

Cambridge IGCSE

Computer Science

Section 3

Hardware

3.1 Computer Architecture (iii)

Objectives

- Describe the purpose and characteristics of an embedded system and identify devices in which they are commonly used

Vocabulary

- embedded
- dedicated
- user interaction
- specialised
- remotely
- sensor
- feedback

Embedded systems

- Not all computers are general or multi-purpose computers.
- Embedded systems use small computers that **form part of a larger system, device or machine**. Their purpose is to control the device and to allow user interaction.
- An embedded system will have a specific set - **a limited number** - of tasks.



Embedded systems

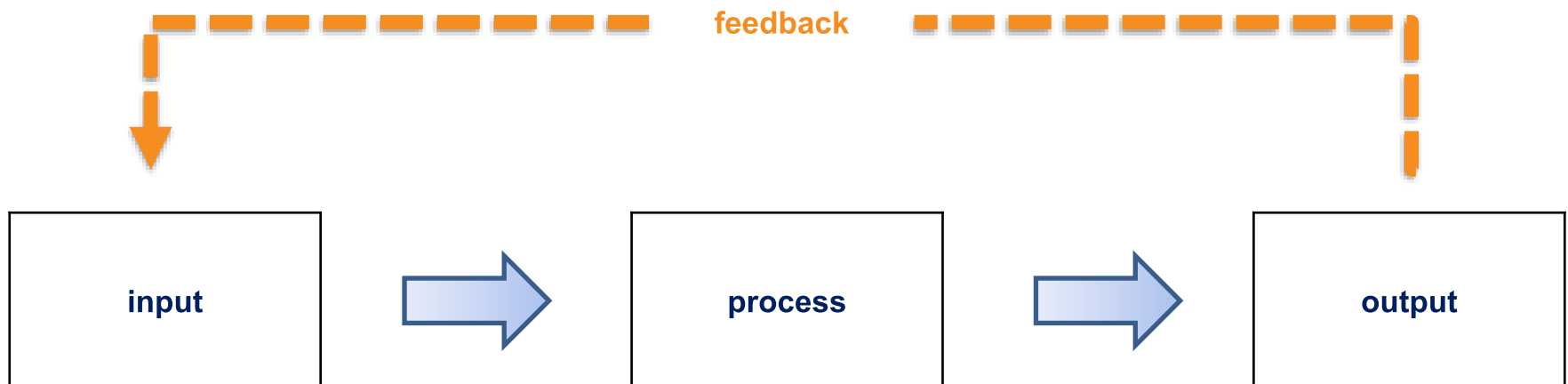
- The computers that are designed to perform a **dedicated function within a larger system**.
- Examples include: MP3 players, digital cameras, GPS, microwave ovens, washing machines, vending machines ...

*A point-of-sale
(PoS) system*



Embedded systems

- Many embedded systems are **feedback** based.
- **Feedback** is when the output from a system affects the input.
- For example, a central heating system.



Embedded systems

- An embedded system is programmed during its manufacturing stage.
- Data can be **input** by users **manually** (eg setting a temperature on a keypad) or **automatically** through **sensors** (eg temperature readings in an office)
- The output will then carry out the function required of the embedded system by sending signals to the components that are being controlled (eg increase power to the heating elements inside an oven).

Embedded systems

- Embedded systems can be programmable or non-programmable
- Programmable devices can be connected to a network (through wi-fi, satellite or mobile phone) to allow the download of software updates (eg updating the GPS maps in a car's satellite navigation system)
- Non-programmable devices may need to be replaced if they require a software upgrade

Embedded systems

- Because embedded systems can be connected to the internet, it is possible to control them remotely using a smartphone or computer.
- For example, while away from home (remotely), setting the central heating system to switch on or off, or instructing a set-top (TV) box to record a television programme, or checking the security cameras in a home.
- As embedded systems are dedicated to a specific set of tasks, engineers can design them in the best way to reduce physical size and cost of the devices.

