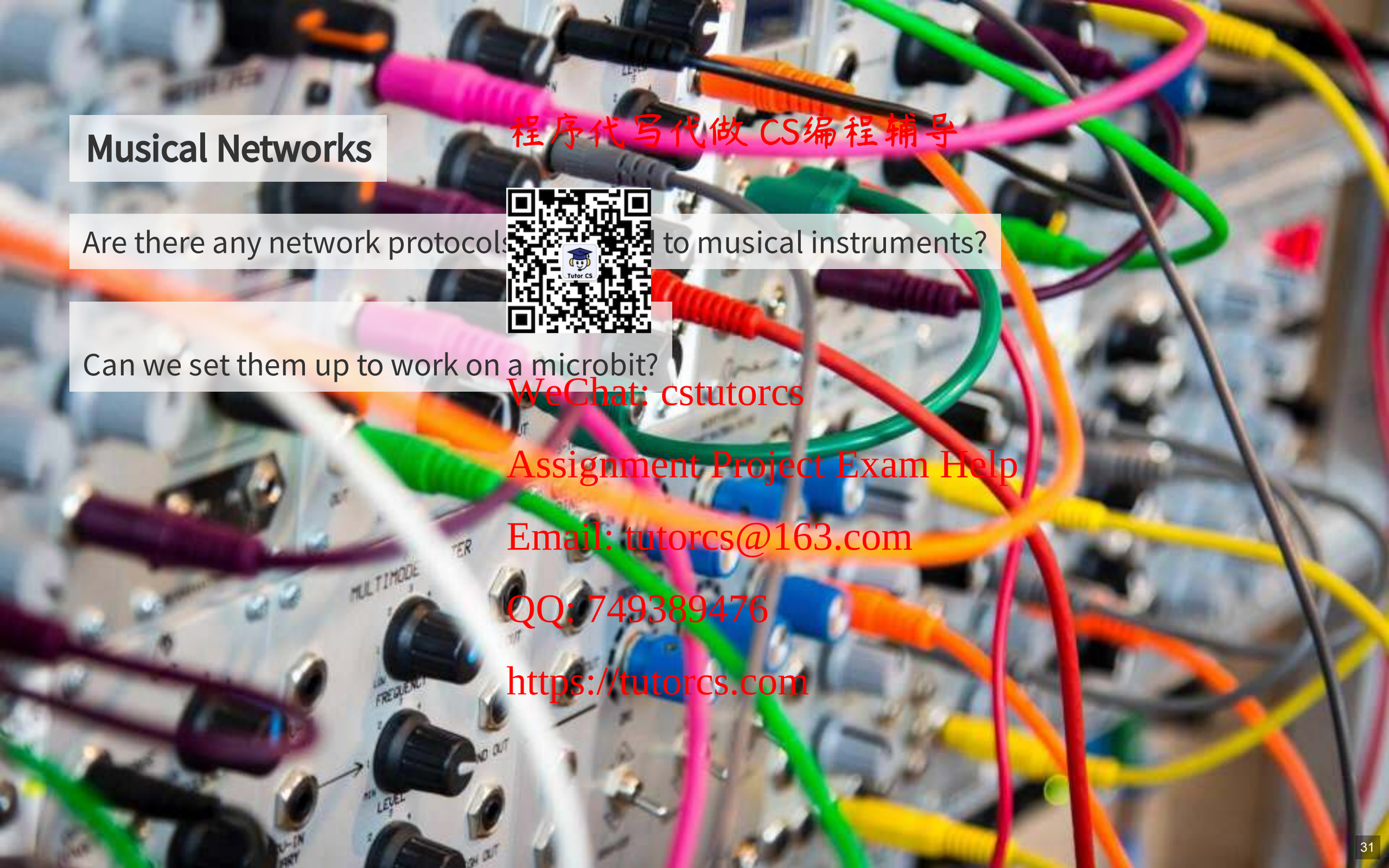
0b01010101

0b01010101



Start bit

Stop bit



Musical Networks

Are there any network protocols to musical instruments?

Can we set them up to work on a microbit?

MIDI

“Musical Instrument Digital Inter L)

A way to send musical “instructi nthesiser.

E.g., (CC BY 2.0, Blurred Ren)

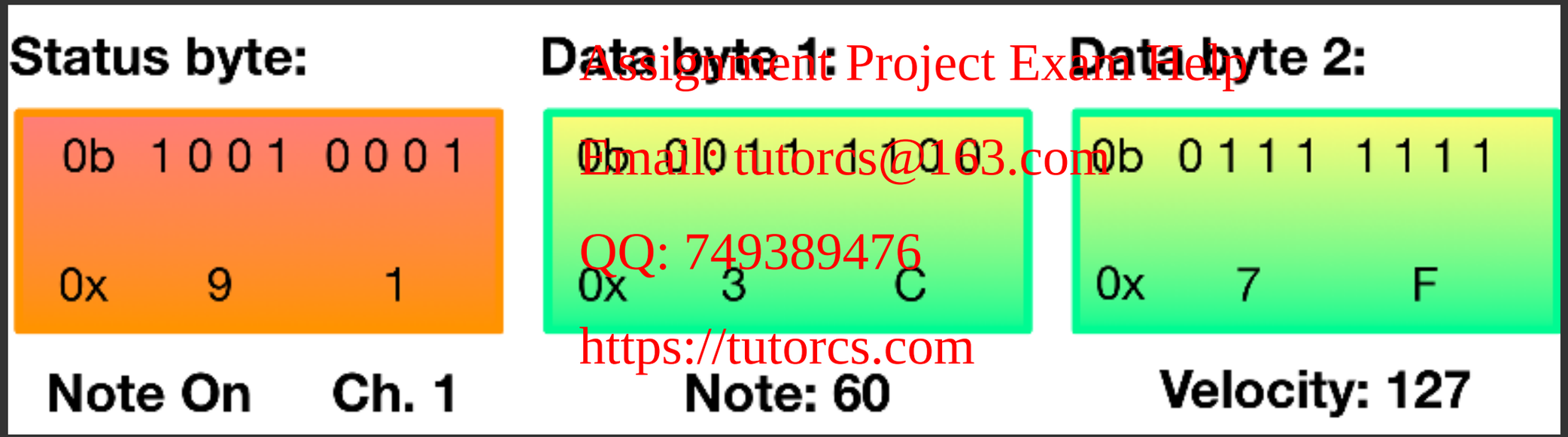
MIDI medium and frames

- MIDI 1.0:
- Sent over UART (basic serial) c

- 31250 bits per second
- each frame has one start bit (0), 8 data bits, one stop bit (1)
- MIDI tutorial on Sparkfun

