Pipeline Ops Teacher Guide: Chapter 1 (v1, 2026-11-23)

Pipeline Ops is a free browser puzzle game. Students build a path that gets rescue cats from the Rescue Van to their Forever Home. Along the way they must turn away muddy cats, copycats and rushes. Each part is a real piece of internet engineering in disguise, and every part card shows its real name. By the end of Chapter 1, students have used the same building blocks that keep video streams, ticket sales and group chats working.

- **Suggested for:** grades 6 to 12. This is the author's estimate, not yet tested in a classroom.
- **Needs:** a web browser. No login, no accounts, no ads, nothing to install. Works on laptops and tablets; phones work but the board is cramped.
- **Student link:** https://taelife01.vercel.app/pipeline-ops/?src=teacher-guide
- **Teacher link (shows a 3-star answer for each level):** https://taelife01.vercel.app/pipeline-ops/?teacher=1&src=teacher-guide This hides the answers from students who use the normal link. It is not a lock: a student who learns the teacher link can use it too.
- **Themes:** Cat Rescue (default), Sheep Farm, and Data Center (real terms only). The puzzles are identical in every theme. This guide uses Cat Rescue, with real terms in [brackets].

Reading the scores. The game counts time in ticks: 20 ticks make one second. "p95" is the time that 95 out of 100 cats beat, so a p95 of 8 ticks means almost every cat got home within 0.4 seconds. A level passes when it meets every rule in its briefing. It earns 1 star for passing, 2 for also hitting the cost or the speed target, and 3 for both.

About the "usually try first" notes. No class has played this yet. Those notes come from the game's automatic solver, which tries thousands of designs per level. They are predictions of common mistakes, not observations.

A 45-minute lesson

Minutes	What happens
0-5	Hook: "When a million people buy concert tickets at once, why doesn't the site melt?"
5-10	Demo Level 1 on the projector. Show the help card (ⓘ) and its "Real name" line.
10-30	Pairs play Levels 1 to 3. One drives, one reads the briefing aloud; swap each level.
30-40	Discussion: pick one level's question (see each level below).
40-45	Exit ticket: "Name one part and the real system it reminds you of."

Fast finishers continue to Levels 4 to 8. Level 2 is the first real wall; see its notes.

Privacy in four lines

- No accounts, names, emails or free text are collected. There is nothing to sign up for.
- The game sends anonymous game facts (for example "level 2 solved, 3 stars") to improve puzzles.
- One tap under the game ("Turn it off") stops that on that browser; the game plays the same.
- Full details: https://taelife01.vercel.app/privacy/

Level 1: Mud Season [Poison Pill Triage]

The real idea: check every incoming message, and send the bad ones somewhere safe instead of letting them break the system (validation and dead-letter queues).

New parts: Vet Check [Schema validator] and **Cat Lounge** [Queue buffer]. The Cat Lounge is available here but not needed until Level 2.

The situation: 20 cats per second arrive, and 1 in 5 is muddy. No muddy cat may reach the Forever Home, at least 98% of clean cats must get there, and p95 must stay at or under 8 ticks. Budget: 150.

What students usually try first: a wire straight from the Rescue Van to the Forever Home. The game answers: "97 muddy cats got into the Forever Home. Add a Vet Check."

Hints:

1. Mild: "Which cats does the Forever Home refuse? Which part can tell them apart?"
2. Strong: "A Vet Check has two doors. Where should the red door lead?"

3-star answer: Rescue Van to Vet Check. The Vet Check's main door goes to the Forever Home and its red door goes to Bath Time [Dead-letter queue]. Cost 100. If the red door is left unwired, muddy cats are simply lost.

Discuss (analogy): "When you upload a file an app can't read, it doesn't crash; it tells you something went wrong. Where might the app put that file so an engineer can look at it later?"

Vocabulary:

- *Validation:* checking that data is in the expected shape before using it.
- *Malformed message:* data that is broken or in the wrong shape (a muddy cat).
- *Dead-letter queue:* a safe holding place for rejected messages (Bath Time).

Level 2: Adoption Rush [Flash-Sale Burst]

The real idea: a waiting room absorbs a sudden rush, and two slow workers side by side handle twice as much (buffering and load balancing). Every message also has to be upgraded to a new format.

New parts: Collar Station [Schema transformer], **Two-Way Hallway** [Load balancer] and **Cat Flap** [Rate limiter].

