NOTE: this is the SOLUTION to Quiz 9.

The correct answers are indicated for each question, with explanations as needed.

Dr. Manikas

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1 4 / 4 points

We have a dual-core processor that allows **out-of-order execution:**

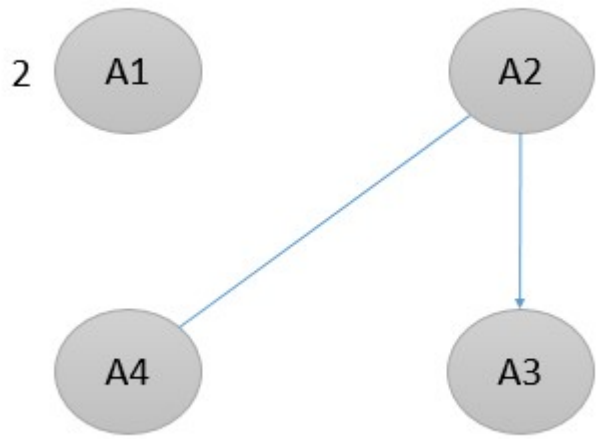
- Operations do not have to be executed in order (e.g. A1, A2, A3, A4), and can be done in *parallel*, as long as dependencies are observed
- Each core has a separate functional unit
- Only one thread can be run on a core at a time

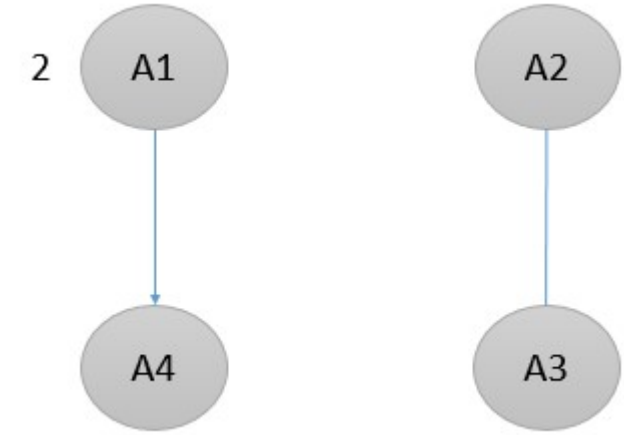
We have a thread running in one of the cores: the thread's operations are specified below:

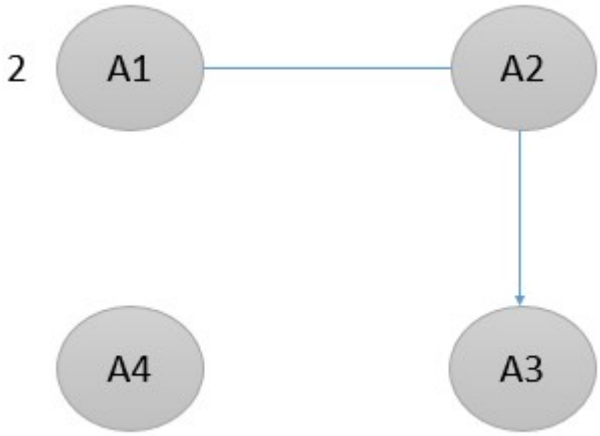
- A1 – takes 2 cycles to execute
- A2 – conflicts for a functional unit with A3
- A3 – conflicts for a functional unit with A2
- A4 – depends on the result of A1

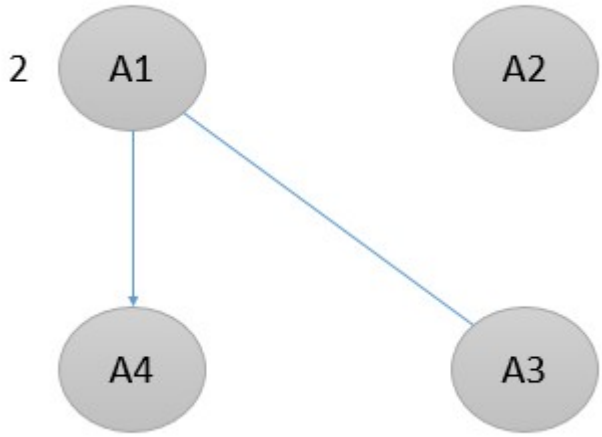
Based on the thread's operations, select the correct **dependency graph** for this thread:

2









2 4 / 4 points

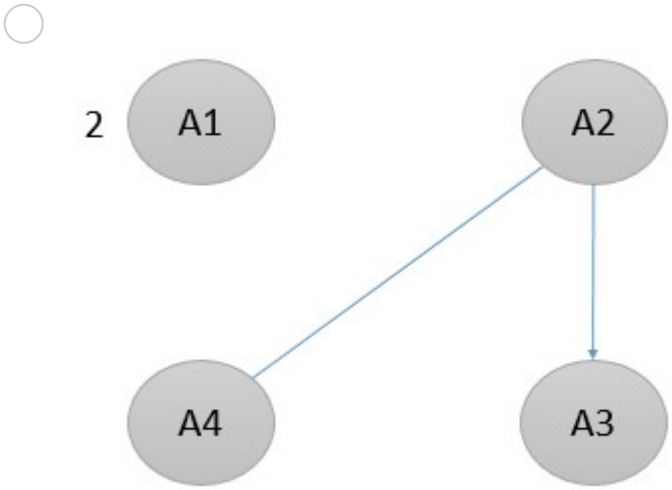
We have a dual-core processor that allows **out-of-order execution:**

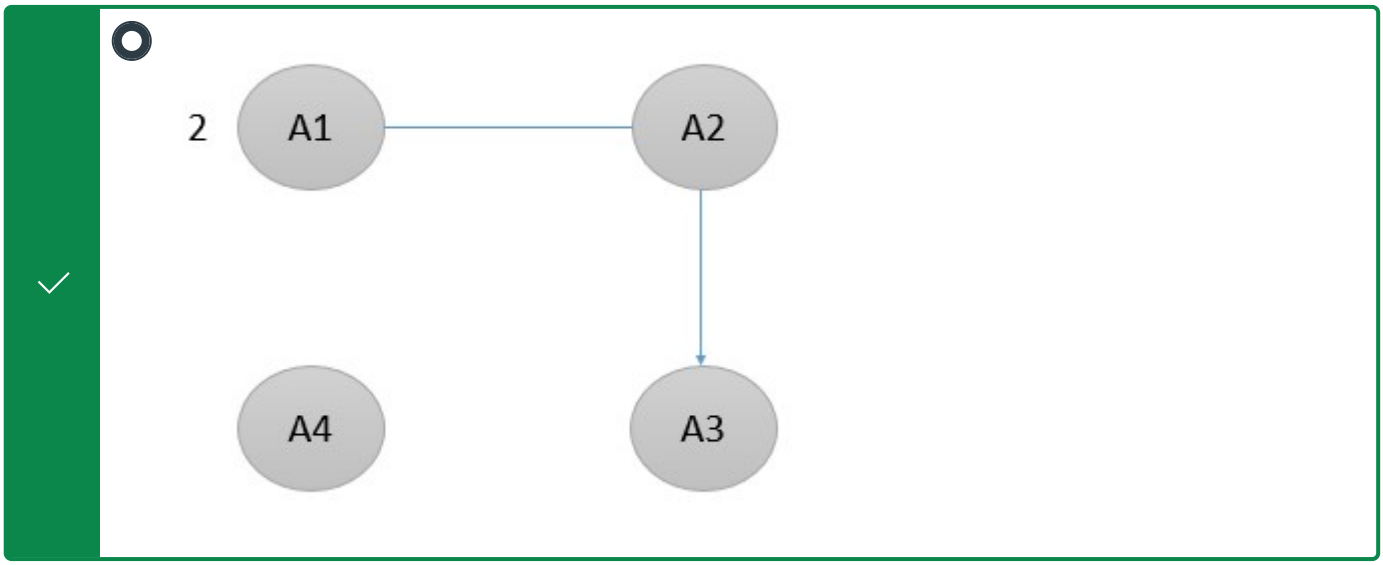
- Operations do not have to be executed in order (e.g. A1, A2, A3, A4), and can be done in *parallel*, as long as dependencies are observed
- Each core has a separate functional unit
- Only one thread can be run on a core at a time

