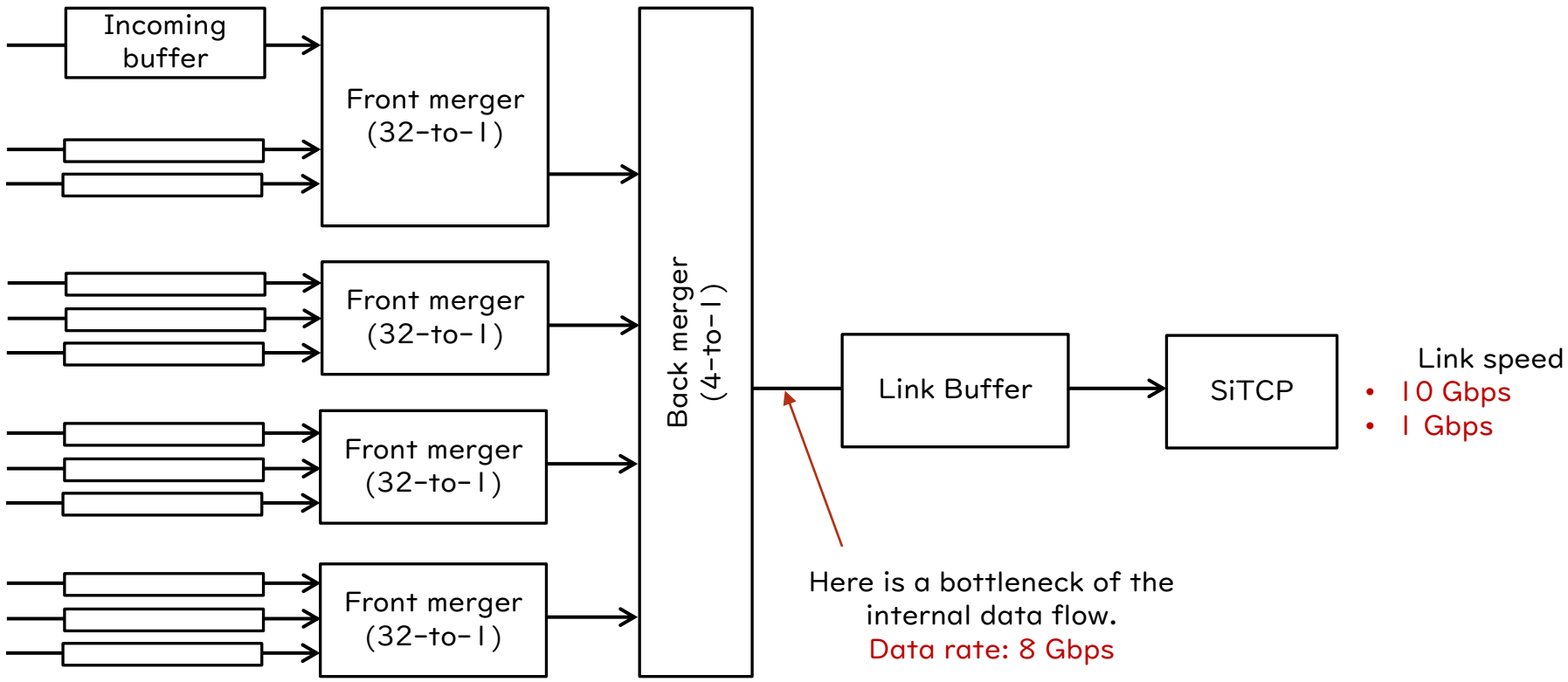
Throttling function

Buffers and programmable full flags

Buffers in the streaming TDC

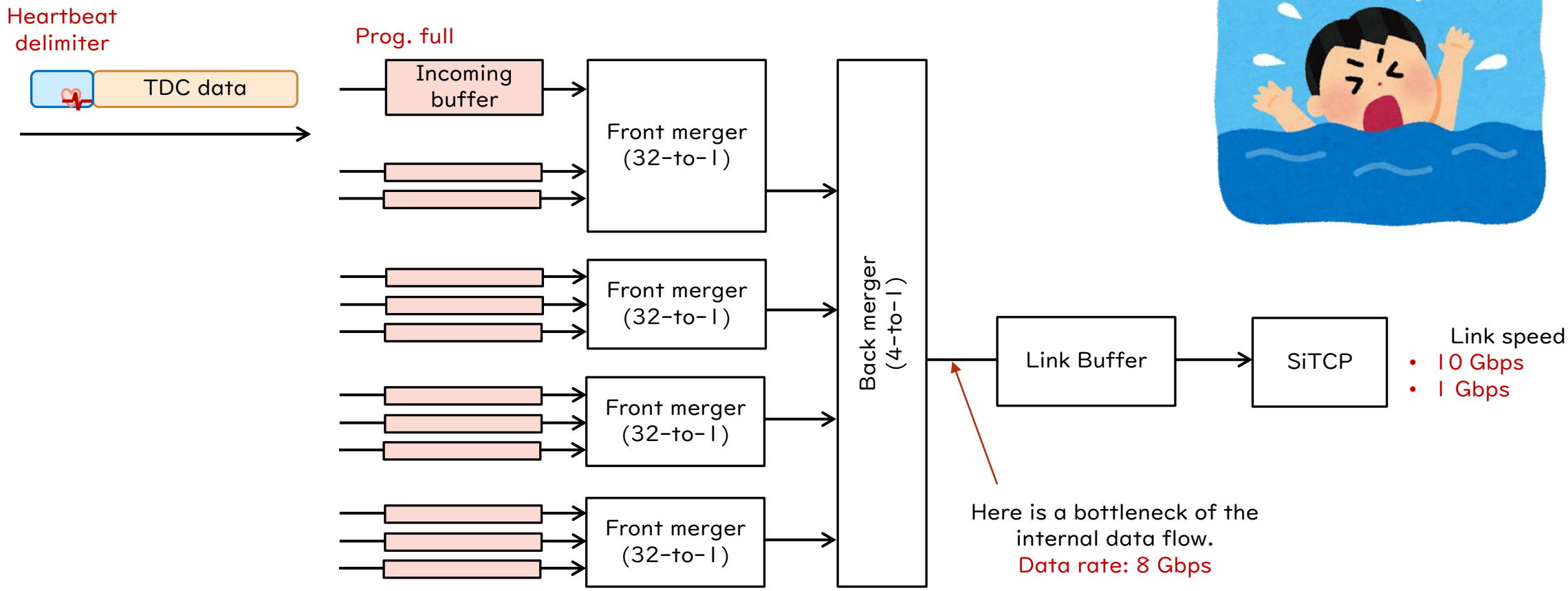
- There are some buffers in TDC, incoming (channel) FIFO, front merger FIFO, back merger FIFO, LinkBuffer, and FIFO inside SiTCP. (In future, 2Gb DDR3 SDRAM is added in this buffer configuration.)
- Each FIFO has a port of the programmable full whose threshold can be determined by programmer.



Present logic when they are full

Protection logic inside the incoming buffer

- When it is programmable full, the TDC data are discarded. It allows to write only the delimiter data. Since delimiter defines the time frame, if delimiters are lost, it crashes the heartbeat frame structure.
  - It causes the local heartbeat frame number mismatch in merger units.
- Incoming buffer tries to protect the system by discarding TDC data, but...
  - The system is getting drowning. Soon (within a few ms), it will die.



Strategy against data structure crash

Software side

Recovery process

- If the local heartbeat frame num mismatch is found, the DAQ software temporarily removes FEE from the DAQ nodes and sends the reset signal to FEE.
  - This function also can be used for the radiation damaged FEE. So, this is essential function, but if the FEE crashed frequently, we might loss much DAQ efficiency.
- Then, FEE should try to survive even under the difficult situation.

