Grade 13 A/L ICT

Lesson 13: New Trends and Future Directions in ICT

- 13.1 New Trends in Computing
- 13.2 Software Agents and Multi-Agent Systems
- 13.3 Beyond von Neumann and New Computing Models

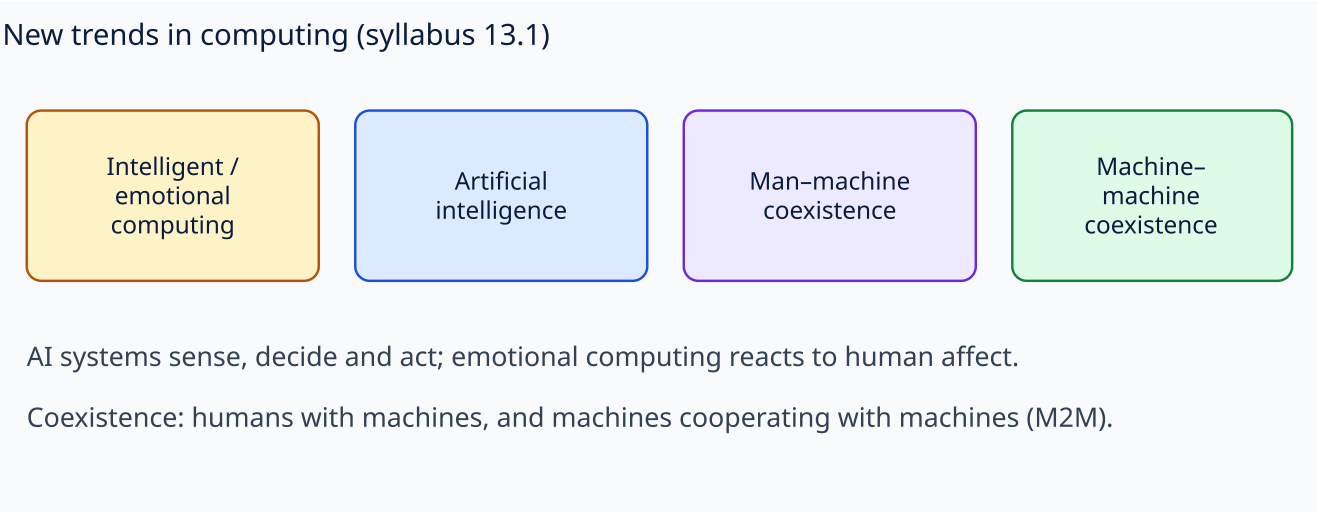
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Grade 13 A/L ICT · Lesson 13

13.1 New Trends in Computing

Syllabus 13.1. Computing keeps changing. **Intelligent and emotional computing** builds systems that sense context and, in some cases, respond to human emotion. **Artificial intelligence (AI)** lets machines learn patterns, reason and act. **Man–machine coexistence** means people and machines work together usefully. **Machine-to-machine (M2M) coexistence** means devices exchange data and act with little human help. Together these ideas shape new products, jobs and ethics questions.

1. Intelligent and emotional computing



Four syllabus themes for 13.1

- **Intelligent computing** – hardware and software that adapt, learn or optimise (sensors, smart devices, adaptive algorithms).
- **Emotional computing** (affective computing) – systems that detect or respond to human emotion (voice tone, facial cues, text sentiment) to improve interaction.
- Goal: more natural, helpful human–computer interaction – not “feelings” inside the chip.

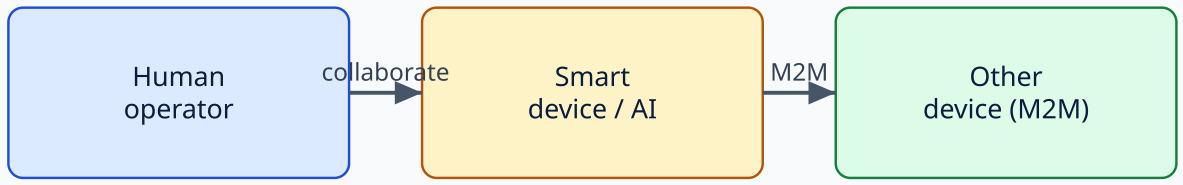
2. Artificial intelligence

- **AI** – techniques that let computers perform tasks that usually need human intelligence: recognising speech/images, planning, recommending, controlling robots.
- Classic ideas: search, knowledge rules, machine learning from data.
- AI is a toolbox used inside intelligent computing products.

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3. Man–machine coexistence

Man–machine and machine–machine coexistence



Example: driver + car AI; sensors on a farm talk to a gateway without a person in the loop.

People and machines working together; devices talking to devices

- Humans remain in control for goals and ethics; machines handle speed, memory and repetition.
- Examples: pilot + autopilot; doctor + diagnostic support; student + adaptive tutor.
- Design must be transparent and safe so people trust the partnership.

4. Machine-to-machine coexistence

- **M2M** – devices exchange data and trigger actions without a person in every step (IoT sensors → gateway → cloud → actuator).
- Needs: identity, reliable networks, security and clear failure behaviour.
- Links to earlier IoT ideas, but here the focus is coexistence as a computing trend.

