Heart beats and time outs

How long to wait for new input

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Window algorithm

Group elements from an **ordered stream** into an ordered stream of *windows of time*.

- Object i has a *data time* T_i, arrives at *real* (aka *system) time* t_i
  - Objects are **strictly ordered** by their T_i to form a *stream*.
  - For simplicity take *data* and *system* clock **rate** as identical, but...
  - In general $T_i \neq t_i$ due to production/transmission latency and jitter.
- Window j spans holds $T_i \in [T_j, T_j + \Delta T)$, half inclusive interval.
  - May require *synchronous window edges*: $\mod(T_j, \Delta T) = 0$
- New T_i arrives:
  - if before current window: drop T_i (tardy)
  - if in current window: add T_i
  - if after window, output the window, start new window at $T_j + \Delta T$

What to do while no new T_i?

- Wait until one arrives $\rightarrow$ unbounded latency
- Time out and output the window, start new window at $T_j + \Delta T$
  - $\rightarrow$ potential future tardy

Latency vs Loss minimax problem

Reduce latency bound $\rightarrow$ more likely next message deemed tardy.

- Pick window $\Delta T = 3$ (in some time unit).
- Assume **mean** *data* time period between messages is 1 unit of time.
  - Pick latency bound: wait no more than 2 units of time with no message.
- At $t_i = 5$ after a gap of 2 units we get either $T = 3$ or $T = 4$

$\leftarrow$ time

t_i:	6	5	4	3	2	1
		PL($T = 3$)	none	none	PL($T = 2$)	PL($T = 1$)
		PL($T = 4$)	none	none	PL($T = 2$)	PL($T = 1$)

PL = payload message type

Latency vs Loss cont

t_i: 6	5	4	3	2	1
	PL, $T = 3$	none	none	PL, $T = 2$	PL, $T = 1$
	PL, $T = 4$	none	none	PL, $T = 2$	PL, $T = 1$

- At $t = 2$ we get $T = 2$, our window is not complete and we start waiting for next.
- At $t = 3$ we have reached max latency time with no input and output window with $\{T = 2, T = 1\}$.
- Scenario 1: $T = 3$ comes at $t = 5$. It should have gone into window but window is output. $T = 3$ is dropped as **tardy**.
- Scenario 2: $T = 4$ comes at $t = 5$. It should NOT have gone into window and we had to wait full latency to learn that.

Latency vs Loss + Heartbeats

Heartbeat (HB) messages vs normal payload (PL) messages:

- sent **in band**, HB and PL ordered together by *data time* T
- HB sent with fixed *data time* period faster than mean of PL
- still subject to latency variances
- optional: do not send HB if PL with identical T

t_i:	6	5	4	3	2	1
		$T = 3$	none	none	$T = 2$	$T = 1$
		$T = 4$	none	none	$T = 2$	$T = 1$