Front-end module side

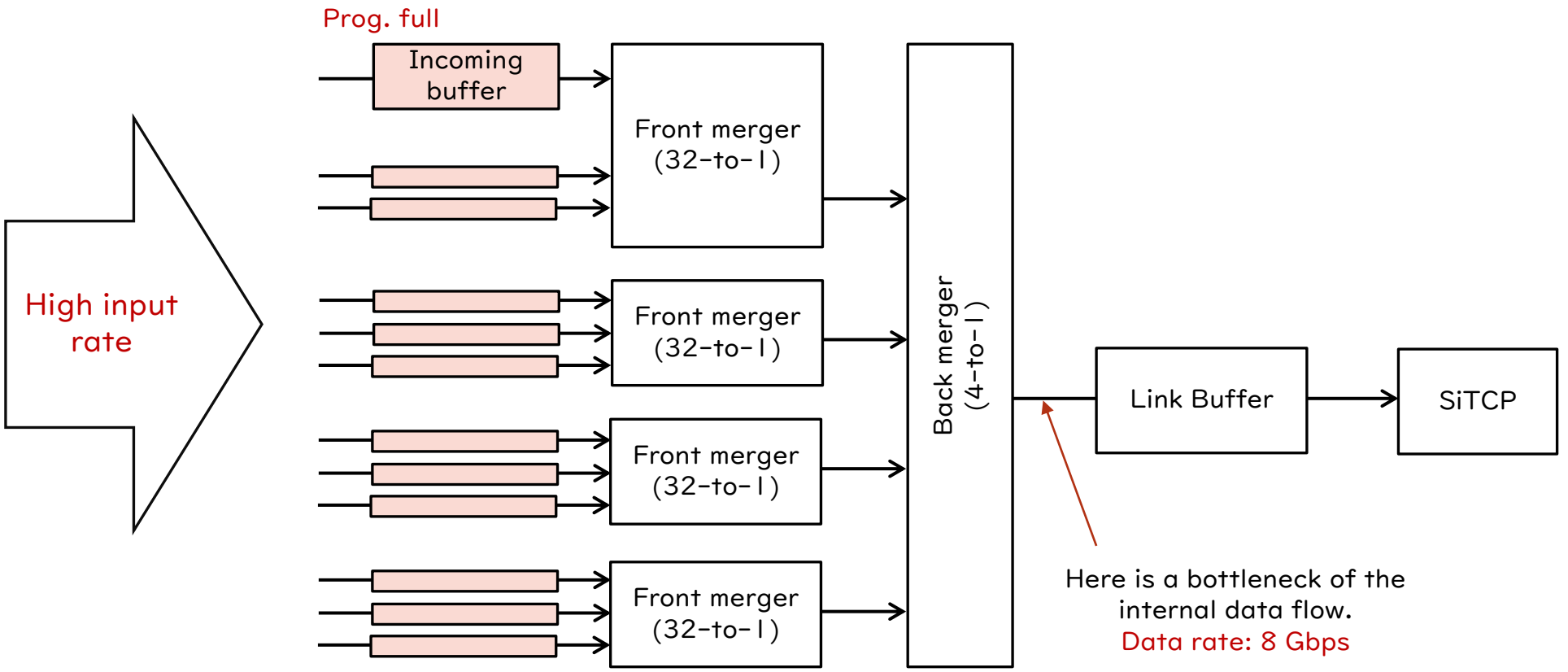
Throttling function

- The throttling function is a kind of flow control. It throttles data rate to protect the system.
- I guess that the programmable full flag indication pattern are categorized at least three cases, and then some throttling functions are necessary.

Case 1

Averaged input rate is lower than the link speed, but it suddenly increases in a short period.
E.g., noise burst