🧱 **Worked example: A hospital uses AI image screening with a radiologist reviewing flagged cases. Which coexistence is this, and why is it not pure M2M?**
Man–machine coexistence: the human radiologist stays in the decision loop. It is not pure M2M because a person reviews and takes responsibility.

💡 Think of AI as the “brain skills”, man–machine as teamwork with people, and M2M as teamwork among devices.

🚀 **Beyond the syllabus (2026 update)** *Not required for the exam – read for interest.* In 2026, generative AI (large language and multimodal models) and on-device AI chips are common in phones and PCs; affective computing appears in call-centre and education tools. Edge AI and 5G/early 6G research cut latency for M2M. These are interest updates – the exam tests the syllabus themes above.

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Key Words

Intelligent computing – Adaptive, learning or optimising computer systems.

Emotional computing – Systems that detect or respond to human emotion.

Artificial intelligence – Techniques for tasks that usually need human intelligence.

Machine learning – Improving performance from data rather than only fixed rules.

Man–machine coexistence – People and machines working together usefully.

M2M – Machine-to-machine data exchange and action.

Affective computing – Another name often used for emotion-aware systems.

Autonomy – Ability to operate with limited direct human control.

Human–computer interaction – How people and computers communicate.

Sensor – Device that measures the physical world for intelligent systems.

Actuator – Device that performs an action in the physical world.

Ethics in AI – Fairness, privacy, safety and accountability in AI use.

Sample Q&A

1. What is intelligent computing?

> **Answer:** Computing that adapts, learns or optimises to solve problems.

2. What does emotional computing try to do?

> **Answer:** Detect or respond to human emotion to improve interaction.

3. Define artificial intelligence briefly.

> **Answer:** Techniques that let machines perform tasks needing human-like intelligence.

4. Give one man–machine coexistence example.

> **Answer:** Pilotilot assisting a pilot; or doctor with diagnostic software.

5. What is M2M coexistence?

> **Answer:** Devices exchanging data and acting with little human intervention.

6. Why do ethics matter for AI?

> **Answer:** To protect privacy, fairness, safety and clear responsibility.

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MCQ

1. Intelligent computing systems mainly

A. print paper only
B. use steam only
C. adapt, learn or optimise
D. ban networks
E. ignore all sensors

2. Emotional computing is also called

A. batch payroll only
B. quantum computing only
C. CRT repair
D. punch-card sorting
E. affective computing

3. AI is best described as

A. techniques for tasks that usually need human intelligence
B. only a brand of keyboard
C. only wooden abacuses
D. only radio valves
E. only ink for printers

4. Man–machine coexistence means

A. machines never helping people
B. banning all computers
C. people never using tools
D. people and machines working together usefully
E. removing all sensors

5. M2M stands for

A. math-to-music
B. man-to-museum
C. machine-to-machine
D. map-to-memory
E. mail-to-modem

6. A farm soil sensor sending data to a gateway is mainly

A. vinyl records only
B. M2M / device coexistence
C. chalkboard only
D. handwritten letters only
E. fountain pens only

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7. A doctor using diagnostic software is mainly

A. man–machine coexistence
B. pure brick retail
C. floppy formatting
D. CRT glow
E. M2M only

8. Machine learning improves systems mainly by

A. printing punch cards forever
B. removing all memory
C. learning patterns from data
D. banning electricity
E. melting the CPU

9. Emotional computing uses cues such as

A. only tide tables
B. only stamp collections
C. only lunar phases
D. only steam pressure
E. voice tone, face or text sentiment

10. A key ethics concern for AI is

A. naming folders only
B. privacy, fairness and safety
C. making icons prettier only
D. choosing wallpaper only
E. sorting paperclips only

11. Which term means: “Adaptive, learning or optimising computer systems”?

A. Artificial intelligence
B. Actuator
C. Autonomy
D. M2M
E. Intelligent computing

12. Which term means: “Systems that detect or respond to human emotion”?

A. Human–computer interaction
B. Machine learning
C. Ethics in AI
D. Emotional computing
E. Affective computing

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13. Which term means: “Techniques for tasks that usually need human intelligence”?

A. Sensor
B. Intelligent computing
C. Autonomy
D. Artificial intelligence
E. Man–machine coexistence

14. Which term means: “Improving performance from data rather than only fixed rules”?

A. Machine learning
B. Human–computer interaction
C. Emotional computing
D. M2M
E. Actuator

15. Which term means: “People and machines working together usefully”?

A. Man–machine coexistence
B. Ethics in AI
C. Artificial intelligence
D. Sensor
E. Affective computing

16. Which term means: “Machine-to-machine data exchange and action”?

A. Machine learning
B. Actuator
C. Autonomy
D. Intelligent computing
E. M2M

17. Which term means: “Another name often used for emotion-aware systems”?

A. Ethics in AI
B. Affective computing
C. Man–machine coexistence
D. Emotional computing
E. Human–computer interaction

18. Which term means: “Ability to operate with limited direct human control”?

A. M2M
B. Artificial intelligence
C. Autonomy
D. Sensor
E. Intelligent computing

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19. Which term means: “How people and computers communicate”?