MIDI messages

- One status byte, one or more d
- Status byte has a “status” (4 b ually) a channel or address (4 bits)
- Data byte is a `0` followed by a 7 bit number.



Sorting concerns into layers

Implementing a connection bet devices seems to be getting *messy*…

specific information about bit-level signals

special timing considerations

application-specific representations of information within and between bytes

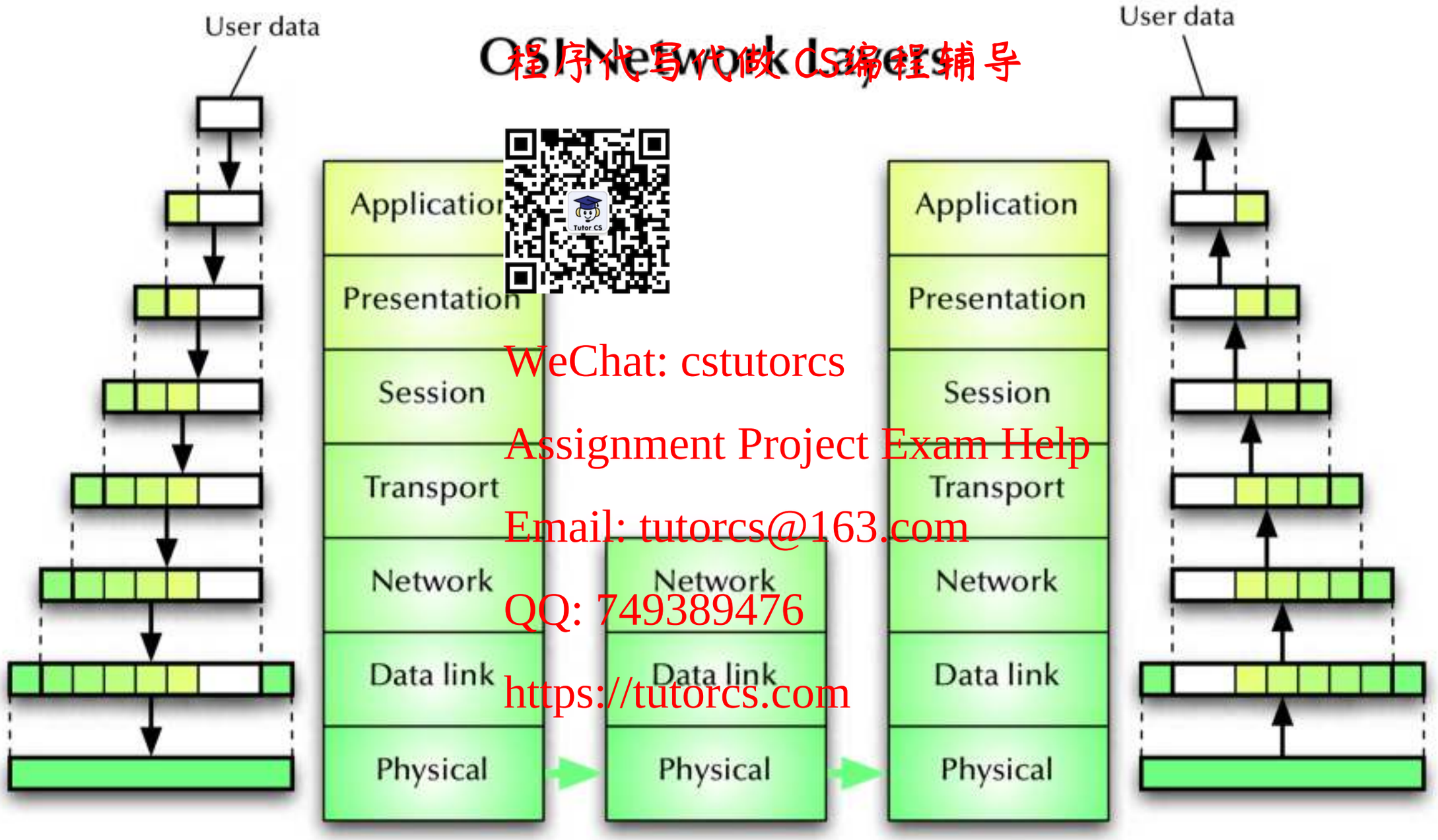
Is there some way to separate concerns here?