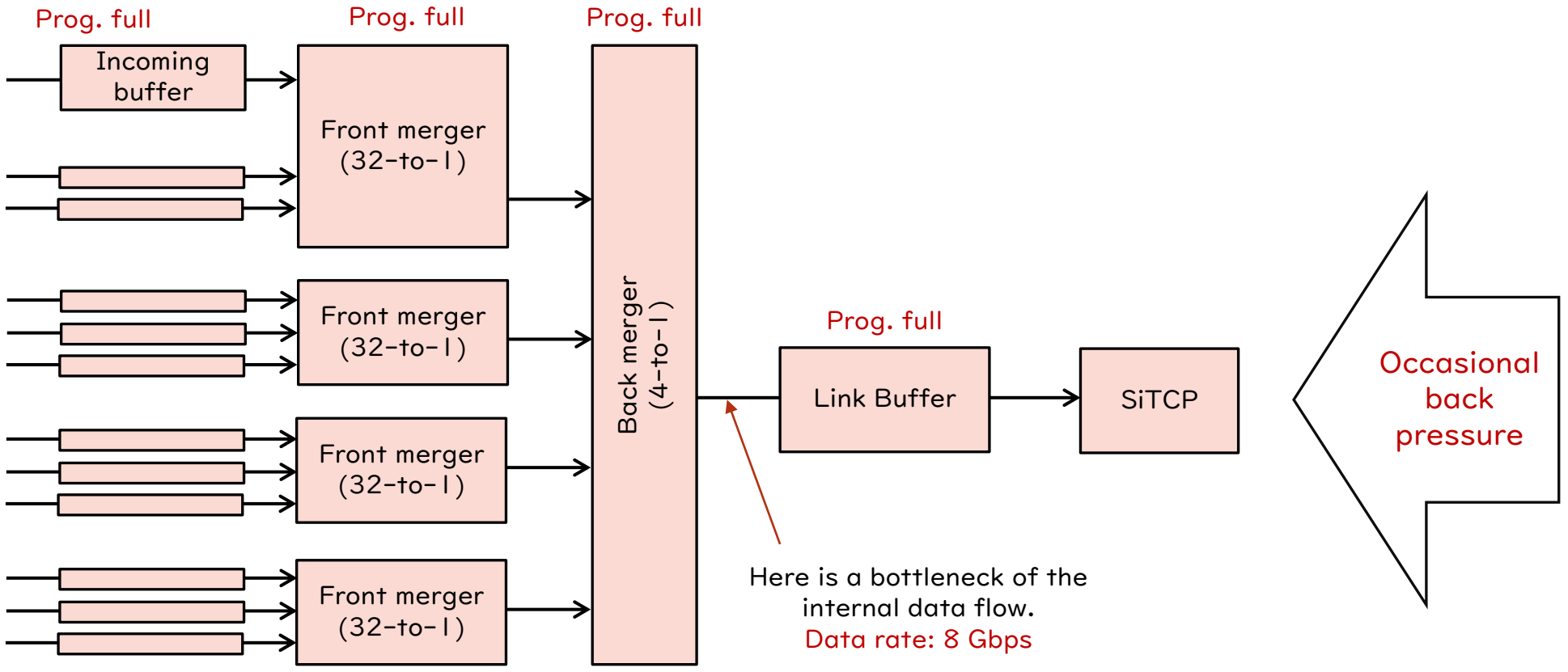
- The prog. full flag from incoming buffer is first asserted even though downstream buffers have room.
  - 10 MHz noise x 32 ch = 320 MHz. Data rate: 0.32 GHz x 64-bit = 20.48 Gbps
- A function to throttle input data rate is necessary.



Case 2

Averaged input rate is lower than the link speed, but the software does not read data occasionally.
E.g., occasional back pressure