A. Emotional computing
B. Human–computer interaction
C. Actuator
D. Machine learning
E. Affective computing

20. Which term means: “Device that measures the physical world for intelligent systems”?

A. Man–machine coexistence
B. Autonomy
C. Ethics in AI
D. Sensor
E. Artificial intelligence

Structured Questions

1. Describe intelligent computing and emotional computing with one example each. *(2 marks)*

> Definitions; one example each.

2. Explain artificial intelligence and how it relates to intelligent computing. *(2 marks)*

> AI definition; used inside intelligent products.

3. Discuss man–machine coexistence with two real examples. *(3 marks)*

> Idea; two examples; safety/trust note.

4. Explain M2M coexistence and list two requirements for it to work well. *(2 marks)*

> Definition; network/security/identity.

5. Compare man–machine and machine–machine coexistence. *(2 marks)*

> Human in the loop vs devices among themselves.

Summary

- Intelligent computing adapts and optimises.
- Emotional computing responds to human affect.
- AI provides techniques for intelligent behaviour.
- Man–machine: people and machines as partners.
- M2M: devices cooperate with little human help.

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MCQ answer key – 13.1

1. **C** – Adaptive systems.
2. **E** – Affective.
3. **A** – Human-like tasks.
4. **D** – Teamwork.
5. **C** – Machine–machine.
6. **B** – Devices talk.
7. **A** – Human + machine.
8. **C** – From data.
9. **E** – Affect cues.
10. **B** – Responsible AI.
11. **E** – Intelligent computing – Adaptive, learning or optimising computer systems.
12. **D** – Emotional computing – Systems that detect or respond to human emotion.
13. **D** – Artificial intelligence – Techniques for tasks that usually need human intelligence.
14. **A** – Machine learning – Improving performance from data rather than only fixed rules.
15. **A** – Man–machine coexistence – People and machines working together usefully.
16. **E** – M2M – Machine-to-machine data exchange and action.
17. **B** – Affective computing – Another name often used for emotion-aware systems.
18. **C** – Autonomy – Ability to operate with limited direct human control.
19. **B** – Human–computer interaction – How people and computers communicate.
20. **D** – Sensor – Device that measures the physical world for intelligent systems.

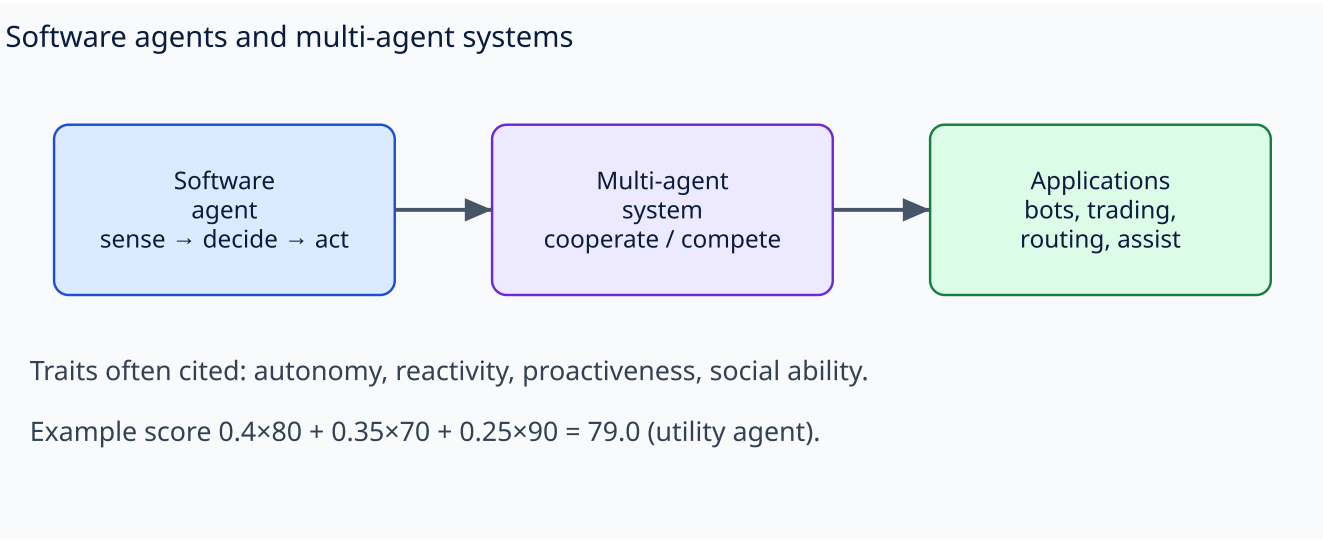
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13.2 Software Agents and Multi-Agent Systems

Syllabus 13.2. A **software agent** is a program that can sense its environment, decide and act with a degree of **autonomy** to meet goals on behalf of a user or system. **Multi-agent systems (MAS)** have several agents that cooperate, coordinate or compete. Applications include personal assistants, recommendation bots, trading agents, network routing helpers and industrial monitoring.

