Teaching London Computing

Programming for GCSE Topic 7.1: Principles of Communication

Queen Mary
University of London

KING'S College LONDON

COMPUTING AT SCHOOL
EDUCATE · ENGAGE · ENCOURAGE

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NETWORK OF EXCELLENCE COMPUTER SCIENCE TEACHING
UNIVERSITY PARTNER

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Outline

- Activity 1
  - Encoding and modulation
  - Error correction
  - Multiplexing
  - Communicate in both directions
- Activity 2
  - Low-level communication
  - Clock synchronisation
  - Framing

Teaching Issues

Teaching Issue

- GCSE material on networks and communication lack concepts
  - It is also quite out of date

- Principles
- Real-world examples

From the specification

- **OCR GCSE Computing.** Candidates should be able to:
- (a) explain the advantages of networking stand-alone computers into a local area network
- (b) describe the hardware needed to connect stand-alone computers into a local area network, including hub/switches, wireless access points
- (c) explain the different roles of computers in a client-server and a peer-to-peer network
- (d) describe, using diagrams or otherwise, the ring, bus and star network topologies

From the specification

- **OCR GCSE Computing.** Candidates should be able to:
- (e) describe the differences between a local area network and a wide area network such as the internet
- (f) explain the terms IP addressing, MAC addressing, packet and protocols
- (g) explain the need for security measures in networks, such as user access levels, suitable passwords and encryption techniques
- (h) describe and justify network policies such as acceptable use, disaster recovery, failover, back up, archiving..

Activity: Transmitting Data

- Simple activity
  - Exchange data
  - Look at principles
- Elaborate activity
  - Notice problem
  - New principle

What's a protocol

Basic Activity

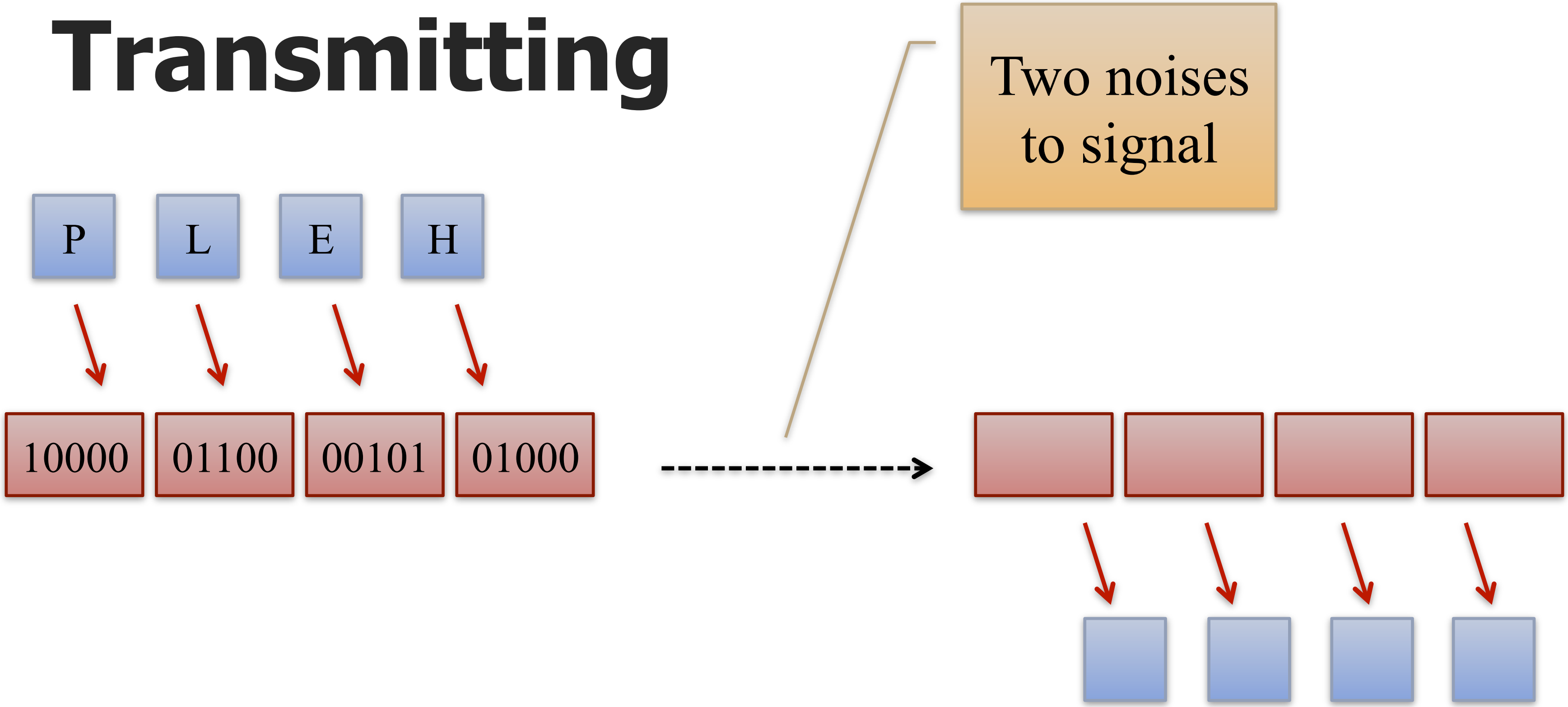
- Sending station
  - Application: create a message
  - Code: text → binary
  - Modulate: binary → noise

