COMP90007 Internet Technologies

THE UNIVERSITY OF MELBOURNE · COMPUTER SCIENCE · GRADUATE COURSEWORK

Full guide + ask Sia about COMP90007

SIDE 1/2 DEFINITIONS · FORMULAS · DECISION RULES · COMPARISONS **EXAM REVISION SHEET** S2 2026 · what the final rewards

0 · Exam Map

COURSE.JSON · BRIEF

HW | P1 15 | P2 15 | WRITTEN EXAMINATION 60%

ASSESSMENT	WEIGHT
Two equally-weighted homework assignments	10%
Networking Project 1	15%
Networking Project 2	15%
Written examination	60%

Permitted materials: not confirmed for this offering in the course materials we hold — check the exam instructions on the LMS.

Assessment and materials framing: course.json and BRIEF.md.

1 · Trace the Stack

C1 P1–3

Application request
Transport exchange
Network packet
Link frame
Physical signal

Encapsulation adds control information down the stack.

Client initiates a service request; a ***server*** accepts it and constructs a reply. A ***packet*** is a formatted message carrying layer-appropriate control information and payload. Name the object at the layer before explaining its path.

TRACE SENTENCE

```
application message → transport exchange → network packet → link frame → physical signal; reverse on receipt.
```

At every hop ask what remains end-to-end and what is replaced locally. A changed first-hop technology does not change the application into a link-layer protocol.

PACKET-TRACE LEDGER

BOUNDARY	RECORD
Application ↔ transport	Requested capability, local interface action, application message.
Transport ↔ network	Endpoint exchange, packet handed down, network-layer delivery identity.
Network ↔ link	Next hop, link frame, fields replaced on the current link.
Link ↔ physical	Frame bits represented as signal states on the medium.

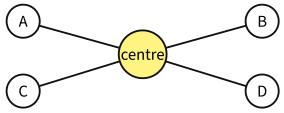
Trace request and reply separately. **Client/server roles belong to the exchange**, not permanently to a machine type. An IP address identifies a network interface for network-layer delivery; the application request remains conceptually distinct from that identifier.

SELF-CHECK → *Label every arrow: upward capability, adjacent-layer access, peer coordination or physical/link movement. If one arrow silently does two jobs, split it.*

2 · Scope ≠ Topology

C1 P1–2

QUESTION	CLASSIFICATION	RULE
Who can receive?	Broadcast	One shared channel; every attached station can receive, addressed recipient processes.
	Point-to-point	Individual pairwise links; traffic is not automatically presented to all machines.
	Multicast	Delivery selects a subset.
How arranged?	Mesh / bus / star / ring	Physical relationship only; does not determine access or forwarding protocol.



A star's centre may repeat or switch traffic.

CHECK → *A bus creates a shared-medium coordination problem; a star identifies central attachment.* State arrangement and behavioural rule separately.

3 · Three Relations

C1 P3

TERM	ASK	WHERE
Service	What capability is made available upward?	Layer to layer above
Interface	How is that service invoked?	Adjacent layers on one machine
Protocol	How do corresponding entities coordinate?	Peers across communication

★ If two things are on the **same machine**, test for an interface. If they are corresponding entities across communication, test for a protocol. Service is the capability, not the message exchange that implements it.

Reference models: OSI supplies a seven-layer reference vocabulary; TCP/IP is tied to a deployed protocol suite; the subject's hybrid view keeps physical and data-link functions distinct while following the Internet stack. Compare by mapping functions, not forcing identical layer counts.

FAULT LOCALISATION

```
wrong name resolution → application; missing route → network; damaged frame → link; noisy signal → physical.
```

REFERENCE-MODEL COMPARISON

MODEL	USE IT TO EXPLAIN	AVOID
OSI	Principled seven-layer vocabulary and visible service boundaries.	Treating layer count as proof of deployed behaviour.

ANSWER ORDER

4 · Two Link Clocks

C2 P1



Serialisation and signal travel are separate clocks.