Embedded systems

Advantages :

- Dedicated to one task, allowing for smaller size and simpler interfaces -> easier to fit into devices
- With mass production comes reliability and relatively low manufacture cost compared to other systems
- Consume very little power
- Can be controlled remotely eg by mobile phone
- Are feedback oriented and so have fast reaction times

Embedded systems

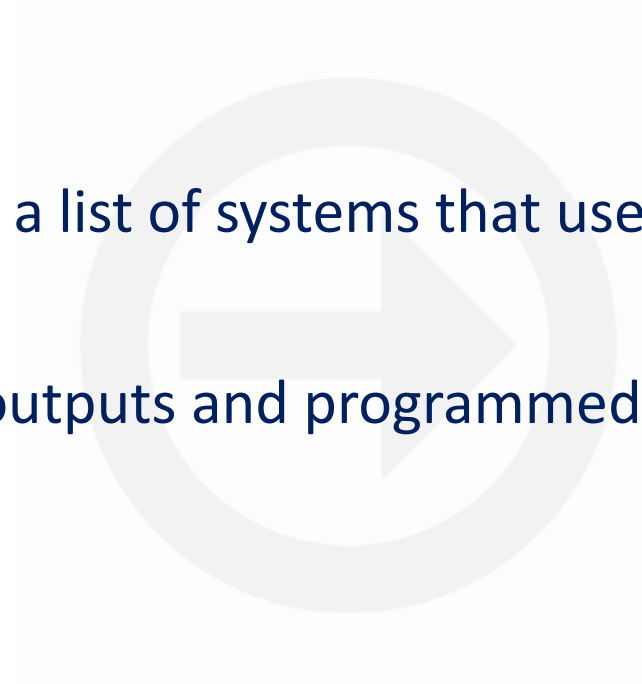
Disadvantages :

- It can be difficult to upgrade some devices to take advantage of new technology
- Troubleshooting faults becomes a specialist task
- Difficulties in upgrading and fault finding mean that devices are often thrown away rather than repaired -> very wasteful
- The 'easier to throw away and get a new one' mindset causes lots of problems eg pollution
- Any device that can be accessed over the internet is also open to hackers, viruses etc

Activity

In pairs, discuss and come up with a list of systems that use embedded computers.

For each, think about the inputs, outputs and programmed instructions.



Activity

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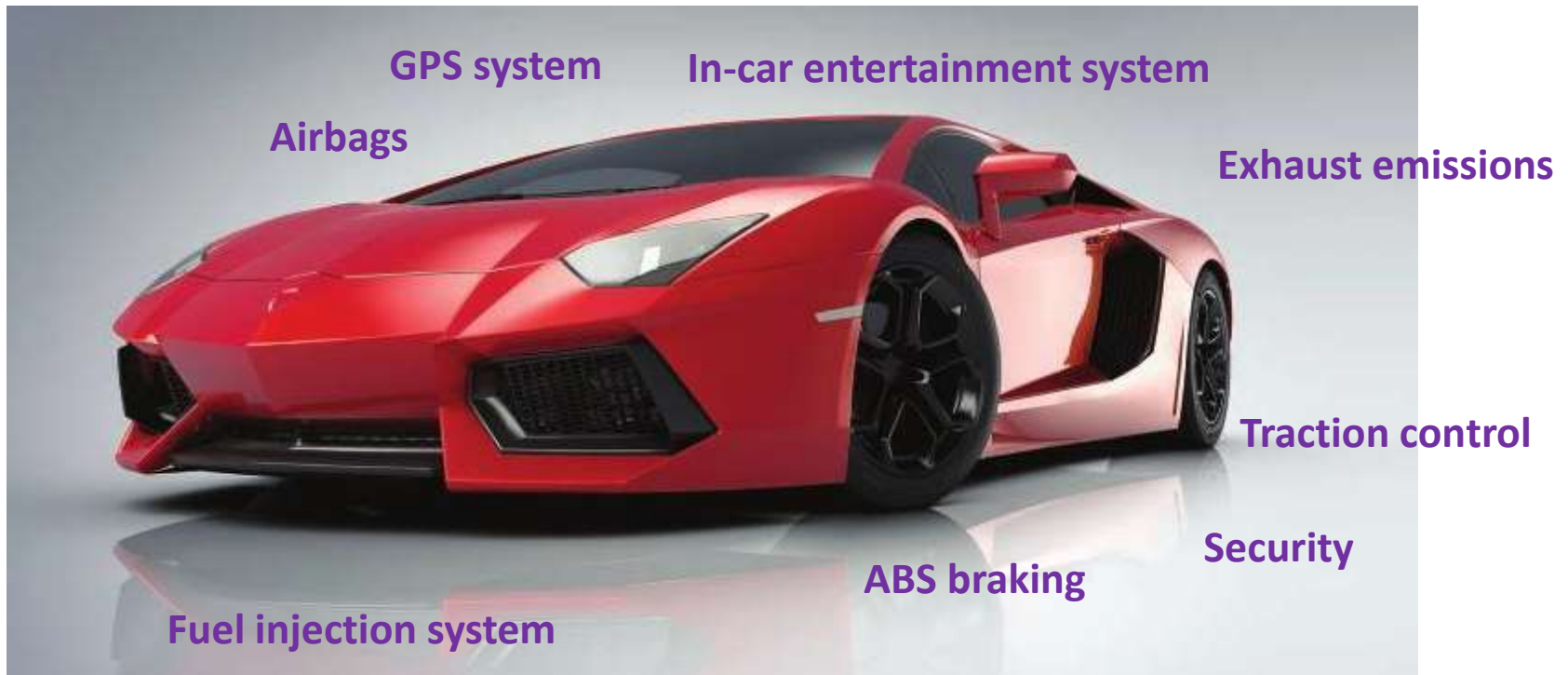
Embedded systems