- Receiving station
  - Demodulate: noise → binary
  - Decode: binary → text
  - Application: enjoy message

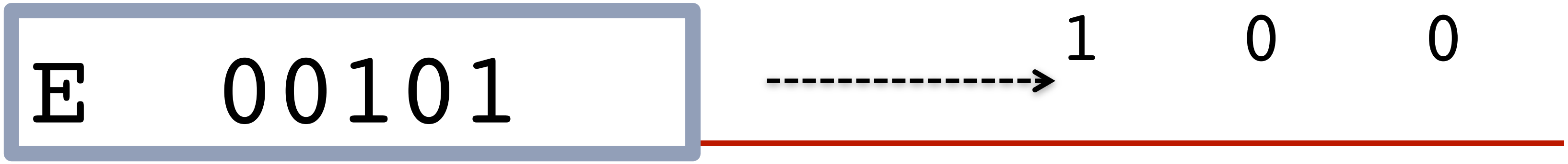
Basic Activity – Code

Space	00000	N	01110
A	00001	O	01111
B	00010	P	10000
C	00011	Q	10001
D	00100	R	10010
E	00101	S	10011
F	00110	T	10100
G	00111	U	10101
H	01000	V	10110
I	01001	W	10111
J	01010	X	11000
K	01011	Y	11001
L	01100	Z	11010
M	01101	?	11011