TRANSMISSION DELAY

$t_{tx} = L / R$

L in bits; R in bit/s → seconds.

PROPAGATION DELAY

$t_{prop} = d / s$

distance and signal speed in matching units → seconds.

STATED ONE-WAY LINK LATENCY

$t = t_{tx} + t_{prop}$

Add processing or queueing only when inputs are supplied.

CHANGE	T_{tx}	T_{prop}
L increases	increases	unchanged
R increases	decreases	unchanged
d increases	unchanged	increases
s increases	unchanged	decreases

Bandwidth is a rate; delay is a time. Faster transmission cannot remove travel time over a long path. Audit every unit before interpreting.

DIMENSION LEDGER

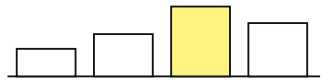
INPUT	WRITE BEFORE SUBSTITUTION	CHECK
Frame length L	bits	Convert bytes if the prompt supplies them; do not mix.
Rate R	bit/s	Keep the stated decimal prefix consistent.
Path d	km or m	Must match the distance unit in s.
Signal speed s	km/s or m/s	d/s must finish in seconds.
Final terms	one time unit	Only then add.

Sensitivity: changing frame size affects serialisation; changing path length affects travel; changing rate cannot alter geography. If a question gives processing or queueing, keep those as separate time terms rather than hiding them inside either link clock.

SANITY CHECK → *Predict which term moves before calculating. A result far outside the estimate triggers a unit and assumption audit.*

5 · Media Choice

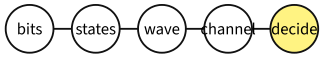
C2 P2



Conceptual reach/impairment comparison; not a scale.

6 · Signal → Capacity

C2 P3–4



Bits become signal states for the receiver to decide.

A scheme with V levels carries **$\log_2 V$ bits per symbol**. More levels encode more per symbol but place states closer together, demanding cleaner reception.

Symbol rate and bit rate differ whenever one symbol carries more than one bit.

NYQUIST · NOISELESS SIGNALLING

$C^N = 2B \log_2 V$ bit/s

Needs bandwidth B and distinguishable levels V.

SHANNON · NOISY CHANNEL

$C^S = B \log_2(1 + S/N)$ bit/s

Needs bandwidth B and linear signal-to-noise ratio S/N.

DECISION RULE

If both channel descriptions apply: $C \le \min(C^N, C^S)$. Convert to the same unit; select the smaller. Never add or average upper bounds.

These are ceilings, not guaranteed throughput. State the binding assumption and distinguish the selected signalling levels from the receiver's noise-limited ability to tell them apart.

CAPACITY ANSWER SCAFFOLD

1. Identify B and its unit. Decide whether the premise gives V, S/N or both.
2. Convert levels to bits per symbol with $\log_2 V$.
3. Evaluate each applicable ceiling in bit/s.
4. If both apply, compare in the same unit and select the lower.
5. Conclude with the *binding assumption*; do not report the bound as achieved throughput.

EVIDENCE	USE	REASON
Noiseless + B + V	Nyquist	Limits symbol changes and information per symbol.
Noisy + B + S/N	Shannon	Limits reliable distinction at the receiver.
Both descriptions	Both, then minimum	Neither independent upper bound may be exceeded.

Do not conflate: bandwidth may denote the rate in the link-delay model, while B in the capacity equations is the stated channel bandwidth. Follow the notation and units of the question rather than swapping terms casually.

7 · Direction & Sharing

C2 P5

CONCEPT	RULE
Simplex	One fixed direction.
Half-duplex	Both directions, not simultaneously.
Full-duplex	Both directions simultaneously, with separated paths/resources.

8 · Frame Boundaries

C3 P1

SCHEME	SENDER	FAILURE / RECEIVER
Character count	Length in header	Corrupted count can lose alignment across later frames.
Flag bytes	Reserve flag; escape a matching payload byte	Receiver recognises boundaries and reverses byte stuffing.
Bit flags	Reserve pattern; insert a zero where required	Receiver removes inserted bits without deleting genuine data.