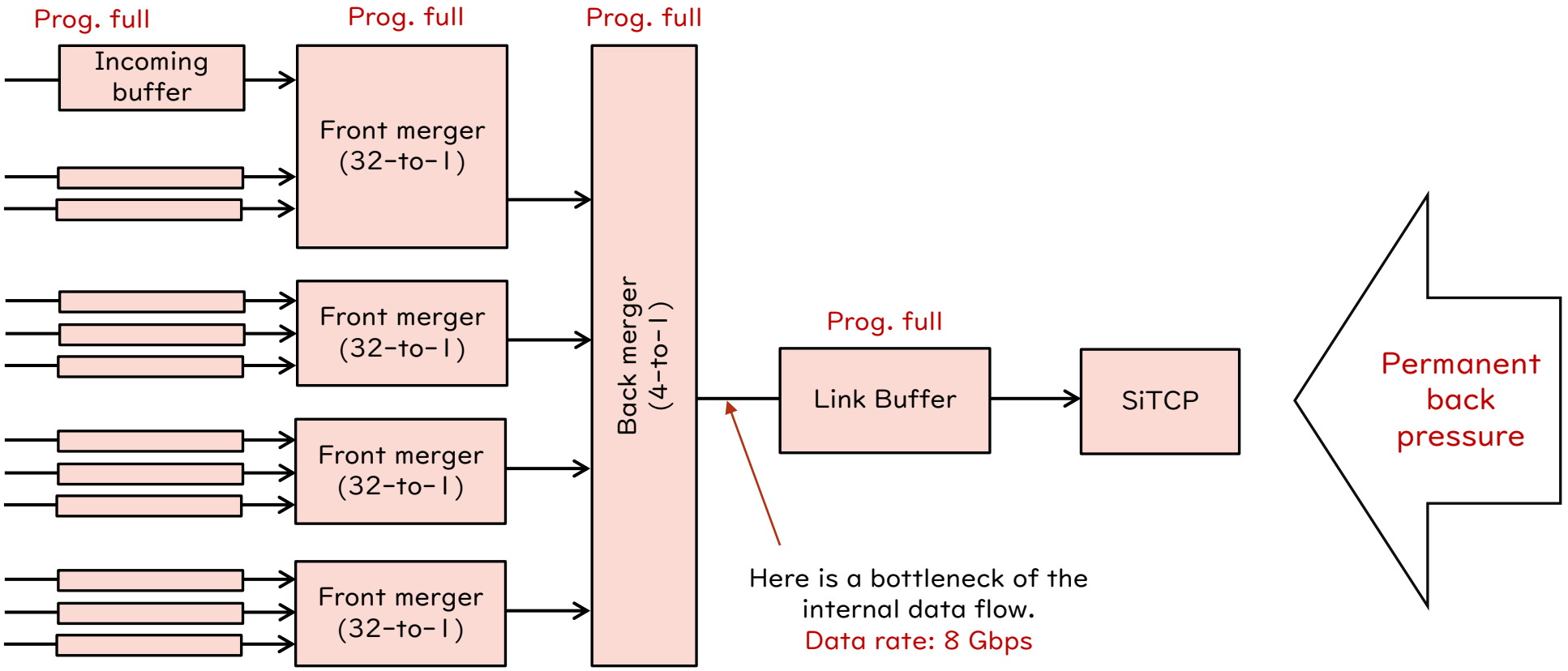
- The system needs to clear the data in buffers to wait that the CPU busy is relieved, and the readout is restarted.
- A function to throttle output data is necessary.



Case 3

The software cannot readout FEE with the maximum link speed due to its low performance.

- The throttling function for case2 can save the system, but it works randomly on each FEE, and then we may loose DAQ efficiency a lot.
- A throttling function having a pre-programmed throttling pattern is necessary.