7-layer OSI model

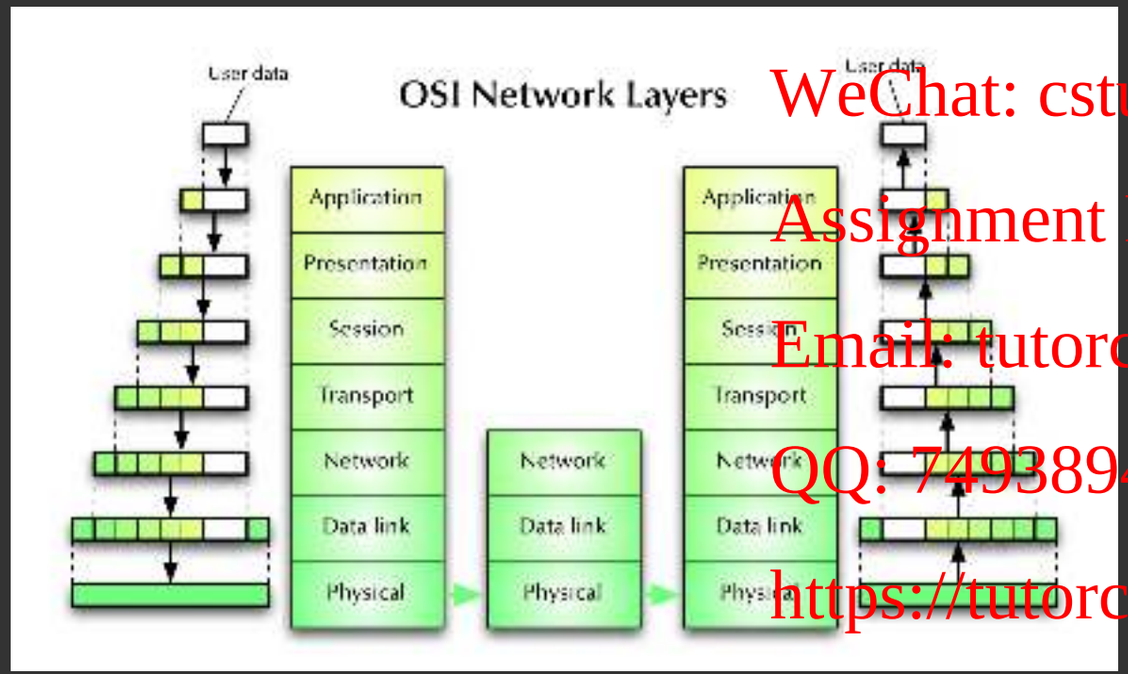
> “ The Open Systems Interconnection model (OSI model) is a conceptual model that characterizes and standardizes the communication functions of a telecommunication or computing system without regard to its underlying internal structure and technology (from **Wikipedia**)

standardised in 1977: 7 layer architecture, connection oriented

not often implemented in full, but concepts and terminology widely used.