Framing solves boundary ambiguity. It does not itself prove that payload bits are correct or that delivery recovered from loss.

9 · Error Guarantees

C3 P2–3

METHOD	OPERATION	WHAT TO SAY
Parity	Add one parity bit	Detects any odd number of flips; cannot locate the error.
Internet checksum	Fixed-width sum + end-around carry; complement	Arithmetic check over words.
CRC	Polynomial modulo-two division	Algebraic remainder; receiver divides by same generator.

HAMMING DISTANCE D_{min}

Guarantee detection of up to e errors if $d_{min} \ge e + 1$.
Guarantee correction of up to e errors if $d_{min} \ge 2e + 1$.

Hamming distance is the minimum bit flips between valid codewords. Detection finds an invalid received word; correction identifies a valid word without retransmission. Use separate inequalities.

CRC SEND-AND-CHECK CONTRACT

1. Let generator degree be r; append r zero bits to data.
2. Divide the extended bits by the generator using XOR in place of subtraction.
3. Replace appended zeros with the remainder; transmit.
4. Receiver divides by the same generator; a valid word leaves zero remainder.

TRAP → *A detected error is not corrected data and is not proof that the original payload reached the application.*

METHOD-SELECTION AUDIT

PROMPT ASKS ABOUT	RELEVANT METHOD	NOT ENOUGH BY ITSELF
Where a frame ends	count / byte flag / bit flag	Parity or CRC
Whether bits changed	parity / checksum / CRC	Boundary flag
Recover without resend	code with correction distance	Error detection alone

10 · Reliable Delivery

C3 P4

OBSERVED PROBLEM	MECHANISM	PURPOSE
Corruption	Parity / checksum / CRC	Detect implausible bits.
Frame or ACK disappears	Timeout + retransmission	Restore progress.
Retransmission duplicates	Sequence number	Distinguish new from repeated.
Fast sender, slow receiver	Flow control / window	Avoid receiver overflow.
Long-delay link idle	Several outstanding frames	Pipeline work across the path.

PROTOCOL	RECEIVER / RETRANSMISSION TRADE-OFF
Stop-and-Wait	One frame, then wait; simple, but a long-delay path sits idle.
Go-Back-N	Simpler receiver state; retransmits the missing frame and later outstanding frames.
Selective Repeat	Buffers acceptable out-of-order frames and retransmits missing frames selectively; more receiver memory.

CHOOSE → *Prefer Selective Repeat when repeating correct frames is costly and buffering is affordable; prefer Go-Back-N when simpler receiver state dominates. Name delay, error rate and memory assumptions.*

11 · Shared Access

C4 P1–2

FAMILY	WHEN IT HELPS	COST
Static time/frequency	Predictable, regular demand	Idle allocations waste capacity under bursty load.
Pure / slotted ALOHA	Dynamic contention	Collisions; slotted starts require synchronisation.
Carrier sense / persistent CSMA	Listen before sending	Local silence may be incomplete evidence.
Collision detection	Abort failed attempt after noticing interference	Collision must be observable during transmission.
Reservation / limited contention	Reduce collision cost under load	Coordination overhead or idle reservations.

12 · Wireless & Ethernet

C4 P2–3

Hidden: two senders cannot hear each other but share a receiver; each may sense idle and collide there. ***Exposed:*** a sender hears activity although different receivers might allow concurrency.

RTS/CTS: sender requests; receiver clears; stations near the receiver hear CTS and defer. This reduces hidden-terminal risk but adds control overhead and is not universal collision prevention.

ETHERNET ELEMENT	JOB
Synchronisation + start	Locate the frame start.
Destination/source addresses	Link delivery interfaces.