Examples include :

- central heating system
- engine management systems in vehicles
- domestic appliances (dishwashers, microwaves, TVs etc.)
- digital watches
- electronic calculators
- GPS systems
- fitness trackers

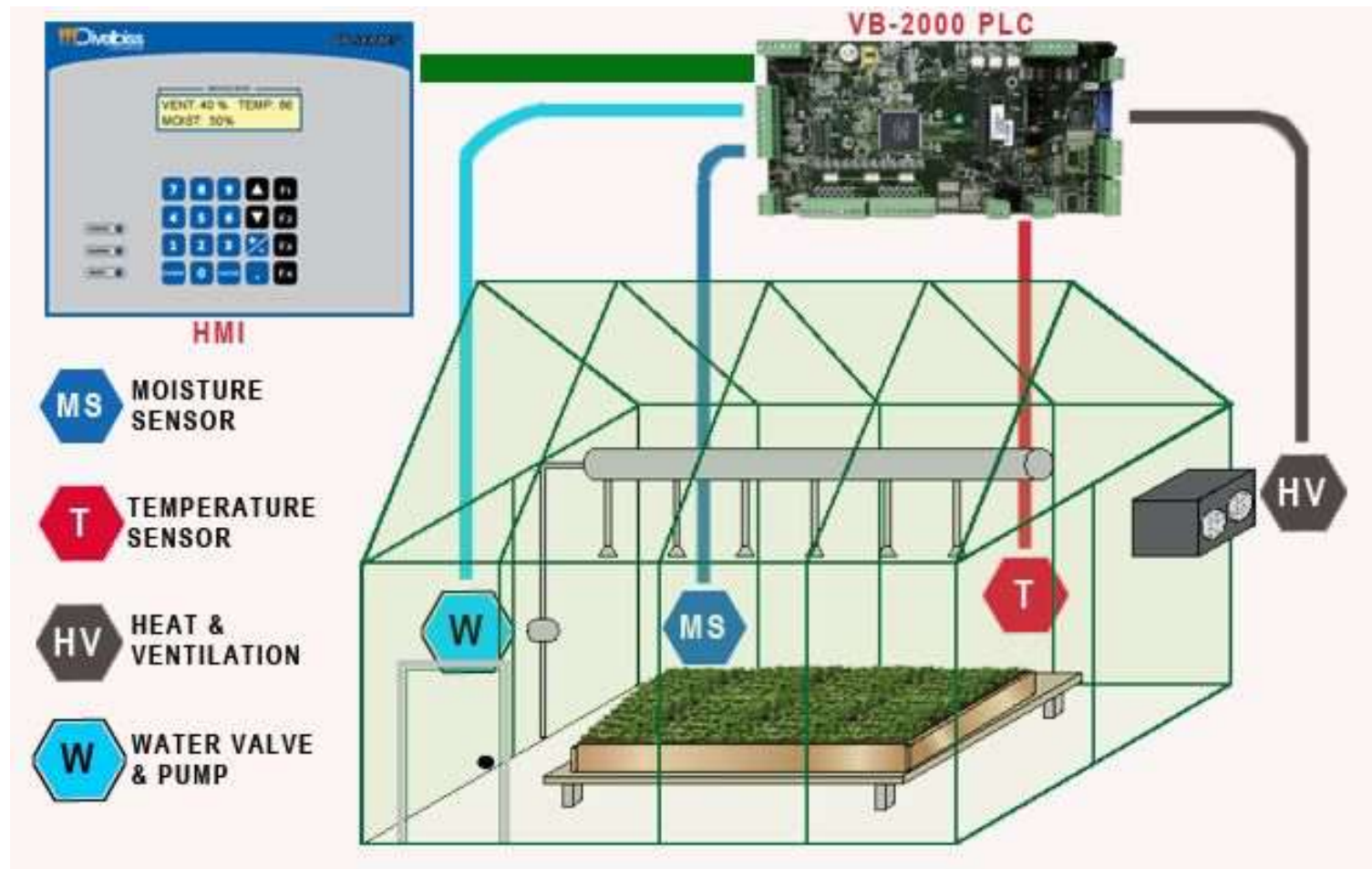
Embedded systems

In a car



Embedded systems

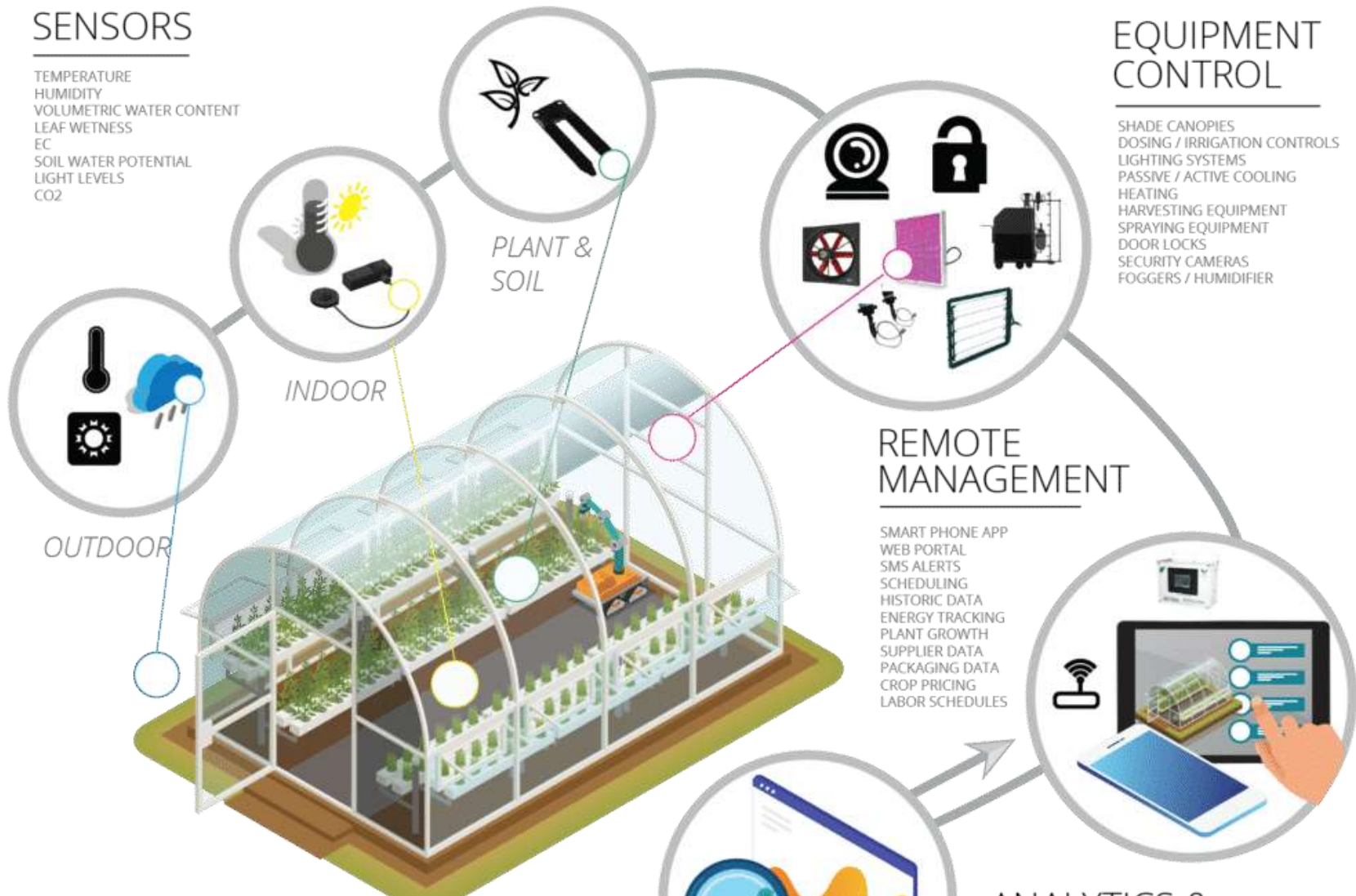
In a greenhouse



Embedded systems

SENSORS

TEMPERATURE
HUMIDITY
VOLUMETRIC WATER CONTENT
LEAF WETNESS
EC
SOIL WATER POTENTIAL
LIGHT LEVELS
CO₂



EQUIPMENT CONTROL

SHADE CANOPIES
DOSING / IRRIGATION CONTROLS
LIGHTING SYSTEMS
PASSIVE / ACTIVE COOLING
HEATING
HARVESTING EQUIPMENT
SPRAYING EQUIPMENT
DOOR LOCKS
SECURITY CAMERAS
FOGGERS / HUMIDIFIER