1. Software agents



From a single agent to multi-agent applications

- **Sense** → **decide** → **act** loop, often continuous.
- Common characteristics: **autonomy**, **reactivity** (respond to change), **proactiveness** (pursue goals), **social ability** (communicate).
- May be simple rule-based or use scored utilities / learning.

🧱 **Worked example: Utility agent weights: price 0.40, time 0.35, trust 0.25. Scores 80, 70, 90. Total?**
Score = 0.40×80 + 0.35×70 + 0.25×90 = **79.0**.

🐍 Software-agent utility score

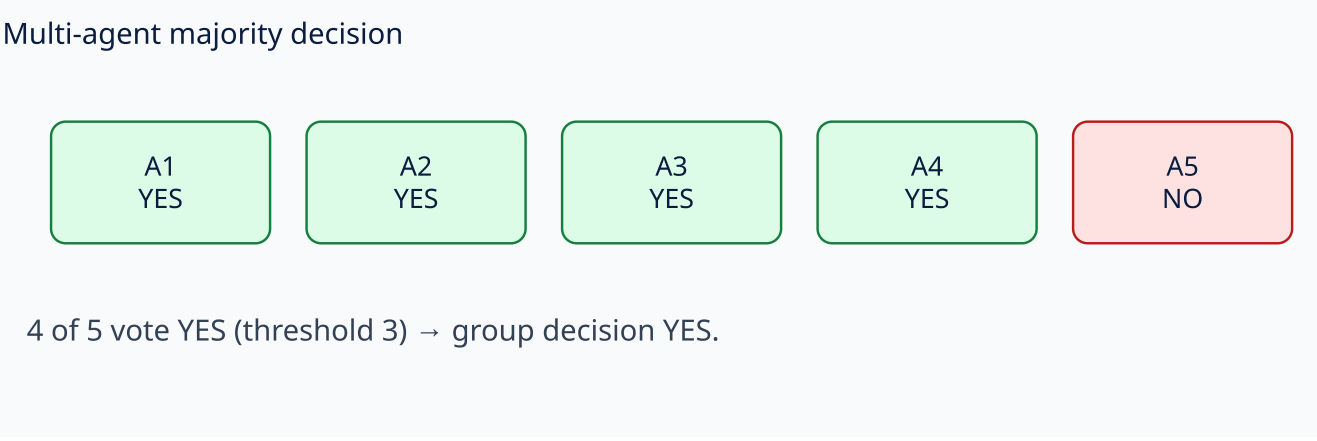
```
w_price, w_time, w_trust = 0.4, 0.35, 0.25
s_price, s_time, s_trust = 80, 70, 90
score = round(w_price*s_price + w_time*s_time + w_trust*s_trust, 1)
print("Agent score:", score)
```

▶ Output

```
Agent score: 79.0
```

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2. Multi-agent systems



Majority vote among five agents

- Several agents share an environment; each has local goals or roles.
- They **cooperate** (team), **coordinate** (plans/messages) or **compete** (markets).
- Need protocols for messages, negotiation and conflict handling.

> 🧮 **Worked example: 5 agents, threshold 3, YES votes = 4. Decision?**
> $4 \geq 3$ → decision **YES**.

🐍 Multi-agent majority vote

```
votes_yes, agents, thresh = 4, 5, 3
decision = "YES" if votes_yes >= thresh else "NO"
print("Votes YES:", votes_yes, "/", agents)
print("Decision:", decision)
```

▶ Output

```
Votes YES: 4 / 5
Decision: YES
```

3. Applications of agent systems

- Personal / chat assistants that schedule and remind.
- E-commerce shopping / price-watch agents.
- Network management and routing helpers.
- Industrial monitoring and alerting agents.
- Simulation and games with many NPC agents.

> 💡 An agent is not “any program” – look for autonomy and a sense–decide–act loop on someone’s behalf.

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🚀 **Beyond the syllabus (2026 update)** *Not required for the exam – read for interest.* In 2026, LLM-powered agents can call tools (search, calendar, code) in loops; multi-agent frameworks assign planner, critic and worker roles. Blockchain oracles and trading bots are other agent-like systems in the news. Interest only – exam focuses on agent characteristics, MAS and classic applications.

Key Words

Software agent – Autonomous program that senses, decides and acts for goals.	**Autonomy** – Operating with limited direct control.
Reactivity – Responding to changes in the environment.	**Proactiveness** – Taking initiative to pursue goals.
Social ability – Communicating with other agents or users.	**Multi-agent system** – System made of multiple interacting agents.
Cooperation – Agents working toward shared goals.	**Coordination** – Organising actions and messages among agents.
Negotiation – Agents bargaining to reach agreement.	**Utility score** – Weighted sum used to choose among options.
Personal assistant agent – Helps a user with tasks such as scheduling.	**Trading agent** – Buys/sells or watches prices under rules.

Sample Q&A

1. Define a software agent.

> **Answer:** Autonomous program that senses, decides and acts for goals.

2. Name four typical agent characteristics.

> **Answer:** Autonomy, reactivity, proactiveness, social ability.