The situation: a steady 20 cats per second, then a rush of 52 per second for 7 seconds; 15% are muddy. Every adopted cat needs the new collar, and one Collar Station handles only 20 cats per second. 99% of clean cats must get home, p95 at or under 30 ticks. Budget: 600.

What students usually try first: a direct wire, then a single Vet Check and a single Collar Station. The direct wire gets three complaints at once: muddy cats got in, cats arrived "without the new collar", and "Only 0.00% made it to the Forever Home". One Vet Check and one Collar Station gets closer but still fails: 79.65% delivered, with 163 cats lost during the rush.

Heads-up for teachers: this is the tightest early level. The solver found no other passing design among the 1,599 it tried, so expect students to need the hints. Struggle here is normal.

Hints:

1. Mild: "During the rush, cats arrive faster than one Collar Station can work. Where can they wait instead of getting lost?"
2. Strong: "Two Collar Stations can share the work. Which part splits cats between two paths?"

3-star answer: Rescue Van to Vet Check (red door to Bath Time), main door to Cat Lounge, Cat Lounge to Two-Way Hallway, left and right halls to one Collar Station each, both Collar Stations to the Forever Home. Cost 570, p95 22 ticks.

Discuss (analogy): "Popular online sales sometimes put you in a 'virtual waiting room'. Why is waiting in line better than the site turning you away?"

Vocabulary:

- *Burst:* a short spike in traffic far above normal.
- *Buffer (queue):* a waiting area that holds work until the next step is free.
- *Load balancer:* splits work across several copies of a slow step.
- *Schema:* the agreed format of a message (the collar); a *transformer* converts old to new.

Level 3: Copycat Chaos [Schema Drift & Dedup Storm]

The real idea: the same message can arrive twice, and the system must notice (deduplication). Data can also show up in a mix of old and new formats.

New part: Copycat Detector [Dedup cache].

The situation: 25 cats per second with copycats and muddy cats mixed in. Halfway through, a wave of 55 per second arrives already wearing the new collar. A single copycat in the Forever Home fails the level. 98% of clean cats must get home, p95 at or under 25 ticks. Budget: 750.

What students usually try first: a direct wire gets four complaints: muddy cats, missing collars, "195 copycats got into the Forever Home. Add a Copycat Detector.", and only 34.79% delivered. A common near-miss uses a side door to a spare Collar Station instead of a Two-Way Hallway: it passes, but with 2 stars, because it is slower.

Hints:

1. Mild: "Copycats look like real cats. Which part remembers who already came through?"
2. Strong: "Clean up the line (mud, copycats) before the slow collar step, then split the line in two."

3-star answer: Rescue Van to Vet Check, to Copycat Detector, to Two-Way Hallway, to two Collar Stations, to the Forever Home. The red doors of the Vet Check and the Copycat Detector both go to Bath Time. Cost 610, p95 7 ticks.

Discuss (analogy): "On weak signal, a chat app may send your message again because it isn't sure the first one arrived. Why don't your friends see it twice?"

Vocabulary:

- *Duplicate message:* the same message delivered more than once (a copycat).
- *Deduplication:* removing repeats by remembering what was already seen.
- *Cache:* a short-term memory a system checks quickly.

Level 4: Callback Frenzy [Retry Storm]

The real idea: order matters. Do the cheap, fast checks before the slow, expensive step, so it never wastes time on work that will be thrown away.

New parts: none. This level is about arranging parts students already know.

The situation: traffic jumps from 20 to 44 cats per second, and during the storm more than half are copycats (55%) and some are muddy. Every cat needs the new collar, and the budget buys only one Collar Station (20 per second). 98% of clean cats must get home, p95 at or under 20 ticks. Budget: 450.

What students usually try first: after the direct wire fails, many will put the Collar Station first because collars are required. That fails: only 75.30% get home, because the Collar Station spends the storm collaring copycats and muddy cats. Putting it in the middle (Copycat Detector, then Collar Station, then Vet Check) passes, but with 2 stars.

Hints:

1. Mild: "The Collar Station is slow. Which cats is it wasting time on?"
2. Strong: "Turn away the cats who will never be adopted before they reach the slow step."