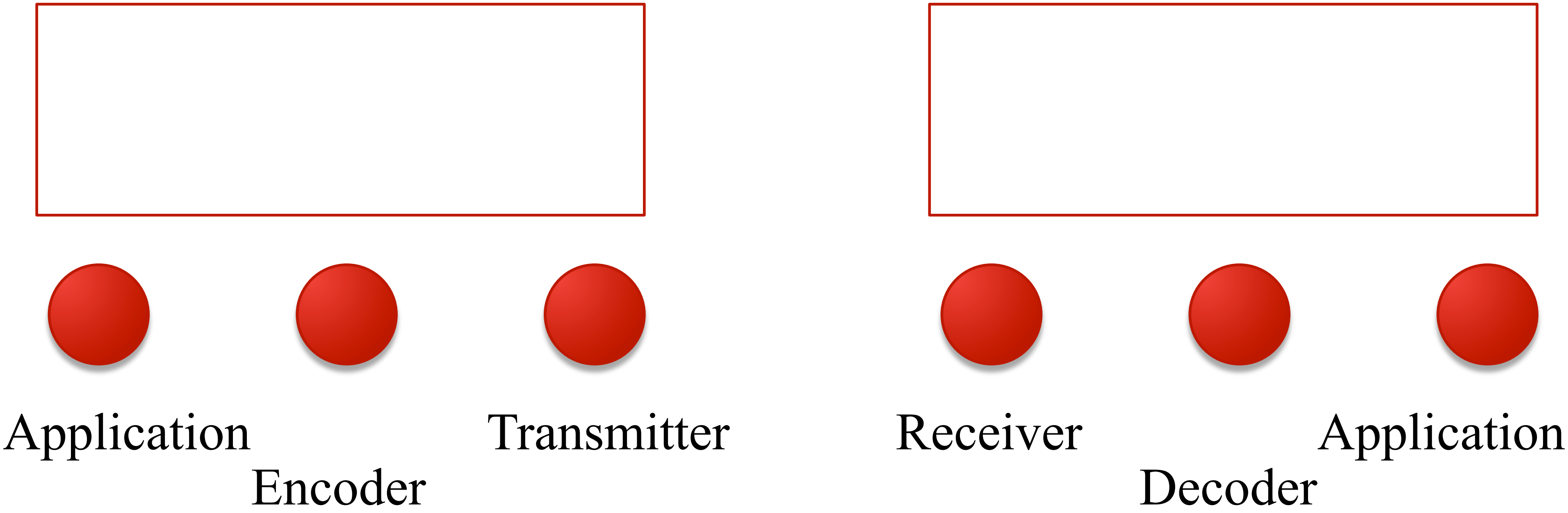
Transmitting



- Message format
  - Read & transmit binary **left to right**



Layout – Seating



Application

Encoder

Transmitter

Receiver