3. What is a multi-agent system?

> **Answer:** Several interacting agents in a shared environment.

4. How can agents interact in an MAS?

> **Answer:** Cooperate, coordinate or compete.

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5. Give three applications of agent systems.

> **Answer:** Assistants; e-commerce/price agents; network or industrial monitoring.

6. Compute the sample utility score 0.40×80 + 0.35×70 + 0.25×90.

> **Answer:** 79.0.

MCQ

1. A software agent mainly

A. senses, decides and acts with autonomy
B. only prints banners
C. only powers a CRT
D. only stores paper files
E. only melts solder

2. Autonomy means the agent

A. has no goals
B. works with limited direct control
C. cannot read input
D. needs a human click every CPU cycle
E. never runs

3. Reactivity means

A. responding to environment changes
B. painting the case
C. deleting the disk
D. banning networks
E. ignoring all sensors

4. A multi-agent system contains

A. exactly one frozen variable
B. only a single LED
C. several interacting agents
D. only a vinyl disk
E. only a paper form

5. Agents that share a team goal mainly

A. never message
B. cooperate
C. only sleep
D. always crash
E. only print

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6. Utility score 0.40×80 + 0.35×70 + 0.25×90 equals

A. 0.0
B. 100.0
C. 50.0
D. 79.0
E. 10.0

7. With 4 YES votes out of 5 and threshold 3 the decision is

A. YES
B. WAIT
C. NO
D. TIE
E. ABORT

8. A price-watch shopping bot is an example of

A. a fountain pen
B. a steam engine
C. a CRT yoke
D. a punch card press
E. an agent application

9. Social ability refers to

A. communicating with users or other agents
B. formatting floppies
C. ignoring messages
D. melting RAM
E. tuning pianos

10. Proactiveness means

A. only reacting once then quitting forever
B. taking initiative toward goals
C. never planning
D. removing sensors
E. banning goals

11. Which term means: “Autonomous program that senses, decides and acts for goals”?

A. Coordination
B. Reactivity
C. Personal assistant agent
D. Software agent
E. Multi-agent system

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12. Which term means: “Operating with limited direct control”?

A. Proactiveness
B. Negotiation
C. Cooperation
D. Trading agent
E. Autonomy

13. Which term means: “Responding to changes in the environment”?

A. Coordination
B. Social ability
C. Software agent
D. Utility score
E. Reactivity

14. Which term means: “Taking initiative to pursue goals”?

A. Multi-agent system
B. Proactiveness
C. Negotiation
D. Autonomy
E. Personal assistant agent

15. Which term means: “Communicating with other agents or users”?

A. Utility score
B. Cooperation
C. Trading agent
D. Social ability
E. Reactivity

16. Which term means: “System made of multiple interacting agents”?

A. Proactiveness
B. Personal assistant agent
C. Multi-agent system
D. Software agent
E. Coordination

17. Which term means: “Agents working toward shared goals”?

A. Negotiation
B. Trading agent
C. Autonomy
D. Cooperation
E. Social ability

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18. Which term means: “Organising actions and messages among agents”?

A. Reactivity
B. Utility score
C. Coordination
D. Multi-agent system
E. Software agent

19. Which term means: “Agents bargaining to reach agreement”?

A. Cooperation
B. Autonomy
C. Negotiation
D. Personal assistant agent
E. Proactiveness

20. Which term means: “Weighted sum used to choose among options”?

A. Reactivity
B. Trading agent
C. Coordination
D. Social ability
E. Utility score

Structured Questions

1. Define a software agent and list four characteristics. *(2 marks)*

> Definition; autonomy, reactivity, proactiveness, social ability.

2. Explain multi-agent systems and how agents may interact. *(2 marks)*

> Definition; cooperate / coordinate / compete.

3. Describe three applications of agent systems. *(2 marks)*

> Three clear application areas.

4. Calculate the utility score for weights 0.40, 0.35, 0.25 and scores 80, 70, 90. *(2 marks)*

> 79.0 with working.

5. Using votes YES=4, agents=5, threshold=3, state the group decision and why. *(2 marks)*

> YES because 4≥3.

Summary

- Agents sense, decide and act with autonomy.

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- Traits: autonomy, reactivity, proactiveness, social ability.
- MAS: many agents cooperate, coordinate or compete.
- Applications: assistants, commerce, networks, industry.
- Utility scores and votes are simple decision methods.

MCQ answer key – 13.2

1. **A** – Sense–decide–act.
2. **B** – Limited direct control.
3. **A** – Respond.
4. **C** – Many agents.
5. **B** – Cooperation.
6. **D** – Weighted sum.
7. **A** – 4≥3 → YES.
8. **E** – E-commerce agent.
9. **A** – Communication.
10. **B** – Initiative.
11. **D** – Software agent – Autonomous program that senses, decides and acts for goals.
12. **E** – Autonomy – Operating with limited direct control.
13. **E** – Reactivity – Responding to changes in the environment.
14. **B** – Proactiveness – Taking initiative to pursue goals.
15. **D** – Social ability – Communicating with other agents or users.
16. **C** – Multi-agent system – System made of multiple interacting agents.
17. **D** – Cooperation – Agents working toward shared goals.
18. **C** – Coordination – Organising actions and messages among agents.
19. **C** – Negotiation – Agents bargaining to reach agreement.
20. **E** – Utility score – Weighted sum used to choose among options.