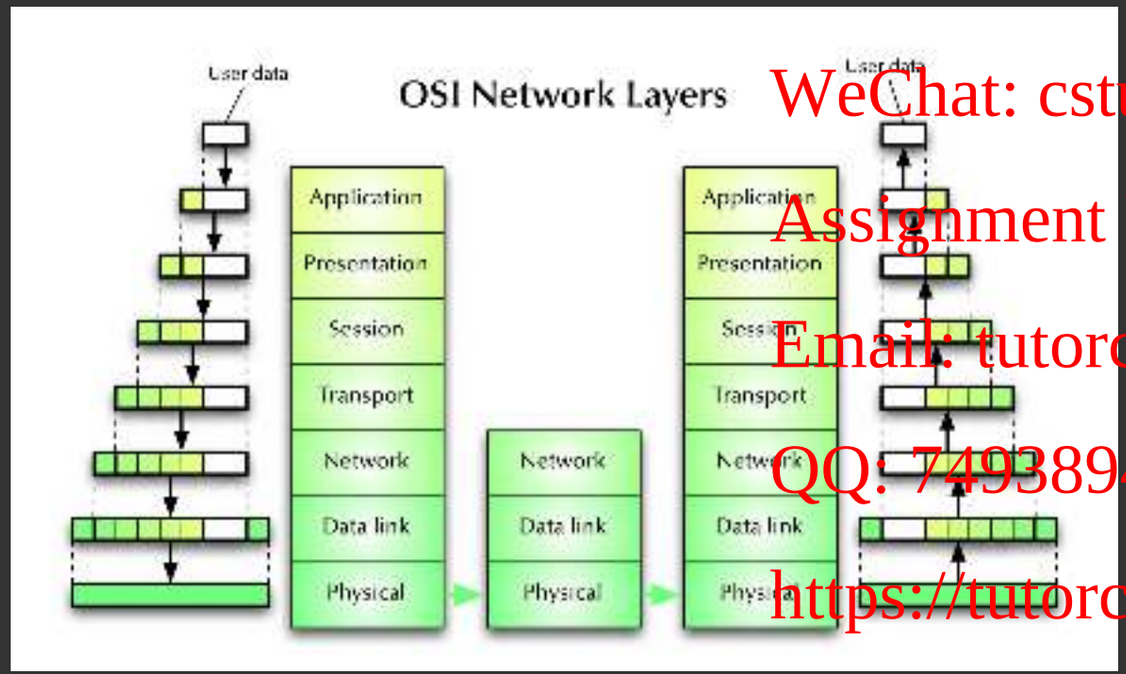


Layer 1: physical layer



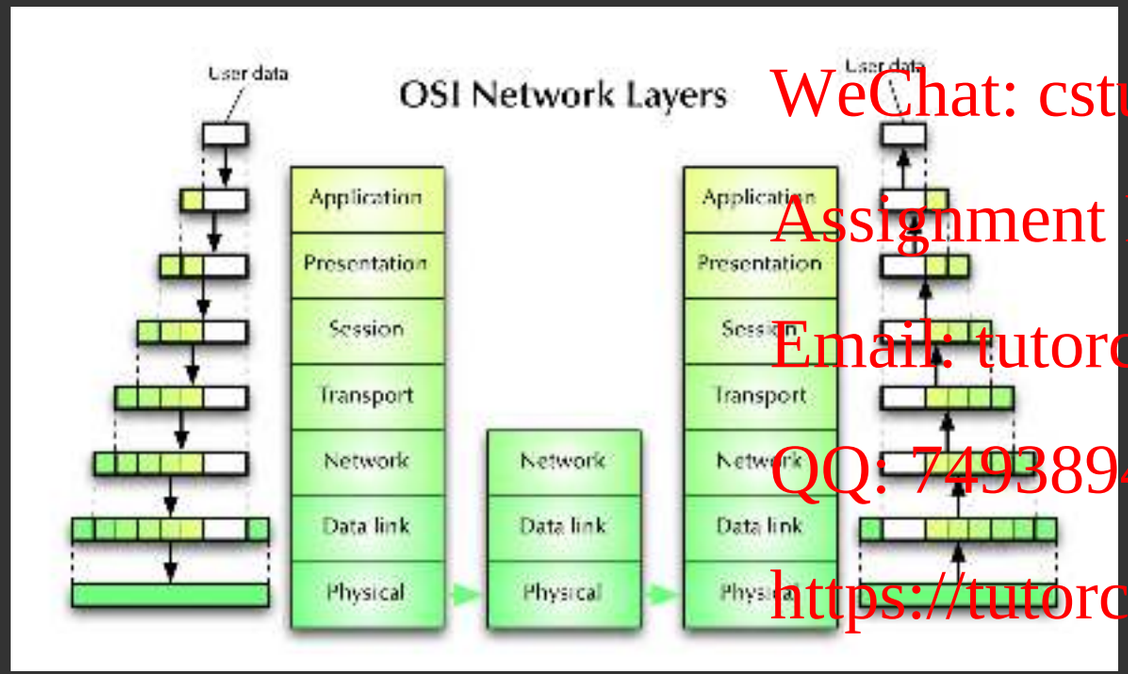
- Service: Transmission of a raw bit stream over a communication channel

Layer 2: data link layer



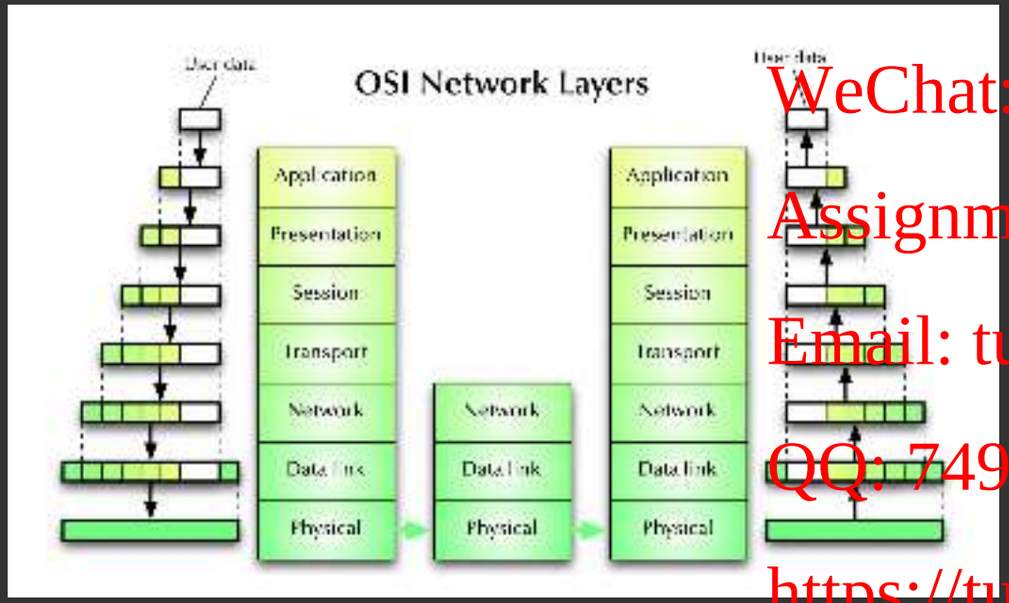
- Service: Reliable transfer of frames over a link

Layer 3: network layer



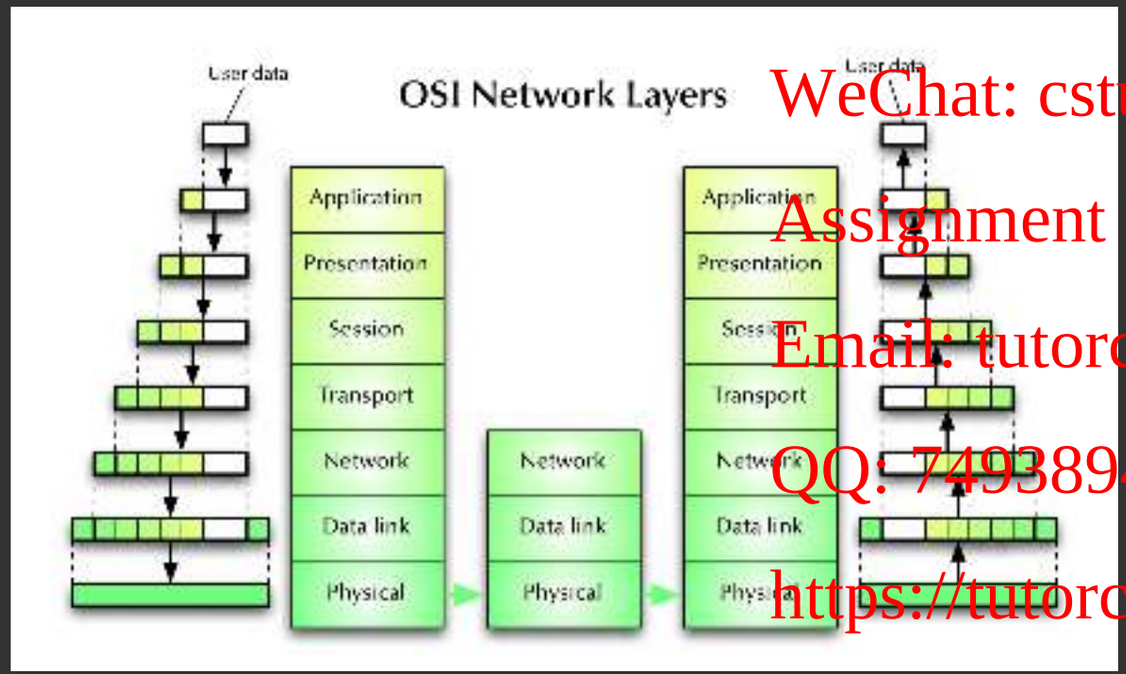
- Service: Transfer of packets inside the network