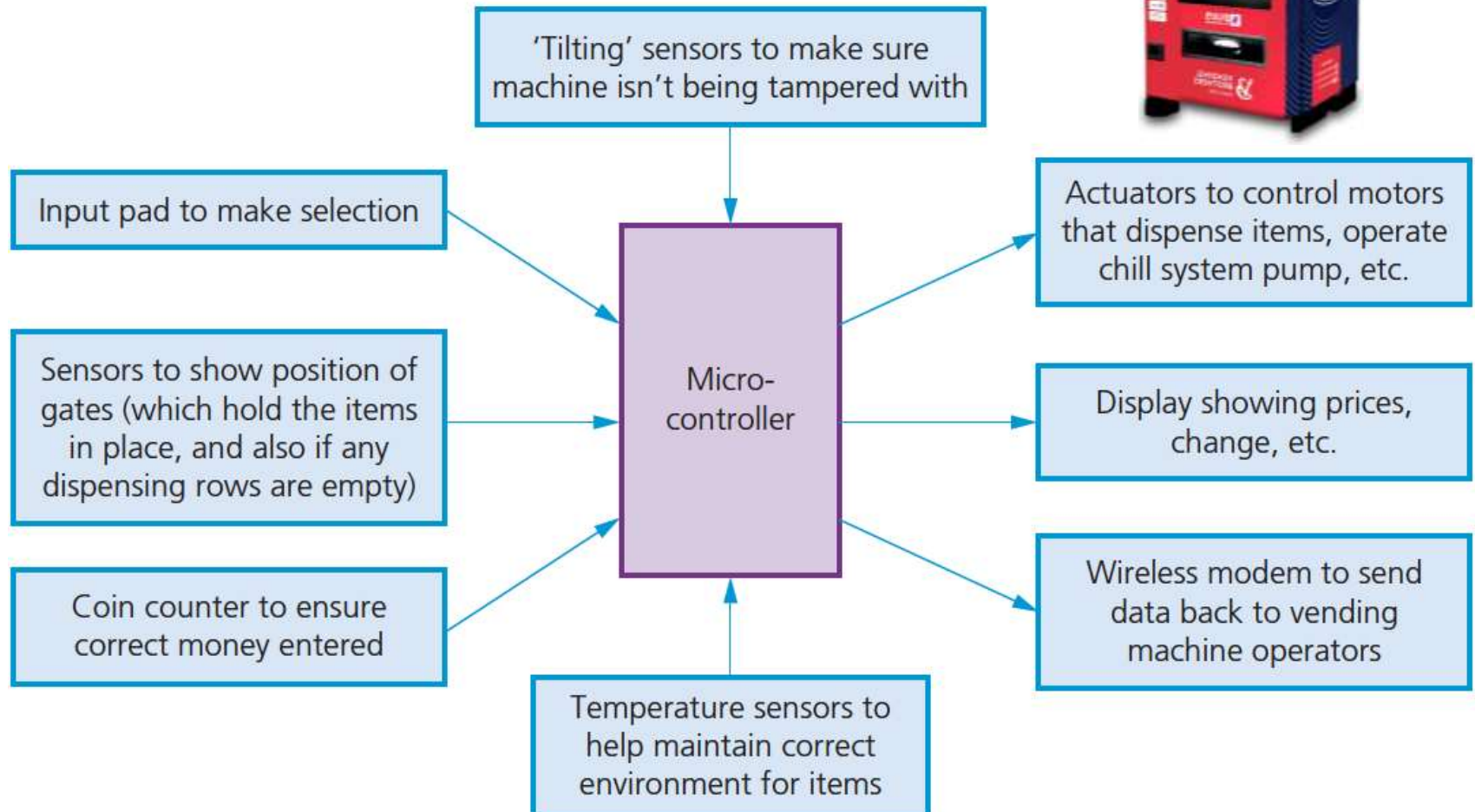
REMOTE MANAGEMENT

SMART PHONE APP
WEB PORTAL
SMS ALERTS
SCHEDULING
HISTORIC DATA
ENERGY TRACKING
PLANT GROWTH
SUPPLIER DATA
PACKAGING DATA
CROP PRICING
LABOR SCHEDULES

ANALYTICS

Embedded systems

A vending machine



Embedded systems

- Wearable gadgets are a category of devices that can be worn by a user to track information related to health and fitness.
- Some wearable gadgets have small motion sensors that transfer the data to smartphones.



Embedded systems

Video - Computer architecture and embedded systems



Homework

1. Describe how embedded system are used in two the following :

- Cars
- Security systems
- Central heating systems
- Microwave ovens

2. Research and explain what is meant by the 'Internet of Things'.



Embedded systems

- An **embedded system** is used to perform a **dedicated function** e.g. domestic appliances (microwave ovens, cookers, a/c, washing machines), cars, security systems, lighting systems, vending machines etc
- This is different to a **general purpose computer** that is used to **perform many different functions** e.g. a laptop that is used for school work, communications, games etc.

Embedded systems

- Only required to perform a single operation during their lifetime.
- As they are dedicated for a particular task, their size is reduced and performance is improved.
- The software in these systems is also dedicated for a single function.