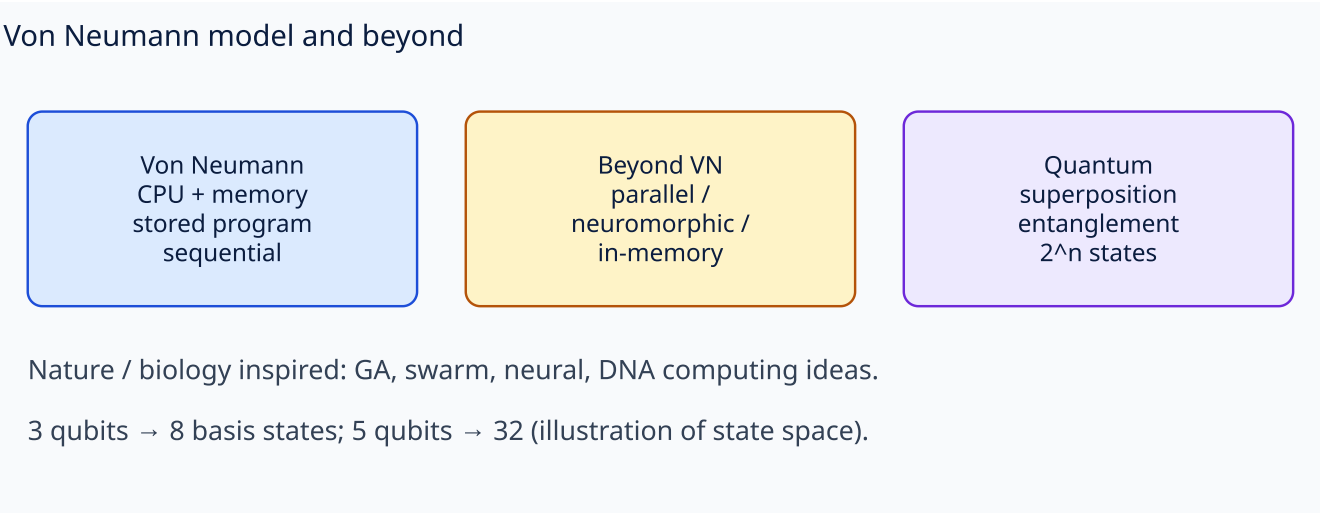
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13.3 Beyond von Neumann and New Computing Models

Syllabus 13.3. Classical computers follow the **von Neumann** model: a CPU, memory and a stored program, mostly sequential. **Beyond von Neumann** looks at parallel, neuromorphic and in-memory ideas. **Nature-inspired** and **biology-inspired computing** borrow from evolution, swarms and living systems. **Quantum computing** uses quantum bits with superposition (and entanglement in real designs); n qubits span 2^n basis states. Students should know fundamentals and example **applications**, and can discuss wider 2026 directions in Beyond boxes only.

1. Beyond the von Neumann computer

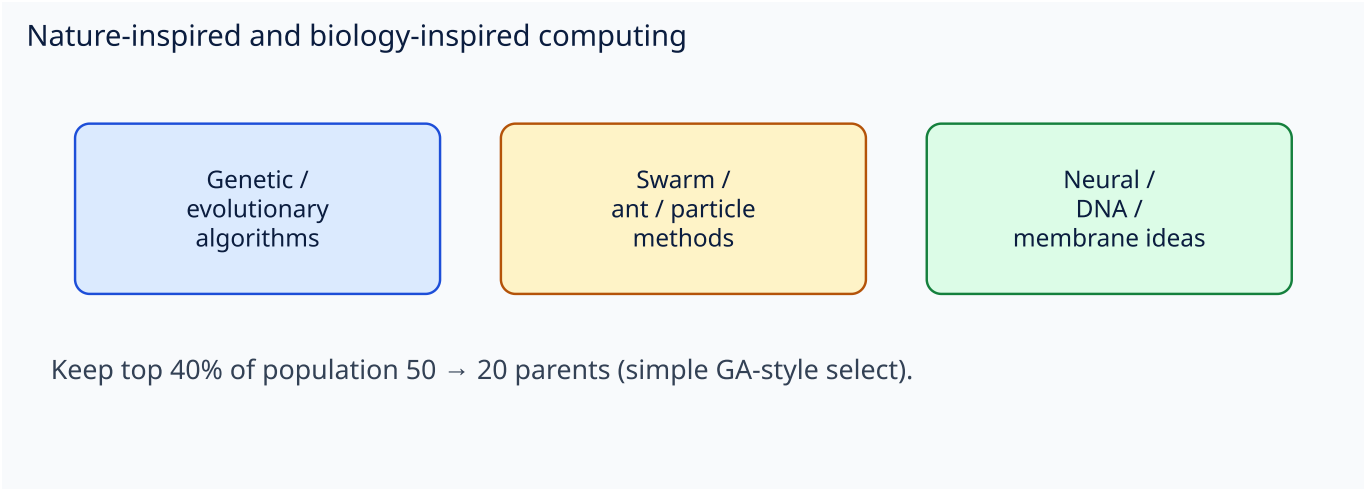


Von Neumann, beyond-VN ideas and quantum state space

- **Von Neumann model** – shared memory, CPU fetches instructions and data; classic bottleneck between CPU and memory.
- **Beyond VN** – more parallelism, specialised accelerators, neuromorphic chips, processing-in-memory, dataflow designs.
- Motivation: speed, energy and problems poorly matched to pure sequential code.

