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The 'Magic' Behind

High-Speed Digital Communications

Jonathan Heathcote

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Motivation

- Computers are **fast**
- Can process **huge amounts of data** per second
- SpiNNaker is (or will be…) a **million-core computer**
- …so **really huge** amounts of data!
- Taster project **building a high-speed link** to communicate with it

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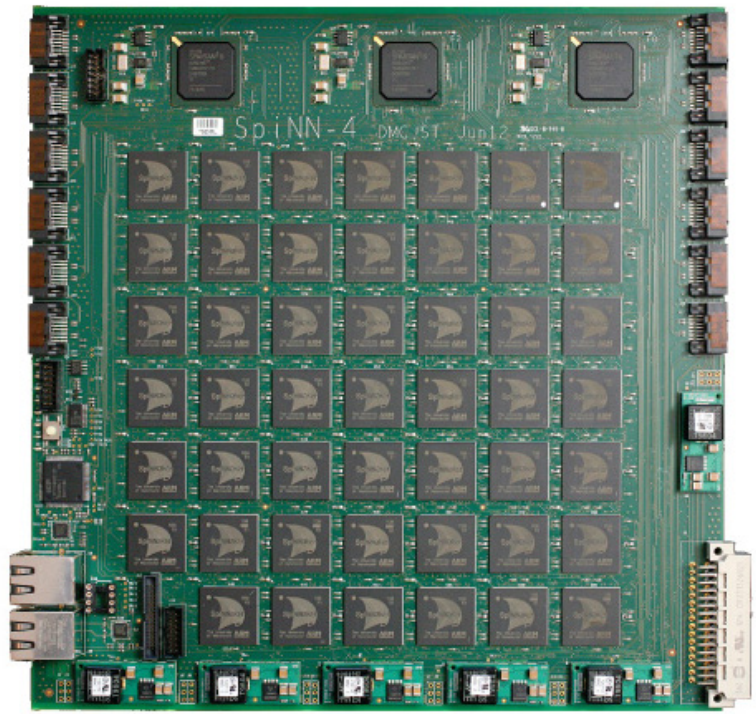
SpiNNaker: A Brain Emulator

- 1, 200 boards, 1,036,800 cores
- 12 Gigabits/sec between boards
- 120 Gigabits/sec within board
- 100 *Mega*bits/sec Ethernet too slow
- Difficult to debug
- Difficult to connect to sensors
- Need **more speed**!



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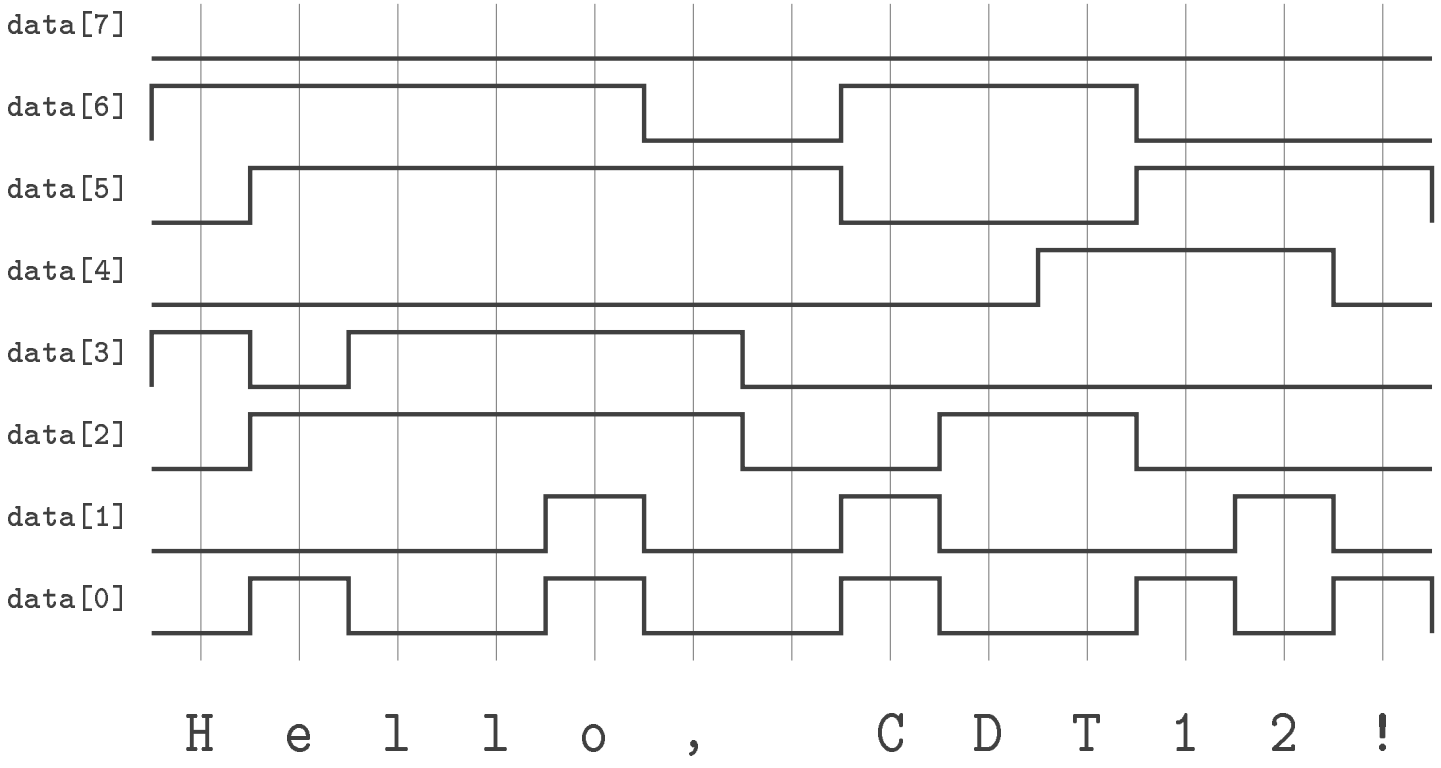
Parallel Communications