Decoder

Application

Transmission in Practice

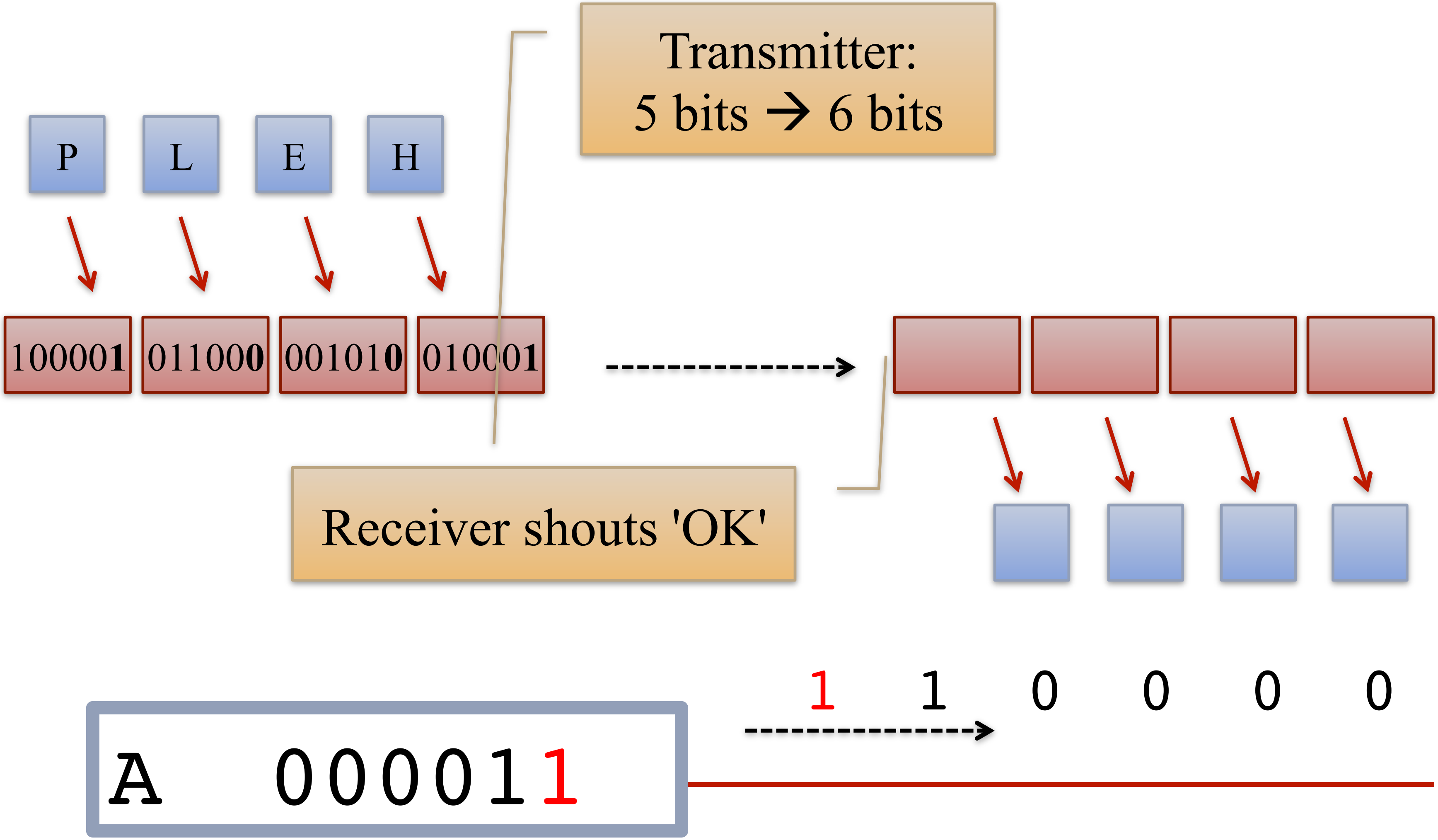
- Data can be sent using 2 signals
  - Two noises resembles 'frequency' modulation (FM)