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2. Nature-inspired and biology-inspired computing



Genetic, swarm and neural / DNA-style ideas

- **Nature-inspired** – genetic/evolutionary algorithms, simulated annealing, swarm and ant-colony style search.
- **Biology-inspired** – artificial neural networks, DNA computing concepts, membrane computing ideas.
- Used for optimisation, learning and hard search problems.

> 🧱 **Worked example: Population 50, keep top 40%. How many parents kept?**
> Kept = 50 × 0.4 = **20**.

3. Fundamentals of quantum computing

- **Qubit** – quantum bit that can be in a superposition of |0⟩ and |1⟩.
- n qubits describe a state in a space of 2^n basis states (illustration of capacity).
- **Entanglement** (in real quantum designs) links qubits so they are described together.
- Not a faster laptop for every task – useful for selected algorithms (search, simulation, crypto research).

> 🧱 **Worked example: How many basis states for 3 qubits? For 5 qubits?**
> 2^3 = **8**; 2^5 = **32**.

🐍 Qubit state space size

```
n = 3
states = 2 ** n
print(n, "qubits ->", states, "basis states")
n5 = 5
print(n5, "qubits ->", 2 ** n5, "basis states")
```

▶ Output

```
3 qubits -> 8 basis states
5 qubits -> 32 basis states
```

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4. Applications and outlook

- Quantum research: chemistry simulation, optimisation trials, cryptography impact studies.
- Nature/bio methods: scheduling, routing, pattern learning.
- Beyond-VN chips: AI accelerators in phones and data centres.

🧱 **Worked example: Green ICT example: cut annual use from 12000 kWh to 7800 kWh. Saving and percent?**
Saved = **4200 kWh**; percent = **35.0%**.

🐍 Green ICT energy saving

```
old_kwh, new_kwh = 12000, 7800
saved = old_kwh - new_kwh
pct = round(saved / old_kwh * 100, 1)
print("Saved kWh:", saved)
print("Percent:", pct)
```

▶ Output

```
Saved kWh: 4200
Percent: 35.0
```

💡 2^n grows fast: that is why “a few qubits” can represent a large state space – but building stable qubits is hard.

🚀 **Beyond the syllabus (2026 update)** *Not required for the exam – read for interest.* In 2026: NISQ quantum processors exist but are noisy; GenAI and AR/VR are mainstream; blockchain underpins some ledgers; edge/cloud split work for latency; 5G is widespread and 6G is in research; green ICT tracks data-centre PUE and device energy. Exam questions stay on von Neumann limits, nature/bio inspiration, quantum basics and applications named in the syllabus.

Key Words

Von Neumann architecture – CPU, memory and stored-program sequential model.

Beyond von Neumann – Parallel, neuromorphic, in-memory and related models.

Nature-inspired computing – Algorithms inspired by natural processes such as evolution or swarms.

Biology-inspired computing – Ideas from neural systems, DNA or cells.

Genetic algorithm – Evolutionary search using selection and variation.

Quantum computing – Computing with qubits using quantum effects.

Qubit – Quantum bit with superposition of basis states.

Superposition – Being in a combination of basis states until measured.

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Entanglement – Quantum correlation between qubits.

Neuromorphic – Hardware inspired by neural brain structures.

Parallelism – Doing many operations at once.

Green ICT – Using ICT with lower energy and environmental cost.

Sample Q&A

1. What is the von Neumann model?

> **Answer:** CPU + memory + stored program, typically sequential.

2. Give two beyond-von-Neumann ideas.

> **Answer:** Parallelism / accelerators; neuromorphic or in-memory processing.

3. What is nature-inspired computing?

> **Answer:** Algorithms inspired by nature (evolution, swarms, …).

4. How many basis states do 3 qubits span?

> **Answer:** 8 (2^3).

5. Name one quantum computing application area.

> **Answer:** Chemistry simulation, optimisation trials or crypto research.

6. Population 50 keep 40% → how many?

> **Answer:** 20.