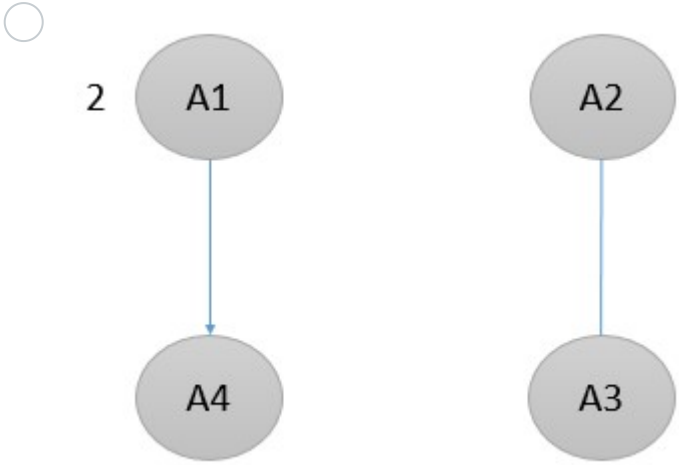
We have a thread running in one of the cores: the thread's operations are specified below:

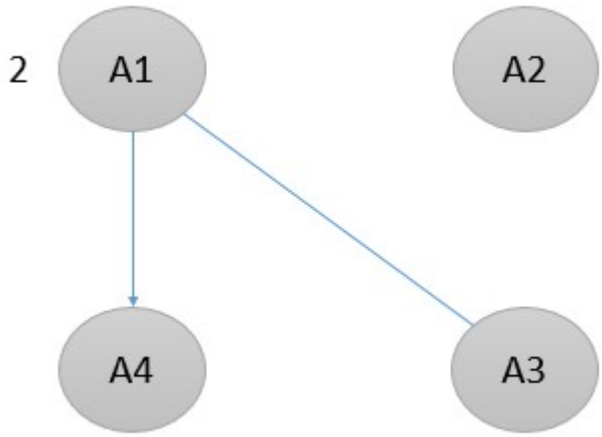
- A1 – takes 2 cycles to execute; conflicts for a functional unit with A2
- A2 – conflicts for a functional unit with A1
- A3 – depends on the result of A2
- A4 – no conflicts or dependencies

Based on the thread's operations, select the correct **dependency graph** for this thread:









3 4 / 4 points

We have a matrix multiplication program running on a single-core system. To speed up program execution, we want to run this program on a multi-core system. Given the parameters below, what is the **execution time** for this program on the multi-core system?

- Matrix multiplication on single-core system = 20 seconds
- Thread start time for each core on multi-core system = 200 ms
- Number of cores in multi-core system = 2

✓ 10.4 s

Feedback

General Feedback

Execution time = (#cores)(thread start time) + (matrix multiplication time)/(#cores)

For our system,

$$Execution\ Time = (2)\left(200 \times 10^{-3}\ \text{sec}\right) + \left(\frac{20\ \text{sec}}{2}\right) = 10.4\ \text{sec}$$

4 4 / 4 points

We have a quad-core shared-memory processor, where each core has its own cache. The system uses the MESI protocol to ensure cache coherence.
If a cache line has the following condition(s) , what is the MESI protocol state for this cache line?

Cache line data is not valid

✓ I

M

E

S

Feedback

General Feedback

- **(M) Modified** - cache line has been modified, is different from main memory
- **(E) Exclusive** - cache line is the same as main memory and is the only cached copy
- **(S) Shared** - Same as main memory but copies may exist in other caches.
- **(I) Invalid** - Line data is not valid

5 4 / 4 points

We have a quad-core shared-memory processor, where each core has its own cache. The system uses the MESI protocol to ensure cache coherence.
If a cache line has the following condition(s) , what is the MESI protocol state for this cache line?

Cache line is the same as main memory but copies may exist in other caches

E

I

M

✓ S

Feedback

General Feedback

- **(M) Modified** - cache line has been modified, is different from main memory
- **(E) Exclusive** - cache line is the same as main memory and is the only cached copy
- **(S) Shared** - Same as main memory but copies may exist in other caches.
- **(I) Invalid** - Line data is not valid (as in simple cache)