- Real modulation schemes **very** complex
  - Achieve very high data rates over twisted pair
  - E.g. see Wikipedia article on OFDM

Elaborations

1. Error detect using Parity
   - Add a parity bit
   - Acknowledge safe receipt
2. Send two messages at once
   - Two applications on each computer
   - Share link – **multiplex**
3. Reply to a message
   - Communication in both directions
   - Channel is **multiple access**

Elaboration 1: Parity



Transmitter:
5 bits → 6 bits

Receiver shouts 'OK'

Parity: Roles

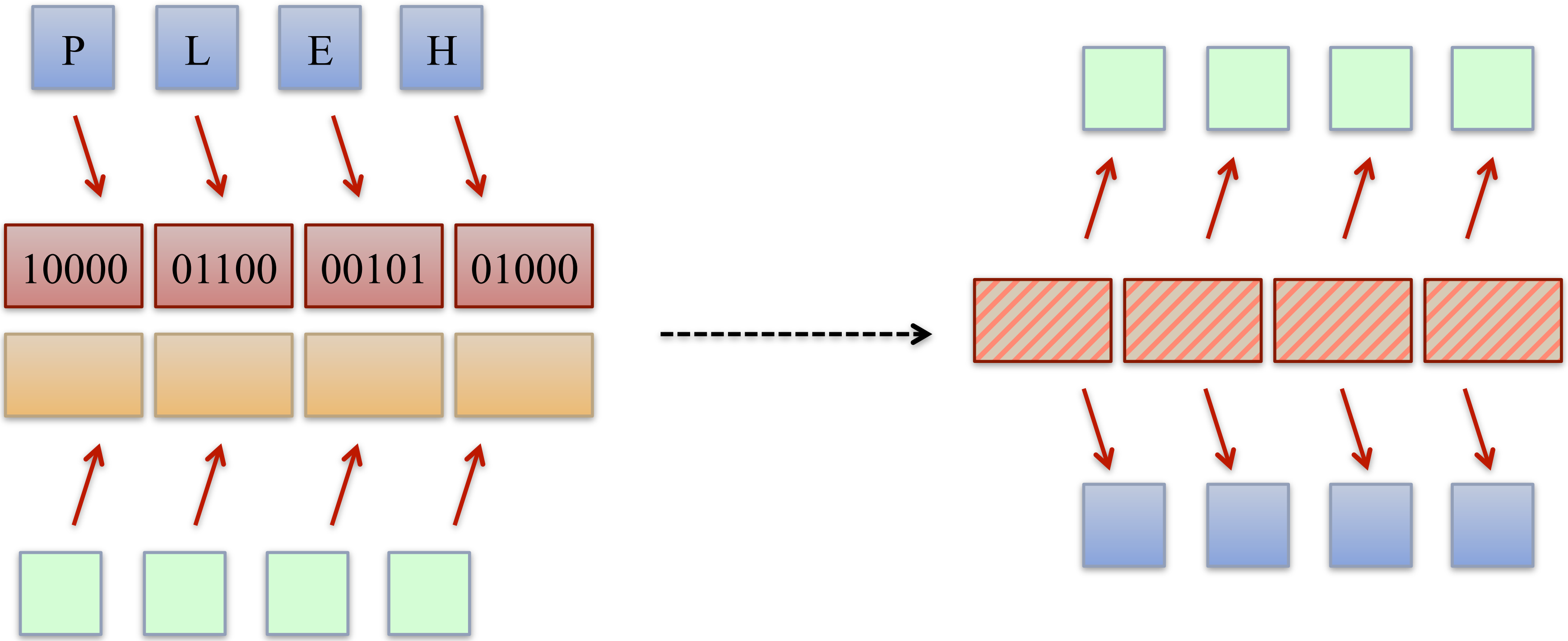
- Transmitter adds parity bit
  - All code words have an **even** number of '1' digits
  - Parity bit at right hand side: transmitted last
- Receiver's decoder counts '1'
  - ACK (acknowledge) correct code word
  - Delete the parity bit
- Retransmission
  - If no acknowledgement then RETRANSMIT the code word