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SIDE 2/2 WORKED MINI-EXAMPLES · IF X → Y · CLASSIC TRAPS · EXAM-MORNING PLAN

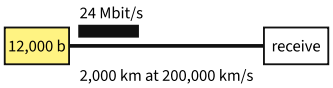
SELF-TEST DRILLS

S2 2026 · answers follow the path

13 · Drill: Link Delay

COURSE WORKED EXAMPLE

Q. A **12,000-bit** frame crosses a **2,000 km** fibre link at **24 Mbit/s**. Use propagation speed **200,000 km/s**. Find transmission delay, propagation delay and stated one-way link latency.



Serialisation and travel stay on separate lines.

1. **Normalise:** 24 Mbit/s = 24,000,000 bit/s.
2. **Transmit:** 12,000 ÷ 24,000,000 = 0.0005 s = **0.5 ms**.
3. **Propagate:** 2,000 ÷ 200,000 = 0.01 s = **10 ms**.
4. **Add times:** 0.5 + 10 = 10.5 ms, before processing or queueing.
5. **Interpret:** distance dominates; increasing R changes only the smaller transmission term.

AUDIT	EXPECTED UNIT
bits ÷ bit/s	seconds
km ÷ km/s	seconds
sum	same time unit

TRAP → *Do not divide distance by bit rate, add kilometres to milliseconds, or call every delay "bandwidth".*

REVERSE-CHECK THE ANSWER

CHECK	WHAT THE RESULT SHOULD SHOW
Dimensions	Each division independently ends in seconds.
Dominance	10 ms propagation is larger than 0.5 ms transmission.
Rate sensitivity	A higher rate can reduce 0.5 ms, not the 10 ms path term.
Scope	10.5 ms is the stated one-way link contribution before unsupplied processing or queueing.

Answer sentence: "Transmission delay is 0.5 ms and propagation delay is 10 ms, giving 10.5 ms one way under the stated link model; propagation dominates." This reports the arithmetic, units, scope and interpretation.

When one input changes, recompute only its term, then rebuild the total.

14 · If You See Delay...

C2 FAQ

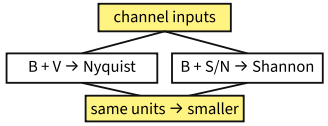
PROMPT EVIDENCE	DO
frame length + rate	L/R
distance + signal speed	d/s
both	calculate separately, then add
rate rises	change t_{tx} only
missing processing/queueing inputs	do not invent them

WRITE-AND-CHECK ORDER

15 · Drill: Tighter Ceiling

C2 WORKED EXAMPLE

Q. A **3 kHz** channel uses **four signal levels** and has an independently calculated Shannon ceiling of **9 kbit/s**. Find the Nyquist ceiling and controlling bound.



Compute applicable ceilings; the smaller one binds.

1. Four levels carry $\log_2 4$ = **2 bits/symbol**.
2. Nyquist: 2 × 3,000 × 2 = **12,000 bit/s**.
3. Shannon is given as **9,000 bit/s**.
4. Compare like units: min(12,000, 9,000) = 9 kbit/s.

ANSWER PATH

```
levels → bits/symbol → Nyquist; place
beside Shannon; select the smaller;
name the noisy-channel bound.
```

CLASSIC WRONG MOVE	CORRECTION
12 + 9 or average	Both are upper bounds; use min.
Call 12 kbit/s throughput	A ceiling is not achieved rate.
Use V inside Shannon	Shannon uses received S/N, not selected levels.

ASSUMPTION AUDIT

LINE	STATE EXPLICITLY
Representation	V=4 permits $\log_2 4$=2 bits per symbol.
Noiseless bound	Nyquist uses B and V; here it permits 12 kbit/s.
Noisy bound	Shannon ceiling is independently supplied as 9 kbit/s.
Conclusion	The channel cannot exceed the tighter 9 kbit/s under the stated assumptions.

Adding levels changes the Nyquist expression, but it does not overrule receiver uncertainty. Adding bandwidth changes both formulas when the corresponding assumptions still hold. A practical implementation may achieve less than either ceiling. A bound states what cannot be exceeded.