Layer 4: transport layer



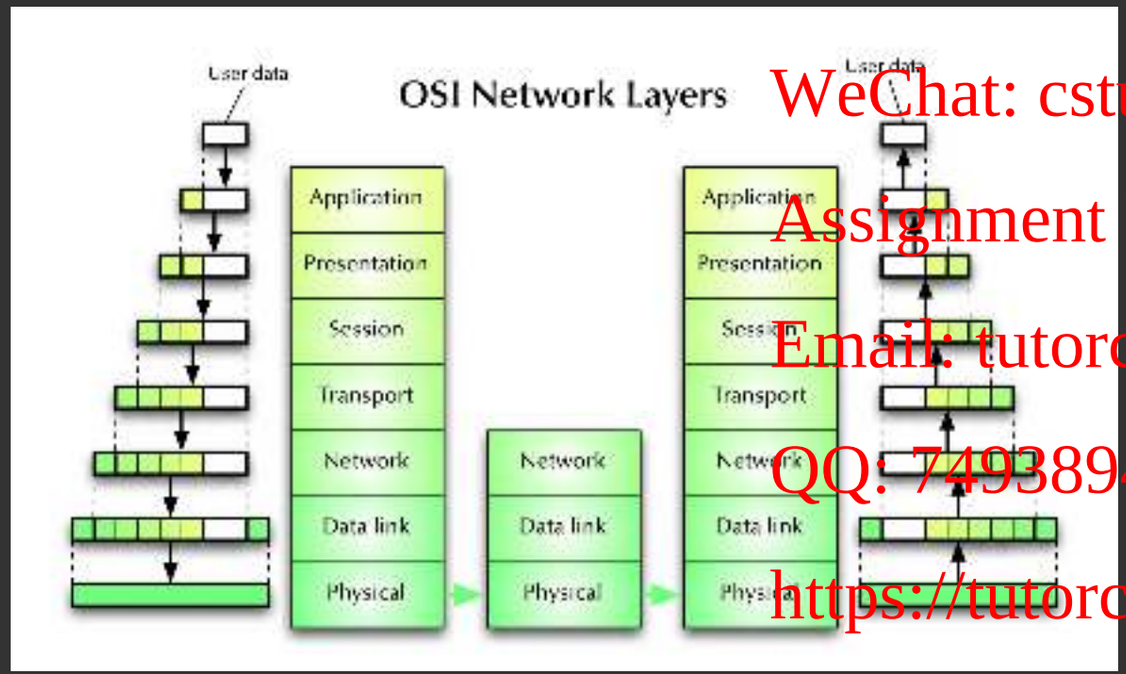
- Service: Transfer of data between hosts

Layer 5: session layer



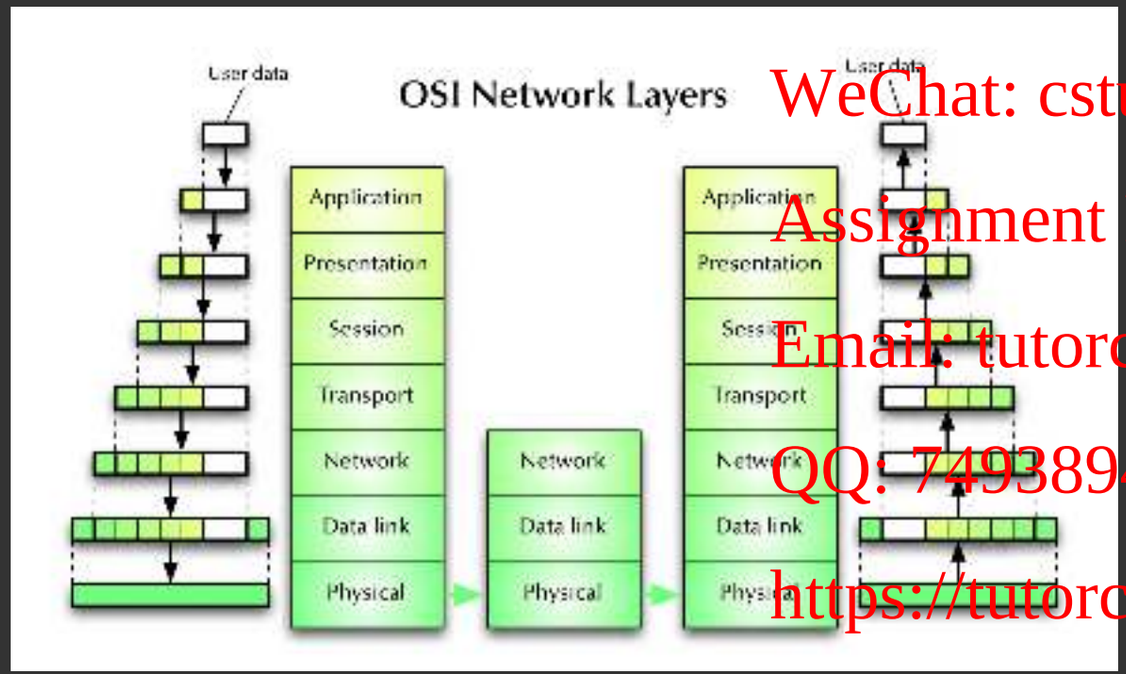
- Service: Coordination of the dialogue between application programs