- The limited number of functions making them cheaper to design, build and run.

(eg less processing power required -> build using cheaper and less powerful processors -> will require less power)

Embedded systems

- User will not be able to modify the program. User can only interact with the embedded system through the user interface provided.
- However, it may be possible to upgrade the software by allowing the device to connect online and download directly from the manufacturer.

Past paper question examples ...

4 A computer has a Von Neumann architecture.

(a) Circle **three** components that are part of the central processing unit (CPU) in this computer.

accumulator (ACC)

hard disk drive (HDD)

memory address register (MAR)

program counter (PC)

random access memory (RAM)

read only memory (ROM)

sensor

solid state drive (SSD)

[3]

(b) Describe the purpose of the control unit (CU) within this computer.

.....

.....

.....

.....

Past paper question examples ...

(c) The computer has a single core CPU.

(i) State **one** purpose of a core in a CPU.

.....
..... [1]

(ii) The computer is upgraded to a dual core CPU.

Explain how the upgrade can affect the performance of the computer.

.....
.....
.....
..... [2]

Past paper question examples ...

(d) The computer uses a bootstrap.

Tick (✓) **one** box to show the part of a computer of which the bootstrap is an example.

A application software ☐

B firmware ☐

C hard disk drive ☐

D MAC address ☐

[1]