SELF-TEST → *Cover the answer and say: "Which input belongs to which formula, what units emerge, and why is the minimum the only defensible conclusion?"*

16 · Signal Judgements

C2 P3–5

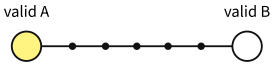
★ If levels increase → more bits per symbol, but states become harder to distinguish. If asked about direction → simplex/half/full duplex. If asked how users share → time/frequency/statistical/code multiplexing. If supplied decibels, convert only when the question requires a linear S/N for Shannon.

DISTINCTION	SAFE SENTENCE
bit vs symbol	One multilevel symbol can carry more than one bit.

17 · Drill: Distance 5

C3 WORKED EXAMPLE

Q. A code has minimum Hamming distance **five**. State the maximum bit errors it guarantees to detect and correct.



Distance 5: detect 4 errors or correct 2.

1. Detection condition: $5 \geq e + 1 \rightarrow e \leq 4$.
2. Therefore guarantee detection of **up to four** bit errors.
3. Correction condition: $5 \geq 2e + 1 \rightarrow e \leq 2$.
4. Therefore guarantee correction of up to two bit errors.

CLAIM	INEQUALITY	D_{min}=5
Detect e	$d_{min} \geq e+1$	e=4
Correct e	$d_{min} \geq 2e+1$	e=2

TRAP → *Distance five does not mean "five detectable" or "five correctable". Write both inequalities before substituting.*

WHY THE GUARANTEES DIFFER

For detection, fewer than five flips cannot reach another valid word. For correction, decoding regions must not overlap: radius two is safe because two plus two remains below distance five.

Complete sentence: "Minimum distance five guarantees detection of four errors and correction of two in a codeword."

18 · Framing & CRC Cards

C3 P1–3

IF YOU SEE...	DO / SAY...
reserved byte in payload	escape at sender; unescape at receiver.
reserved bit pattern	insert/remove the specified zero; preserve genuine data.
generator degree r	append r zeros before modulo-two division.
CRC subtraction	use XOR: no borrow or carry.
non-zero receive remainder	report detected corruption, not repaired data.

Checksum versus CRC: checksum uses arithmetic over fixed-width words and complements the sum; CRC treats bits algebraically and divides by a generator polynomial. Do not transfer the operation or guarantee of one to the other.

Boundary diagnosis: corrupted length can desynchronise character counts; payload flags require stuffing; error-control redundancy is a separate layer of the answer.

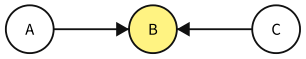
ONE RECEIVER TRACE

1. Locate the candidate frame boundary using the selected framing convention.

19 · Drill: Hidden Senders

C4 WORKED EXAMPLE

Q. A and C cannot hear each other, but both can reach receiver B. Each senses idle and transmits to B. Explain the failure and how RTS/CTS changes available information.



CTS from B is heard near the receiver → defer

Sender silence does not prove receiver safety.

1. A and C are **hidden** from each other; local sensing cannot reveal the other transmission.
2. Their frames overlap at **B**, where interference matters.
3. A sender's RTS asks B for permission; B's CTS is heard by stations near B.
4. A station hearing CTS defers, reducing hidden-terminal risk.
5. State the trade-off: extra control frames; not universal collision prevention.

JUDGEMENT	EVIDENCE TO NAME
Hidden	senders cannot hear each other; share receiver.
Exposed	senders hear each other; receivers may not interfere.
Safe?	evaluate at intended receiver, not just sender.

Each sender observes the wrong location. Draw sensing and receiver-interference relationships separately.

CONTRAST → *Hidden senders are over-confident after hearing silence; exposed senders may be over-cautious after hearing activity.*

20 · Access Chooser

C4 P1–2

IF SCENARIO SAYS...	PRIORITISE...
regular demand, predictability	static allocation; mention idle-share waste.
bursty, sparse arrivals	dynamic contention; mention collision cost.
listen before transmit	CSMA; state persistence rule.
abort on detected collision	collision detection; check observability.
high contention	reservation/limited contention; count coordination cost.