3-star answer: Rescue Van to Vet Check, to Copycat Detector, to one Collar Station, to the Forever Home, with both red doors to Bath Time. Checking copycats first and mud second also earns 3 stars. Cost 360, p95 6 ticks.

Discuss (analogy): "If you tap 'Pay' three times because an app seems frozen, why should the store only charge you once? And where should it check, before or after the slow bank step?"

Vocabulary:

- *Retry storm:* many clients resending at once after a hiccup.
- *Bottleneck:* the slowest step, which limits the whole line.
- *Filter early:* remove junk before expensive work.

Level 5: Side Door [Spillway]

The real idea: when the next step is full, extra work can spill to a spare instead of being dropped (overflow routing). Spilled work still has to be done properly.

New idea: the **Side door (when the next room is full)** [OVERFLOW port]. Every part has one. It only gets cats when the next room's line is full.

The situation: traffic doubles from 20 to 42 cats per second for 18 seconds; 15% are muddy. One Collar Station handles 20 per second, and there are no Two-Way Hallways in this level. 98% of clean cats must get home, p95 at or under 30 ticks. Budget: 400.

What students usually try first: one Collar Station after the Vet Check. It fails: 74.04% delivered, with 264 cats lost when the Collar Station's line is full. Wiring the Vet Check's side door straight to the Forever Home saves those 264 cats, but they arrive without the new collar, and the game says so.

Hints:

1. Mild: "When the Collar Station's line is full, where does the next cat go right now?"
2. Strong: "Give the full room's side door somewhere useful to send cats, somewhere that still puts collars on."

3-star answer: Rescue Van to Vet Check (red door to Bath Time). The Vet Check's main door goes to one Collar Station and its side door to a second Collar Station; both go to the Forever Home. Cost 380, p95 17 ticks.

Discuss (analogy): "A supermarket opens an extra checkout only when the lines get long. What is good about that? What is the risk if the extra checkout is staffed by someone who can't scan?"

Vocabulary:

- *Overflow:* extra work that doesn't fit, sent elsewhere.
- *Backpressure:* a full step pushing back on the step before it.
- *Dropped message:* lost because there was nowhere for it to go.

Level 6: Gone Viral [Ticket Drop]

The real idea: when you can't serve everyone, turn some away early and on purpose so the rest are served quickly (load shedding with a rate limiter).

New parts: none.

The situation: traffic jumps from 20 to 64 cats per second for 9 seconds; 15% are muddy. Two Collar Stations (40 per second together) are all you can afford, so not every cat can get home, and that's allowed: 85% is enough. But p95 must stay at or under 22 ticks, so the cats who do make it must be fast. Budget: 600.

What students usually try first: a Cat Lounge to hold the rush, in front of two Collar Stations. It gets 99.09% of cats home but fails anyway: they wait far too long (p95 of 61 ticks against a limit of 22). This is the level's lesson. The solver also found designs that pass with 2 stars (about 88% delivered, p95 17 to 18 ticks); none of those reached 3 stars.

Hints:

1. Mild: "You don't have to adopt every cat today. Which cats should you turn away, and when?"
2. Strong: "Turning cats away early is better than making everyone wait. Which part only lets so many through?"

3-star answer: Rescue Van to Vet Check (red door to Bath Time), main door to Cat Flap, to Two-Way Hallway, to two Collar Stations, to the Forever Home. The Cat Flap's short line turns the extra cats away before they can wait. Delivers 87.24%, p95 11 ticks, cost 580.

Discuss (analogy): "When tickets for a huge concert go on sale, is it kinder to tell some people 'sold out, try later' right away, or let everyone wait an hour and then fail?"

Vocabulary:

- *Load shedding:* deliberately dropping some work to protect the rest.
- *Rate limiter:* lets through at most a set amount per second.
- *Latency:* how long one message takes from start to finish.

Level 7: Mud Storm [Bot Flood]

The real idea: add more workers only where traffic is heaviest, then merge back to one lane where it is light (scaling out, then fanning back in).

New parts: none.

The situation: for 20 seconds, 104 cats per second arrive, and 87% are muddy. Only about 14 clean cats per second are hidden in the crowd. One Vet Check can look at 80 cats per second, so one isn't enough, and the budget can't buy two complete paths. 98% of clean cats must get home, p95 at or under 16 ticks. Budget: 500.