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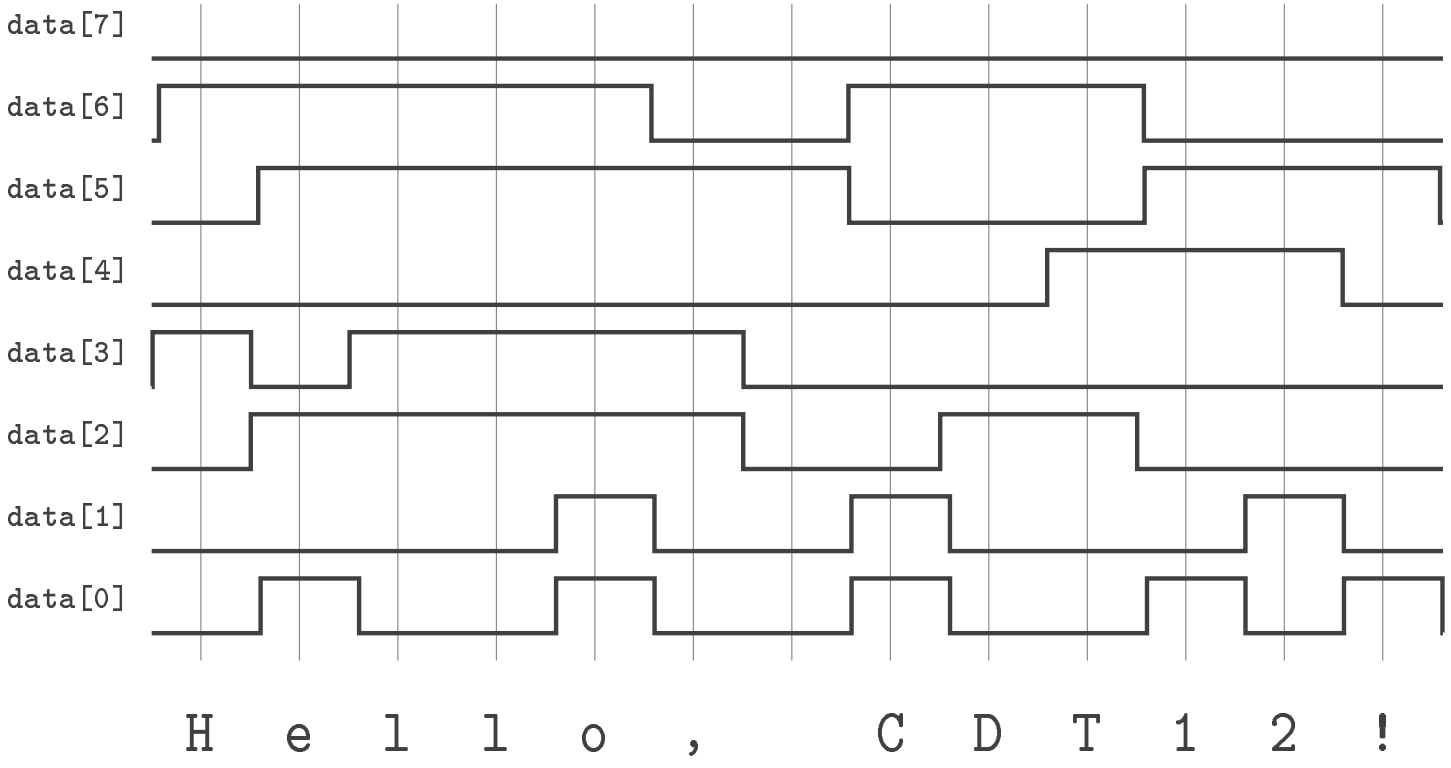
Parallel Communications