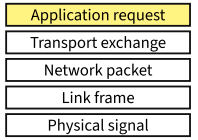
Hold offered load, slotting, sensing and timing assumptions constant when comparing throughput claims; otherwise the scenario changed with the protocol.

RECOMMENDATION SENTENCE

21 · Drill: Three Relations

C1 WORKED EXAMPLE

Q. A browser requests a page over a wireless first hop. Distinguish application service, local interface and peer protocol.



Wireless changes the hop, not the application.

1. **Service:** capability requested by the browser, such as retrieving the named resource.
2. **Interface:** local hand-off from application to transport, or transport to network.
3. **Protocol:** coordination between corresponding transport entities, or wireless link entities on one hop.
4. **Boundary check:** wireless changes the first hop; it does not make the Web a link protocol.

ONE-LINE ANSWER

```
Service = what the upper layer
receives; interface = how adjacent
local layers interact; protocol = how
peers coordinate.
```

TRAP → *The Web is an application over Internet infrastructure; it is not the Internet itself and not a property of every packet.*

TRACE THE SAME SCENARIO

VIEW	CORRECT STATEMENT
Application	Browser requests the named resource; server constructs a reply.
Local boundary	Each upper layer invokes the lower service through an interface.
Peer relation	Corresponding entities follow their protocol agreement.
First hop	Wireless link entities frame and signal locally.
End-to-end check	Lower representation changes while the application meaning is carried.

Scope test: broadcast, point-to-point or multicast says who can receive; bus, star, ring or mesh says how devices and links are arranged. Neither classification automatically names the peer protocol.

FAULT DRILL → *Wrong name, missing route, damaged frame, noisy signal: explain only at application, network, link or physical respectively before discussing downstream effects.*

22 · Reliability Chooser

C3 P4

IF YOU SEE...	REACH FOR...
bad bits	detection/correction code
silence after sending	timeout + retransmit

23 · Classic Traps

C1–C4 FAQ

TEMPTING CLAIM	REPAIR
"Star means switched."	Star is arrangement; centre behaviour determines repeated/switched traffic.
"Faster rate removes latency."	It reduces L/R only; distance still sets d/s.
"More levels always raise capacity."	Noise limits distinguishability; check Shannon.
"CRC corrects the frame."	Here CRC detects corruption; recovery is separate.
"ACK makes delivery reliable."	Loss needs timeout; repeats need sequence numbers.
"Carrier idle means safe."	Wireless interference is evaluated at receiver.
"Switching removes Ethernet framing."	It separates collision domains; frame/address/CRC functions remain.

24 · 60-Second Method

STUDY STRATEGY



answer mechanism—not neighbour

Classify → assume → apply → interpret → audit.

1. **Classify:** layer, object, failure or allocation question.
2. **Expose assumptions:** units, load, synchronisation, sensing locality, duplex, buffer or error conditions.
3. **Apply:** formula, inequality, protocol rule or comparison table.
4. **Interpret:** name the binding term and the mechanism's cost.
5. **Audit:** units, direction, scope and whether the conclusion exceeds the evidence.

25 · Exam-Morning Plan

BRIEF · STRATEGY

PASS	SELF-TEST
1 · Recite	service/interface/protocol; L/R vs d/s; Nyquist vs Shannon; detect vs correct.
2 · Redraw	layer trace; link clocks; CRC contract; hidden-terminal receiver view.
3 · Rework	10.5 ms; 9 kbit/s; d=5 → 4 detect/2 correct; RTS/CTS path.
4 · Contrast	GBN/SR; static/contention; hidden/exposed; hub/switch.
5 · Verify	current exam instructions on the LMS.

Stop when you can explain the choice, not merely name it. Every strong answer connects evidence → mechanism → limitation. Record the first mistaken distinction in a correction log; fixing that fork improves many later answers.

FINAL CHECK → *For a numeric answer, show units and the controlling bound. For a protocol answer, state the failure it solves and the resource or overhead it spends.*

LAST RECALL GRID