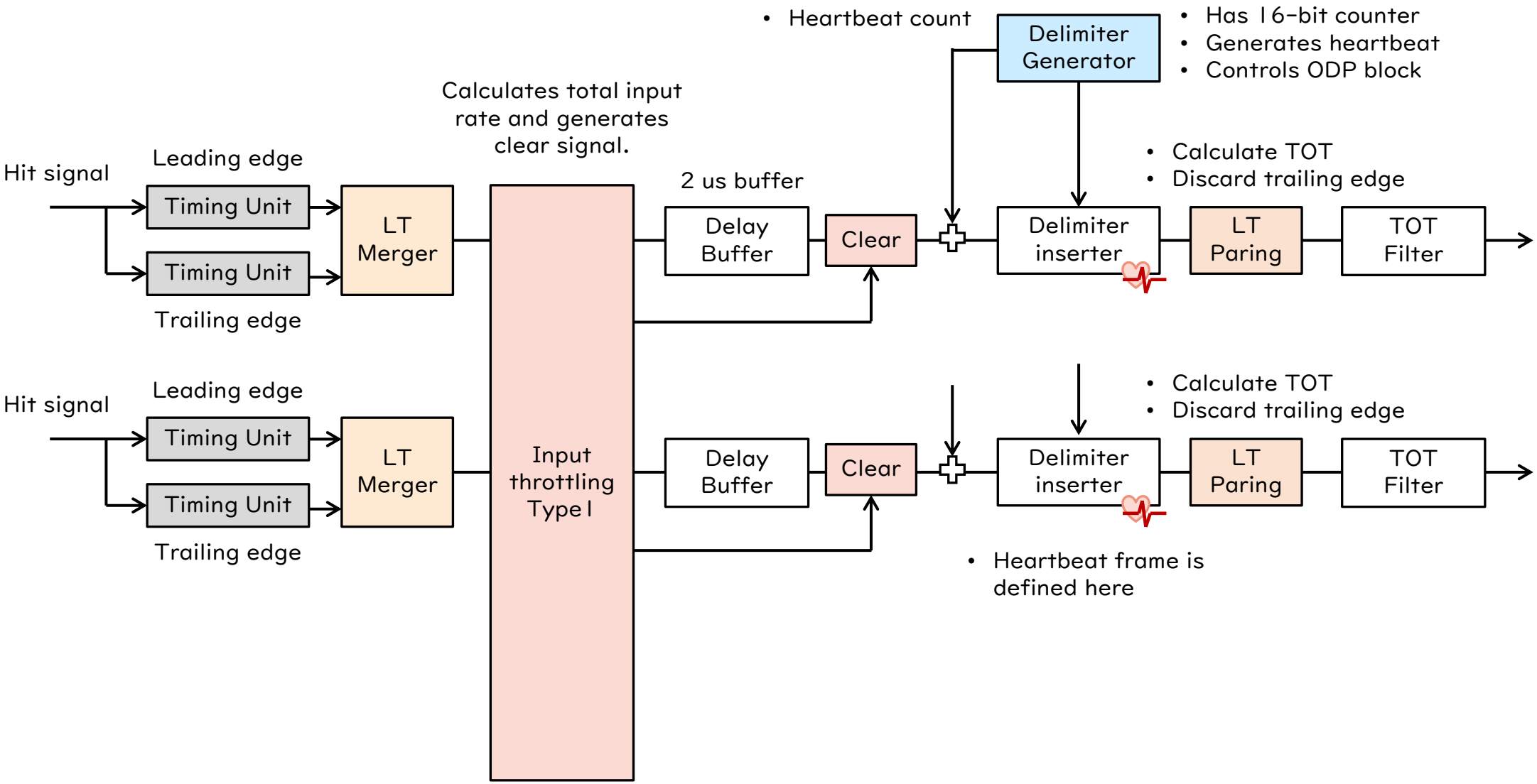


Throttling functions

We introduce four types throttling functions.

- Input throttling type l (for case l)
- Input throttling type2 (for case l)
- Output throttling (for case2)
- HBF throttling (for case3)

Block structure of ODP block



Functions in ODP block

Input throttling Type I

- It throttles the input hit rate. It calculates the total hit rate from all the input, and if it exceeds the threshold, the clear signal is asserted. The calculation logic is inserted before the delay buffer and the clear logic is implemented after the delay buffer because the integration circuit having a time lag is necessary for rate calculation.
- Clear method. It blocks the data before reaching the memory. It has higher performance than that of type2, but it clears all the hits including narrow signals, which can be filtered out by the TOT filter.
- Not implemented yet.

Delay buffer

- Fixed latency 2 us delay buffer. It is necessary when using the trigger emulation mode to wait the trigger.
- It can be bypassed by setting the bypass register, but it is recommended to utilize it due to the relation between the input throttling type I .