In Practice: Parity and ACK

- Error detection VITAL
  - Parity cannot detect two erros
  - CRC – more complex than parity
- By shouting 'ok', we have cheated
  - It's a third symbol!
- ACK is a separate message (a reply)
  - Latency: if you have to wait for a ACK then the messages over long distances are slow

Elaboration 2: Multiplex

- How can we share link?



Elaboration 2: Multiplex

- Sending station
  - Application: create a message
  - **Multiplex: 0 or 1**
  - Code: text → binary
  - Modulate: binary → noise

Each character: now 7 bits

- Receiving station
  - Demodulate: noise → binary
  - Decode: binary → text
  - **De-multiplex: 0 or 1**
  - Application: enjoy message

Message Format

- Application
  - 1 bit address of destination application

```
1A
```

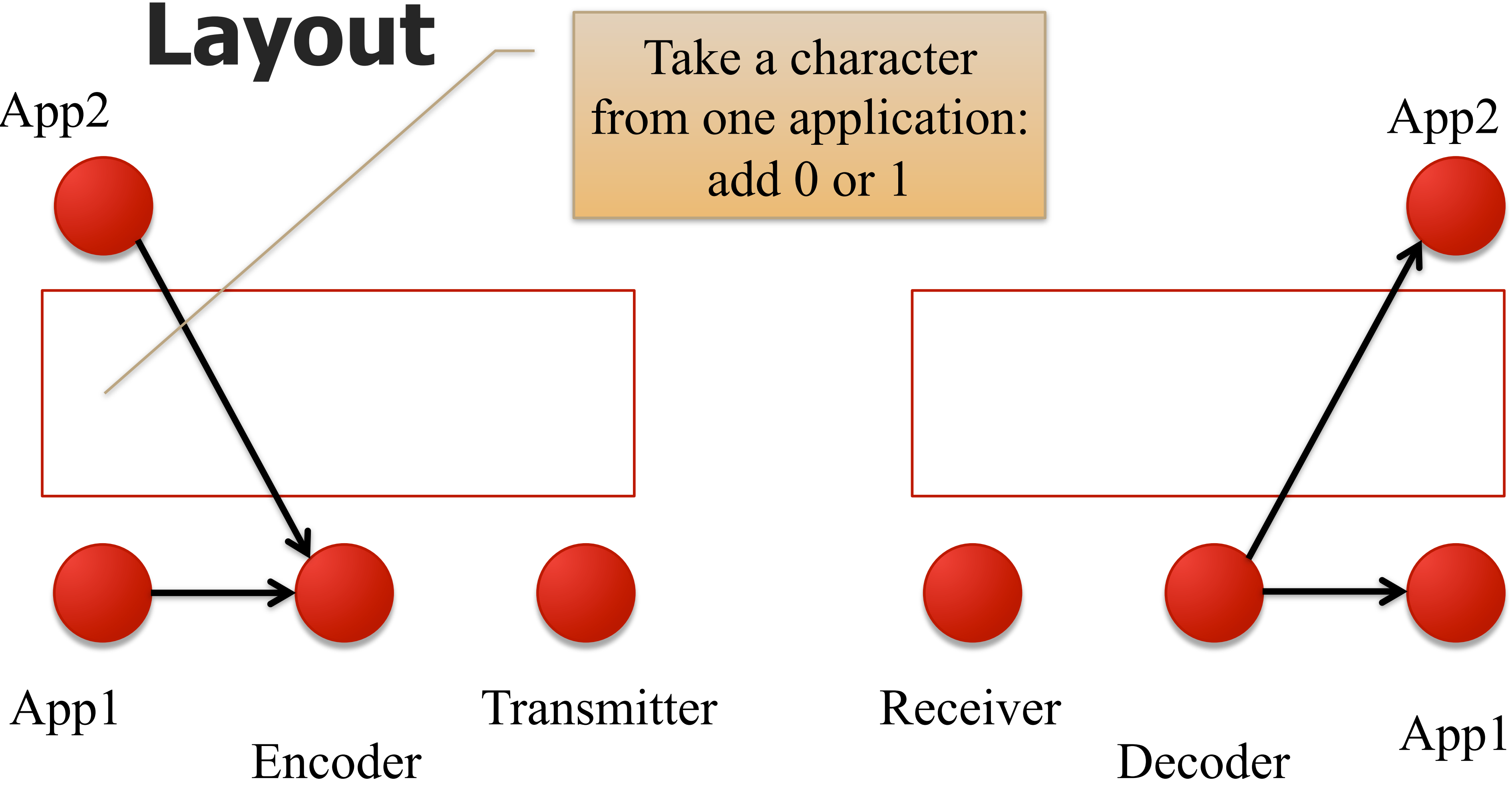
- Encoder

```
1A   100001
```

- Transmitter
  - Add parity
  - Transmitted left to right

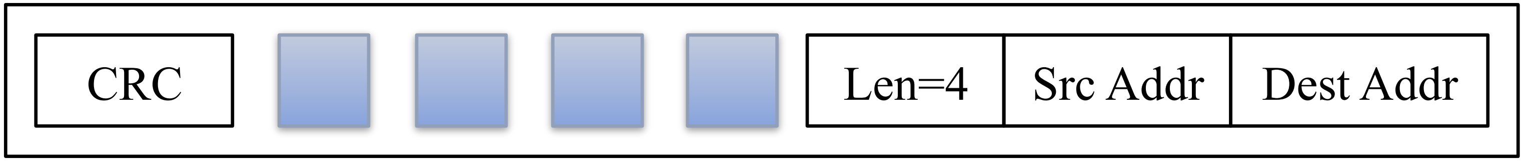
```
1A   1000010
```

Layout


Take a character from one application: add 0 or 1
App2
App2
App1
Encoder
Transmitter
Receiver
Decoder
App1

Multiplex in Practice

- Message of multiple code words
  - Message length
  - Error check for whole message
- Source and destination address



Elaboration 3: Multiple Access and Reply

- Shared channel
  - Wi-fi
  - Bus-topology (old Ethernet)
- *How to avoid confusion?*

Elaboration 3: Multiple Access

- Shared channel
  - Wi-fi
  - Bus-topology (old Ethernet)
- How to avoid confusion?
  - Token exchange
  - **Random turn taking** (wifi)

Elaboration 3: Multiple Access

- 2 stations at either end
  - Sender
  - Receiver
- Rules for transmitting
  - Listen for silence before starting
  - … transmit when you have data
  - If two stations transmit at once
    - LONG BLAST then STOP
  - Wait a bit; try again