Layer 6: presentation layer



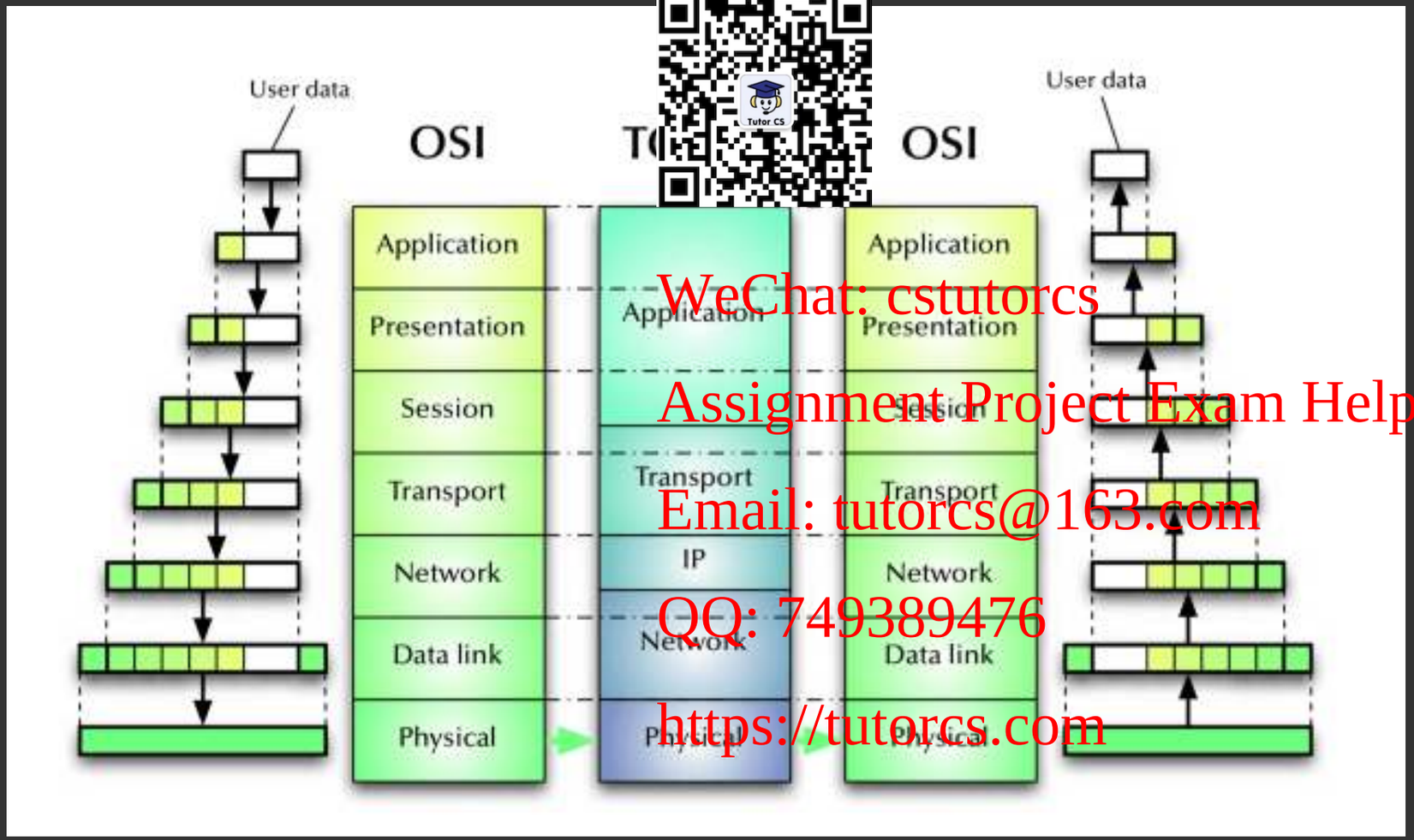
- Service: Provision of platform independent coding and encryption

Layer 7: application layer



- Service: Network access for application programs

TCP/IP, not an ideal fit with OSI



What about synchronous? Did we miss that? And what else is on the microbit?

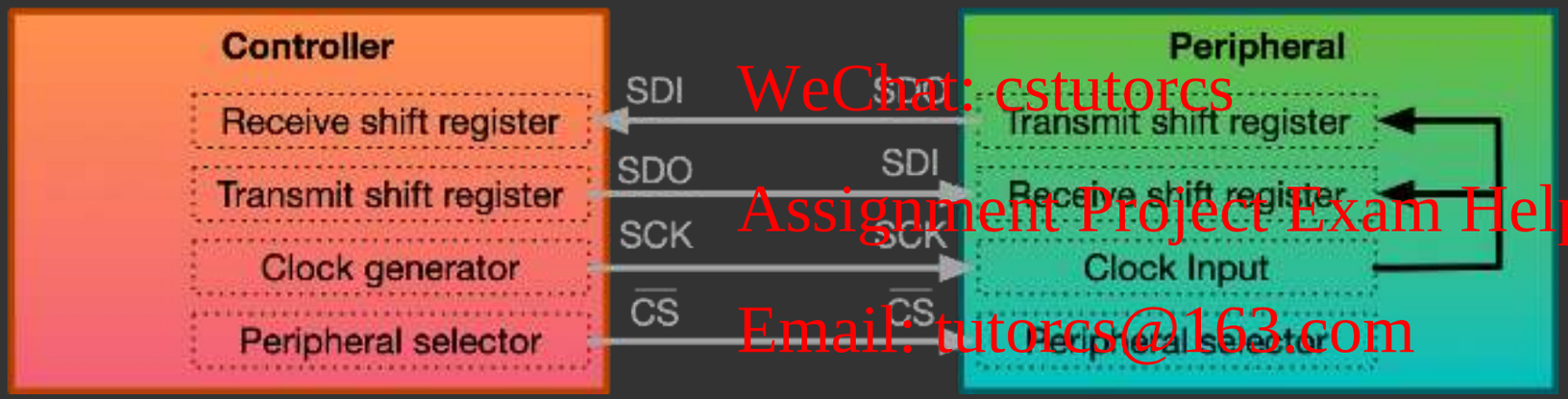
SPI: Serial Peripheral Interface

- used by gazillions of devices… ot even a formal standard!
- speed only limited by what bo n survive
- *synchronous* protocol, so it's quite easy to implement in software

(NB: the pin terminology of SPI has **changed recently** to use more inclusive language).