Functions in ODP block

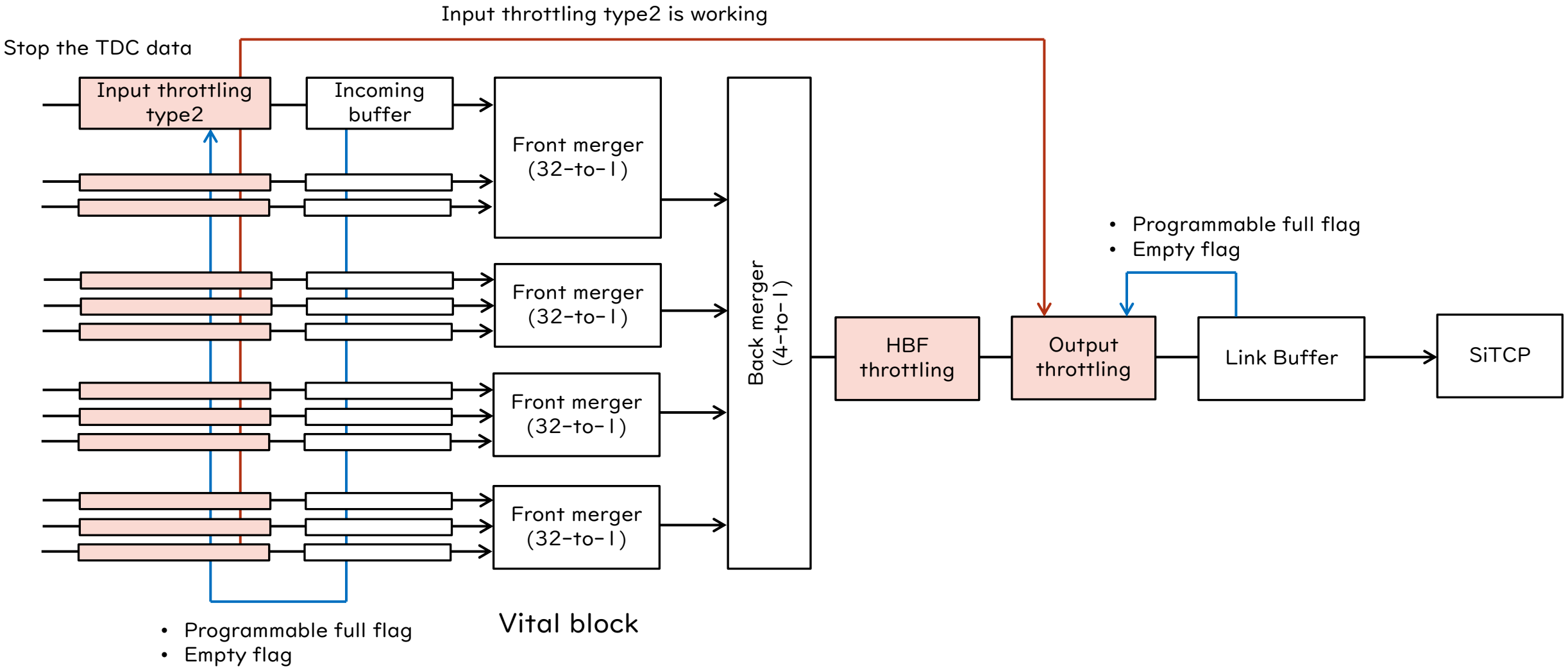
LT Paring

- It finds a pair of leading and trailing edges. Max measurable TOT length is 4000 ns. The trailing edge data is discarded.
- If a pair is not found, the leading edge data with the TOT value of 0 is transferred. In any cases, trailing edge data is discarded.
- If a hit strides across two HB frames, e.g., L, D, D, T, the leading edge data is inserted at the left hand side of delimiters after calculating TOT.
  - L: Leading, D: Delimiter, T: Trailing
- There is a potential risk of silent drop of the leading edge data when data come as follows, L, D, D, L, L, L. Red colored data could be silently dropped if interval among leading data coming after delimiter words is quite short.
- It can be bypassed by setting the bypass register. If bypassing, both leading and trailing edge data are transferred to a PC, but the data size becomes double.

TOT Filter

- It filters out the data, which does not match the condition of min_th < TOT < max_th.
- We can select whether the data with the TOT value of 0 is filtered out or not.

Block structure of vital block



Functions in vital block

Input throttling type2

- When the programmable full flag is asserted from incoming buffer, it starts to work. It blocks the TDC data and keeps blocking until the incoming buffer becomes empty again. This decision is done channel by channel. The delimiter data can pass through this unit.
- At the throttling start/end timing, the InputThrottlingType2Start/End timing data are inserted. (Currently, the start data is not returned due to a bug...)
- Stop method. Bad events are already stored in the buffer, and we need to wait that those are read. Type2 is backup of type1. In addition, this is the trigger to start output throttling.

HBF throttling

- It sends a HB frame once per N frames. It is used if the PC cannot receive full bandwidth of the data link due to its low performance.
- To use it, we need to activate it by register.

Output throttling

- It starts to work if the programmable full flag is asserted by the LinkBuffer when the input throttling type2 is working. When working, it turns on the read enable to the BackMerger and discard the TDC data and keeps reading until the LinkBuffer becomes empty. The delimiter data passes through this unit.
- A protection from the back pressure.