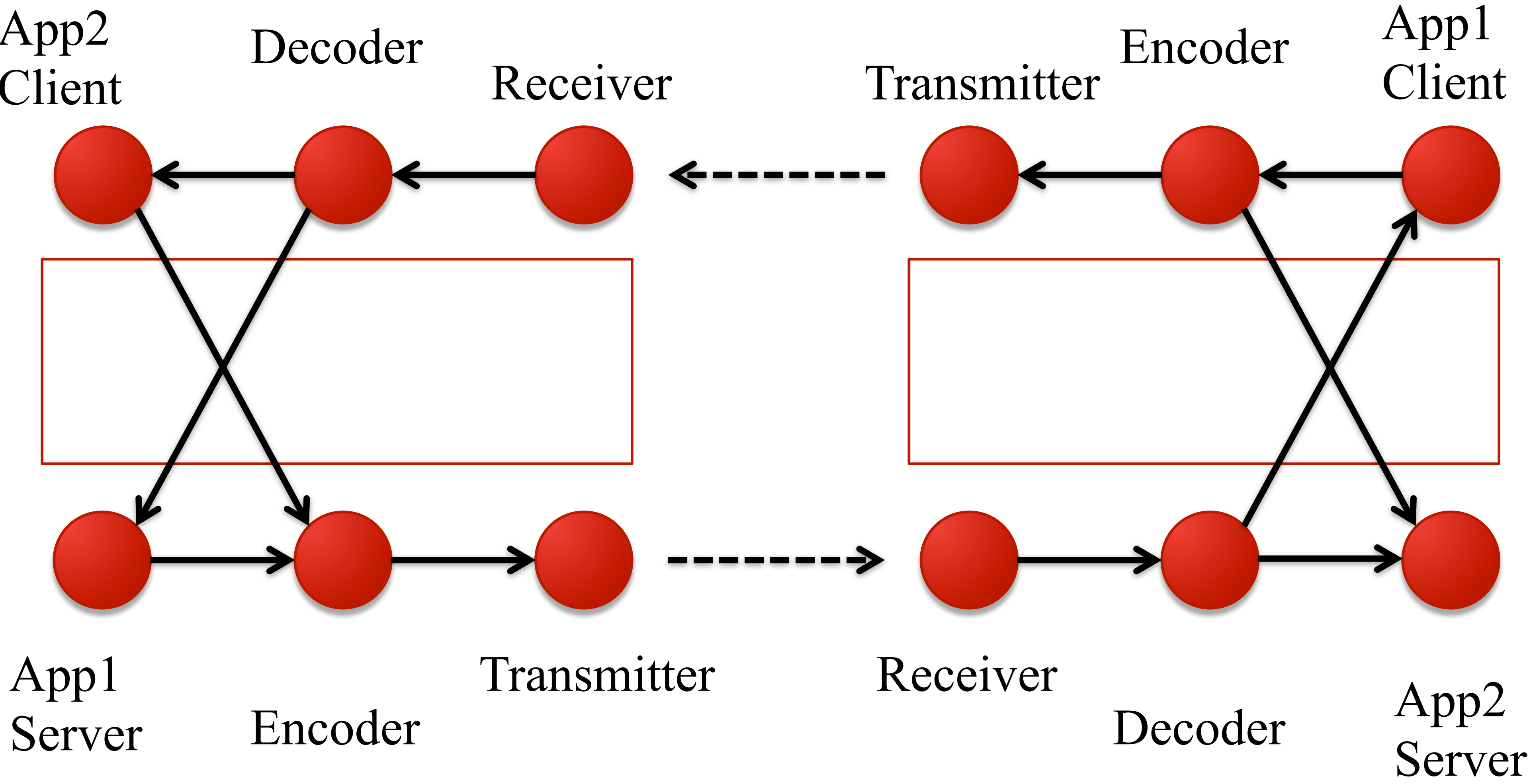
Note: with multiple access we could have more than two tables but more addresses needed

Elaboration 3: Reply

- Applications are either
  - Server – answers a question
  - Clients – asks a question
- Place one server and one client on each table
  - Client asks
  - Server responds
- Application protocol
  - Question ends with a '?'

Note: HTTP is an application protocol to display web pages. It sends messages like 'get index.html'

Layout - Seating



In Practice: Multiple Access

- Multiple access is used in
  - Original Ethernet
  - Wifi
- Switches now avoid multiple access in Ethernet
- We have ignored
  - Station address: MAC address is used in Ethernet, Wifi and Bluetooth

In Practice: Reply

- Client / server is the basis of the Internet
  - E.g. web, email
  - Conservations are between **applications** on **hosts**
  - Ok to browse same web site twice
  - Our address (1 bit) is a combination of an IP address (for a **host**) and TCP 'port' (for an **application**)
- We have assumed sender address is same as destination address
  - In practice, need both

COMMUNICATION PRINCIPLES

Summary

Concepts

- Signal: transmit binary
- Modulate: encode the binary to transmit
- Parity: detect errors
- Multiplex: share a link

- Protocol: agree on rules of communication