What students usually try first: two Vet Checks joined by a side door. It passes with 2 stars and is the cheapest passing design (cost 340), but the second Vet Check only helps after the first one's line is already full, so cats wait.

Hints:

1. Mild: "Where is the crowd biggest: before the Vet Check, or after it?"
2. Strong: "Split the crowd before checking, then bring the clean cats back together. How many Collar Stations do about 14 clean cats per second need?"

3-star answer: Rescue Van to a Two-Way Hallway, left and right halls to one Vet Check each (both red doors to Bath Time), both Vet Checks to a single Collar Station, to the Forever Home. Cost 450, p95 6 ticks.

Discuss (analogy): "Bots sometimes flood a game's sign-up page. Why might a site add extra checking power at the front door but not everywhere?"

Vocabulary:

- *Bot traffic:* automated requests, often junk.
- *Scale out:* add more copies of a part to share the load.
- *Fan-out / fan-in:* split into parallel lanes, then merge again.

Level 8: The Big Day [Cyber Monday]

The real idea: bottlenecks move. Spend your one scarce resource where the most real customers would otherwise wait (capacity planning).

New parts: none. This is the Chapter 1 final.

The situation: first a mud storm, 110 cats per second with 75% muddy. Then a real rush, 64 per second, half real cats and 40% copycats. Every cat needs the new collar. The budget covers exactly one Two-Way Hallway. 98% of clean cats must get home, p95 at or under 24 ticks. Budget: 720.

What students usually try first: a Two-Way Hallway at the front, as in Level 7, with one Collar Station. That handles the mud storm but swamps the Collar Station during the real rush: 85.41% delivered, a fail. Adding a spare Collar Station on a side door passes, but only with 2 stars (p95 19 ticks). This is the hardest level; treat it as a challenge for fast finishers.

Hints:

1. Mild: "There are two rushes. Which one has more real cats that need the slow collar step?"
2. Strong: "The front can grow with a side door instead of a hallway. Save the hallway for the Collar Stations."

3-star answer: The Rescue Van's main door goes to one Vet Check and its side door to a second Vet Check (both red doors to Bath Time). Both Vet Checks go to one Copycat Detector (red door to Bath Time), then to the Two-Way Hallway, then to two Collar Stations, then to the Forever Home. Cost 710, p95 9 ticks.

Discuss (analogy): "An online store expects bots in the morning and real shoppers in the evening. If it can afford one upgrade, where should it go, and how would it decide?"

Vocabulary:

- *Capacity planning:* deciding how much of each resource you need, and where.
- *Trade-off:* giving up one thing to get another, here cost against speed.

Glossary: Cat Rescue, real terms and Sheep Farm

Cat Rescue	Real term	Sheep Farm
Rescue Van	Stream source	Sheep Truck
Forever Home	Production sink	Green Pasture
Bath Time	Dead-letter queue	Wash Pen
Vet Check	Schema validator	Sheepdog Check
Copycat Detector	Dedup cache	Head Counter
Cat Flap	Rate limiter	Narrow Gate
Cat Lounge	Queue buffer	Holding Pen
Two-Way Hallway	Load balancer	Split Chute
Collar Station	Schema transformer	Shearing Shed
Main door	OUT port	Gate
Red door (rejects)	ERROR port	Wash lane (rejects)
Side door (when the next room is full)	OVERFLOW port	Spare gate (when the next pen is full)
Left hall	SPLIT_A port	Left chute
Right hall	SPLIT_B port	Right chute
tabby cat	valid message	sheep
muddy cat	malformed message	muddy sheep
copycat	duplicate message	double-counted sheep
chonky cat	oversized message	extra-woolly sheep
royal cat	priority message	prize ram
the old collar / the new collar	schema v1 / schema v2	last season’s wool / this season’s cut

Chonky and royal cats are reserved for later chapters. In Chapter 1 they behave like ordinary tabby cats.

What this does not teach

- **No code is written.** Students design systems by connecting parts; they don't program them. A "write the logic" layer is planned but not built.
- **The simulation is simplified.** Real systems have network delays, failures, costs that change over time, and many more kinds of parts. Every level is a fixed, repeatable scenario, so the same design always gets the same score.

- **The numbers are made up for the puzzle.** Speeds and costs are chosen to make good puzzles, not copied from real products.
- **No claims about learning outcomes or standards.** This guide has not been tested in a classroom yet. Please tell us what worked and what didn't.