

2.1 Networks: latency, throughput and layered delivery

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS throughput • latency

Objective

Networks: latency, throughput and layered delivery. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

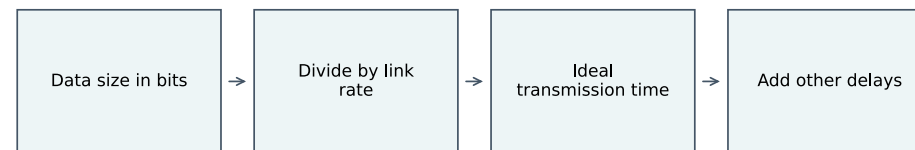
1 Key knowledge and worked examples

■ What would explain this observation?

- A small message can arrive late on a high-bandwidth link. Capacity and delay measure different properties.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ Build the model

- Packets carry addressed data through a network. A layered model separates responsibilities such as application meaning, transport delivery and network routing. Bandwidth describes capacity; **throughput** is the achieved data rate; **latency** is delay.
- throughput: Achieved rate of useful data transfer; latency: Delay experienced in communication.



■ Choose evidence that can test it

- Transmission time depends on data size and rate. Total delay may also include propagation, processing and queueing. Encryption protects content under its assumptions but does not remove congestion or every metadata exposure.
- Trace a message route using a documented local model. Record payload size, units and measured time. Use school-approved networks and synthetic messages; do not scan or intercept another user traffic.

■ Work from known quantities

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: an 8 megabit file crosses a 2 megabit/s link. Ideal transmission time = $\text{size/rate} = 8/2 = 4$ s. Protocol overhead, other users and latency can make observed completion slower.

Example:

A 12 megabit file crosses a 3 megabit/s link. Calculate ideal transmission time. Use the same sequence: known quantities → model → relation → substitution → unit and interpretation.

■ Check the conclusion and its limits

- A megabyte is eight megabits before considering overhead. A faster rated link does not guarantee low latency or secure endpoints.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

A high-bandwidth connection guarantees zero latency. This claim is false: A megabyte is eight megabits before considering overhead. A faster rated link does not guarantee low latency or secure endpoints.

Key:

Networks: latency, throughput and layered delivery: Transmission time depends on data size and rate. Total delay may also include propagation, processing and queueing. Encryption protects content under its assumptions but does not remove congestion or every metadata exposure.

■ Runnable trace and boundary

```
size_Mb, rate_Mbps, propagation_s = 12, 3, 0.10
for rate in [rate_Mbps, 2 * rate_Mbps]:
    transmission_s = size_Mb / rate
    print(round(transmission_s + propagation_s, 2))
```

Expected output:

```
4.1
2.1
```

Measure from transmission start to last-bit arrival. Serial transmission time and propagation delay add under this ideal model. Increasing bandwidth changes only the first term; store-and-forward hops and queueing would add further terms.

2 Practice

2.1 Why can completion exceed file-size divided by link rate? Choose one answer.

- **A** Overhead, queueing and other delays
- **B** Bits have no size
- **C** All networks transmit instantly

[1]

2.2 A 12 megabit file crosses a 3 megabit/s link. Calculate ideal transmission time. Show the relation, substitution and units.

[2]

2.3 Decide whether this claim is true and justify: A high-bandwidth connection guarantees zero latency.

[2]

2.4 Achieved rate of useful data transfer: write the technical term.

[1]

3 Exam-style questions

3.1 A 12 Mb file crosses a 3 Mb/s link with 0.10 s propagation delay. Give ideal time until the last bit arrives. Can doubling bandwidth remove all delay?

[4]

Solutions

2.1 A Transmission time depends on data size and rate. Total delay may also include propagation, processing and queueing. Encryption protects content under its assumptions but does not remove congestion or every metadata exposure.

2.2 $\text{transmission time} = \text{size} / \text{rate} = 12 / 3 = 4\text{s}$.

2.3 False. A megabyte is eight megabits before considering overhead. A faster rated link does not guarantee low latency or secure endpoints.

2.4 throughput. throughput means Achieved rate of useful data transfer.

3.1 $\text{Time} = 12 / 3 + 0.10 = 4.10\text{ s}$, omitting other delays. Doubling bandwidth gives 2.10 s; propagation remains. Protocol and queueing may add delay.