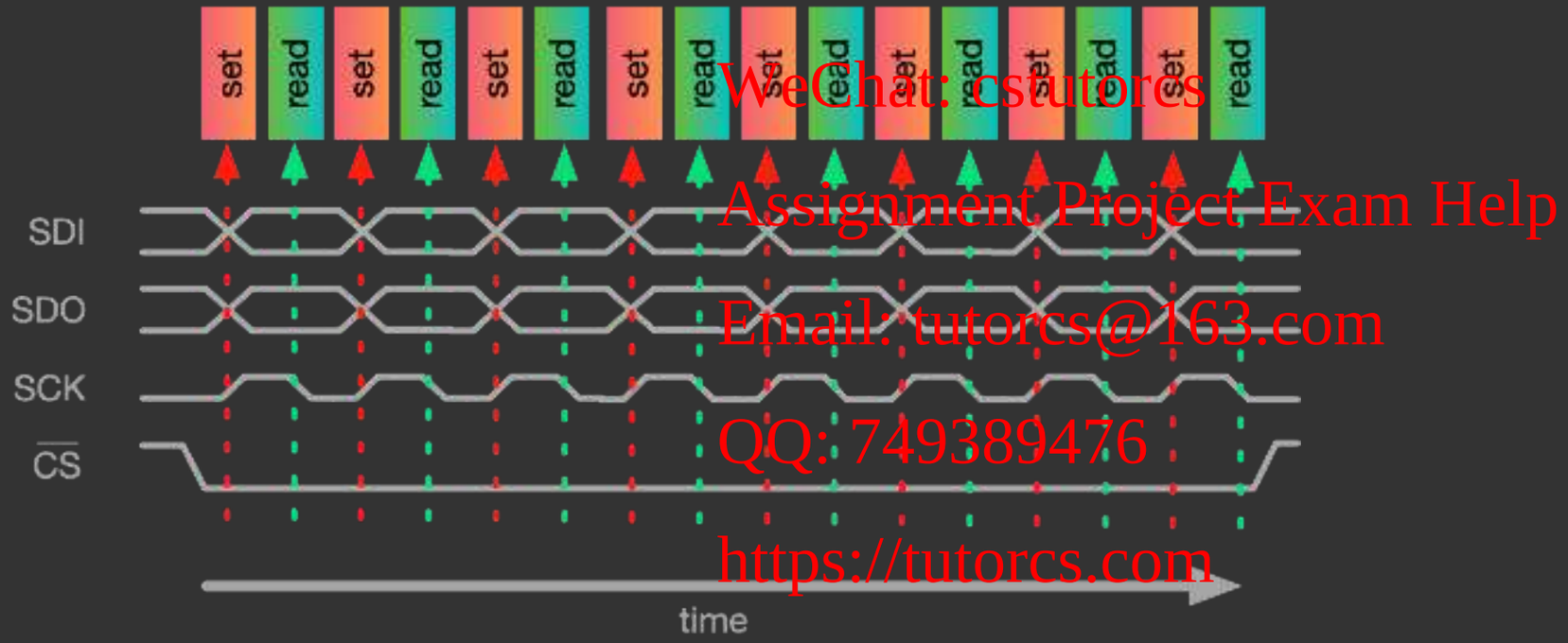
SPI connections

full duplex, 4-wire, flexible clock



(SDI: “Serial Data In”, SDO: “Serial Data Out”, SCK: “Serial Clock”, CS: “Chip Select”)

SPI timing and data



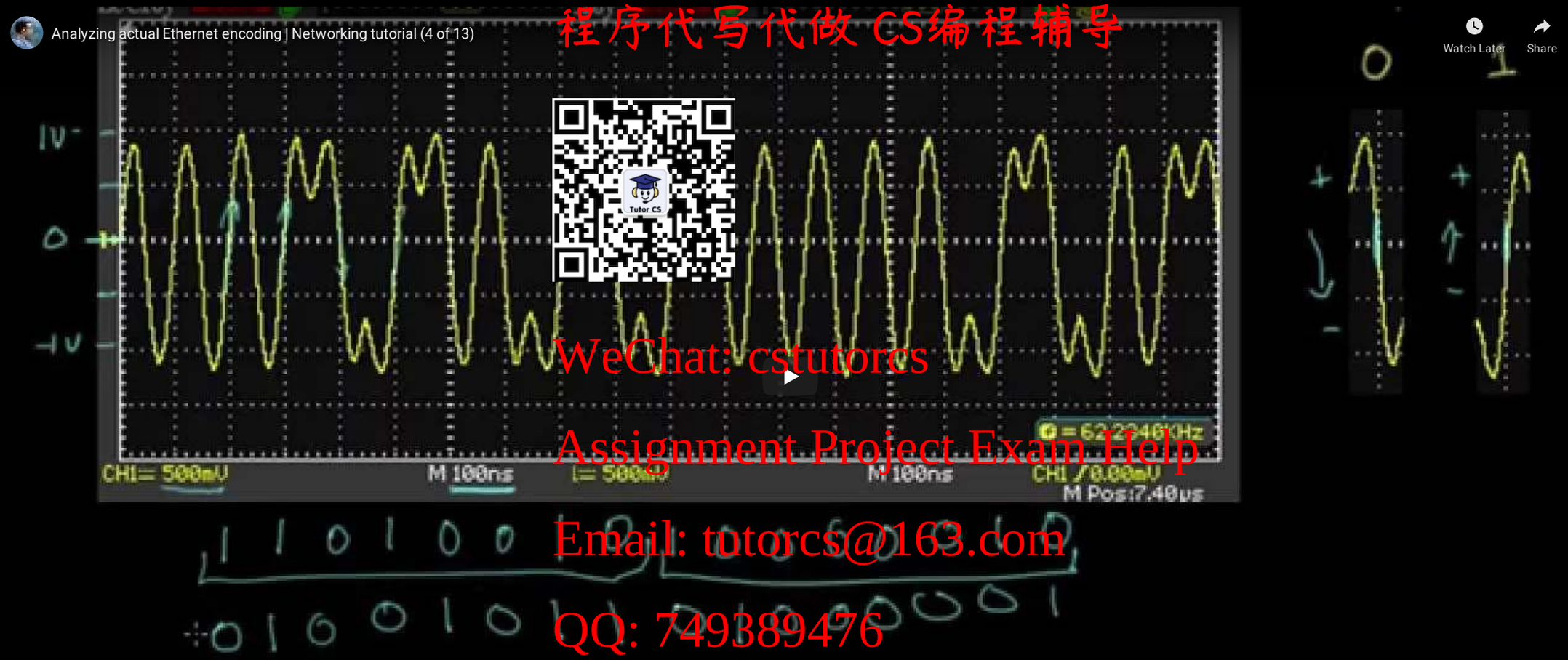
What can you do with Synchronous Connections?