MCQ

1. The von Neumann model mainly uses

A. only abacuses
B. CPU, memory and a stored program
C. only steam looms
D. only vinyl disks
E. only paper ledgers

2. A classic von Neumann concern is

A. lack of chairs
B. too many paperclips
C. the CPU–memory bottleneck
D. ink colour only
E. window size only

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3. Nature-inspired computing includes

A. only handwriting drills
B. only stamp collecting
C. only chalk dust
D. genetic or swarm-style algorithms
E. only candle making

4. Biology-inspired computing includes

A. only knitting patterns
B. neural or DNA-computing ideas
C. only weather vanes
D. only sundials
E. only pottery wheels

5. A qubit differs from a classical bit because it can be in

A. only ink states
B. only steam states
C. only paper states
D. only wooden states
E. a superposition of basis states

6. 3 qubits span

A. 3 states
B. 1 state
C. 6 states
D. 9 states
E. 8 basis states

7. 5 qubits span

A. 32 basis states
B. 64 states
C. 5 states
D. 10 states
E. 16 states

8. Keeping top 40% of population 50 leaves

A. 10
B. 5
C. 20 parents
D. 50
E. 40

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9. Green ICT saving from 12000 to 7800 kWh is

A. 4200 kWh
B. 12000 kWh
C. 100 kWh
D. 1000 kWh
E. 7800 kWh

10. Neuromorphic hardware is inspired by

A. only pencil erasers
B. neural brain structures
C. only bicycle chains
D. only oven timers
E. only door hinges

11. Which term means: “CPU, memory and stored-program sequential model”?

A. Von Neumann architecture
B. Parallelism
C. Quantum computing
D. Nature-inspired computing
E. Superposition

12. Which term means: “Parallel, neuromorphic, in-memory and related models”?

A. Biology-inspired computing
B. Entanglement
C. Qubit
D. Green ICT
E. Beyond von Neumann

13. Which term means: “Algorithms inspired by natural processes such as evolution or swarms”?

A. Genetic algorithm
B. Superposition
C. Neuromorphic
D. Nature-inspired computing
E. Von Neumann architecture

14. Which term means: “Ideas from neural systems, DNA or cells”?

A. Quantum computing
B. Entanglement
C. Parallelism
D. Biology-inspired computing
E. Beyond von Neumann

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15. Which term means: “Evolutionary search using selection and variation”?

A. Neuromorphic
B. Qubit
C. Genetic algorithm
D. Nature-inspired computing
E. Green ICT

16. Which term means: “Computing with qubits using quantum effects”?

A. Quantum computing
B. Superposition
C. Parallelism
D. Biology-inspired computing
E. Von Neumann architecture

17. Which term means: “Quantum bit with superposition of basis states”?

A. Genetic algorithm
B. Beyond von Neumann
C. Qubit
D. Green ICT
E. Entanglement

18. Which term means: “Being in a combination of basis states until measured”?

A. Von Neumann architecture
B. Neuromorphic
C. Quantum computing
D. Superposition
E. Nature-inspired computing

19. Which term means: “Quantum correlation between qubits”?

A. Parallelism
B. Entanglement
C. Biology-inspired computing
D. Qubit
E. Beyond von Neumann

20. Which term means: “Hardware inspired by neural brain structures”?

A. Genetic algorithm
B. Nature-inspired computing
C. Green ICT
D. Superposition
E. Neuromorphic

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Structured Questions

1. Explain the von Neumann model and why designers look beyond it. *(3 marks)*

> CPU/memory/stored program; bottleneck; parallel/neuromorphic/in-memory.

2. Describe nature-inspired and biology-inspired computing with examples. *(3 marks)*

> GA/swarm; neural/DNA; uses.

3. State quantum computing fundamentals: qubit, superposition, 2^n states. *(3 marks)*

> Definitions; 2^n; not universal speedup.

4. Calculate basis states for 3 and 5 qubits; parents kept from 50 at 40%. *(3 marks)*

> 8; 32; 20.

5. Outline applications of new computing models and one green-ICT idea. *(2 marks)*

> Quantum/nature apps; energy saving example.

Summary

- Von Neumann: CPU, memory, stored program.
- Beyond VN: parallel, neuromorphic, in-memory.
- Nature/bio inspired: GA, swarm, neural, DNA ideas.
- Qubits: superposition; n qubits → 2^n states.
- Applications in simulation, optimisation and learning.

MCQ answer key – 13.3

1. **B** – Stored program.
2. **C** – CPU–memory.
3. **D** – Evolution / swarm.
4. **B** – Neural / DNA.
5. **E** – Superposition.
6. **E** – 2^3=8.
7. **A** – 2^5=32.
8. **C** – 50×0.4.
9. **A** – 12000−7800.
10. **B** – Brain-inspired.
11. **A** – Von Neumann architecture – CPU, memory and stored-program sequential model.
12. **E** – Beyond von Neumann – Parallel, neuromorphic, in-memory and related models.
13. **D** – Nature-inspired computing – Algorithms inspired by natural processes such as evolution or swarms.
14. **D** – Biology-inspired computing – Ideas from neural systems, DNA or cells.

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15. **C** – Genetic algorithm – Evolutionary search using selection and variation.
16. **A** – Quantum computing – Computing with qubits using quantum effects.
17. **C** – Qubit – Quantum bit with superposition of basis states.
18. **D** – Superposition – Being in a combination of basis states until measured.
19. **B** – Entanglement – Quantum correlation between qubits.
20. **E** – Neuromorphic – Hardware inspired by neural brain structures.

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