- Read/Write from SD cards! (se here
- Read/Write to peripherals (e.g ensor) with I2C (Inter-Integrated Circuit Protocol)

Ethernet / IEEE 802.3

Local area network (LAN) develo ox in the 70's

- 10 Mbps specification 1.0 by D , Xerox in 1980
- First standardised as IEEE 802.3 in 1983 (10 Mbps over thick co-ax cables)
- currently 1 Gbps (802.3ab) copper cable ports used in most desktops and laptops
- currently standards up to 100 Gbps (IEEE 802.3ba 2010)
- more than 85% of current LAN lines worldwide (according to the International Data Corporation)



See **Ben Eater's youtube channel** are great

Bluetooth LE

Microbit has a “Bluetooth® 5.1, IEEE 802.15.4-2006, 2.4 GHz transceiver”

- wireless data
- originally from 1998, but 5.1 released in 2019
- typically for connecting wireless connections between multiple devices with one user: e.g. headphones, speakers, mouse, keyboard, remote control, smartwatches, etc.

How does it work? Let’s look at section 6.18 of the nRF52833 manual!

Further study

Essentials of Computer Organis Architecture (Lobur & Null), Chapter 12: Network Organization and Architecture - online for ANU students, has a particularly good explanation of the OSI layers

IP over Avian Carriers

this was a *really* high-level overview, a whirlwind tour

to go deeper, you could take COMP3310

What communication hardware is on the microbit?

Last time, we sent bytes *manua* mer.

The microbit has hardware to help us.

Let's try the same thing with the UART hardware.

Sending Bytes with UART: Preparation


```
.set ADR_UART, 0x40002000
.set OFS_UART_STARTTX, 0x008
.set OFS_UART_TXDRDY, 0x11c
.set OFS_UART_ENABLE, 0x500
.set OFS_UART_PSEL_TXD, 0x50c
.set OFS_UART_TXD, 0x51c
.set OFS_UART_BAUDRATE, 0x524
.set OFS_UART_CONFIG, 0x56c

.type setup_output, %function
setup_output: @ Set RING0 (P0.2) to output
    ldr r0, =ADR_P0
    ldr r1, =OFS_GPIO_DIRSET
    ldr r2, =(0b1 << 2)
    str r2, [r0, r1]
    bx lr
.size setup_output, . - setup_output

.type turn_on_ring_0, %function
turn_on_ring_0: @ Set RING0 (P0.2) to high
    ldr r0, =ADR_P0
    ldr r1, =OFS_GPIO_OUTSET
    ldr r2, =(0b1 << 2)
    str r2, [r0, r1]
    bx lr
.size turn_on_ring_0, . - turn_on_ring_0
```

Sending Bytes with UART: configuring UART


```
@ 0. Set RING0 (P0.2) to output and high
bl setup_output
bl turn_on_ring_0
@ 1. Clear UART config register
ldr r0, =ADR_UART
ldr r1, =OFS_UART_CONFIG
mov r2, 0x0 @ default values
str r2, [r0, r1]

@ 2. set baudrate
ldr r1, =OFS_UART_BAUDRATE
ldr r2, =0x00800000 @ 31250 baud
str r2, [r0, r1]

@ 3. set tx pin to RING0 (P0.2) - =(0x0 << 31 | 0x0 << 5 | 0x2) @ connect (clear 31), port 0, pin 2
ldr r1, =OFS_UART_PSEL_TXD
ldr r2, =(0x0 << 31 | 0x0 << 5 | 0x2) @ connected, port 0, pin 2
str r2, [r0, r1]

@ 4. enable UART
ldr r1, =OFS_UART_ENABLE
ldr r2, =4
str r2, [r0, r1]
```

Sending Bytes with UART: sending the bytes


```
@ 5. put byte to send into txd
ldr r1, =OFS_UART_TXD @ this is the transm                e byte to actually send
mov r2, 0xFF @ <--- this is the byte to be
str r2, [r0, r1]

@ 6. set starttx task
ldr r1, =OFS_UART_STARTTX
mov r2, 1
str r2, [r0, r1]
```

- Once `starttx` task has started, whenver you put a byte into `UART_TXD`, that byte will be sent.
- Just need to check `TXDRDY` register to make sure previous byte has completed sending.
- Can also set `TXDRDY` to generate an interrupt if you want

Questions