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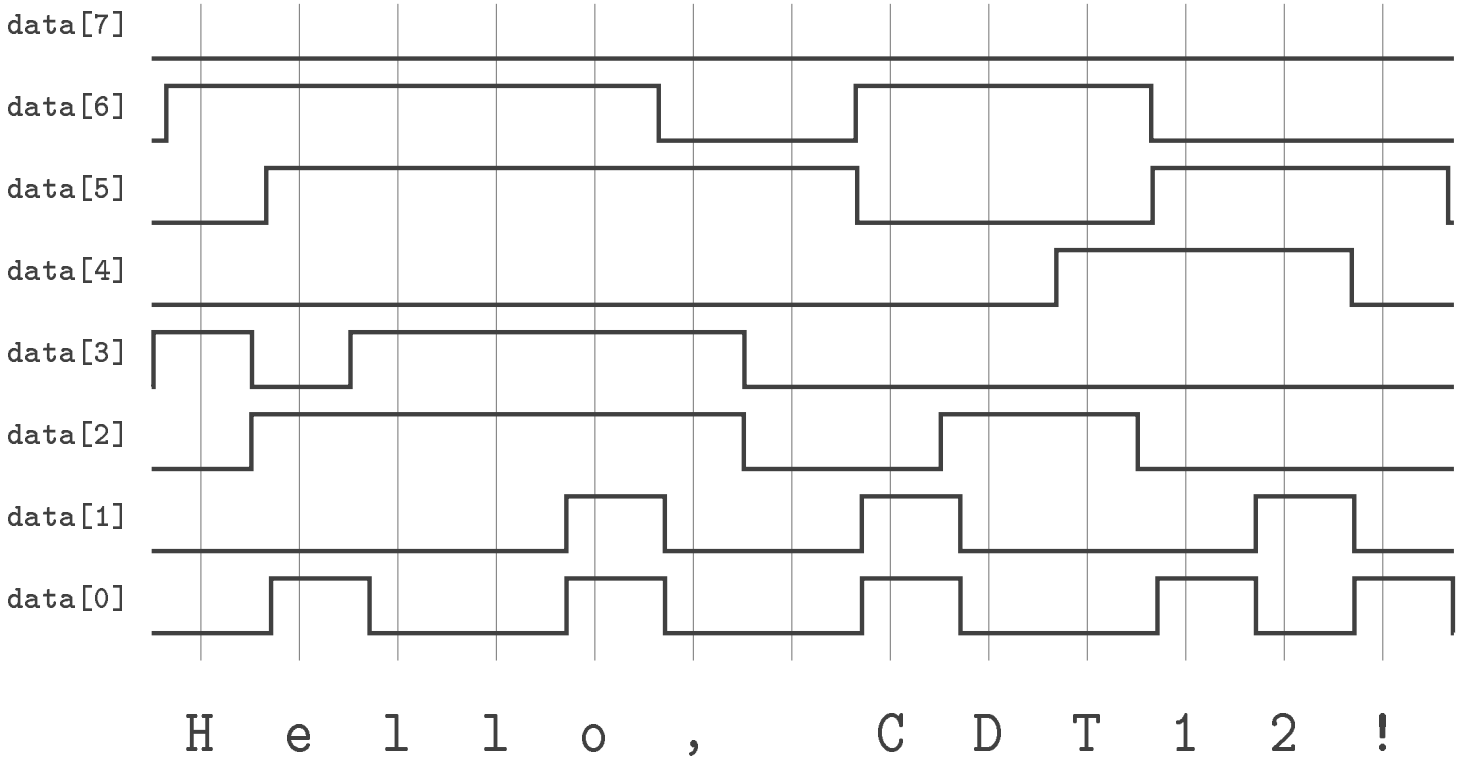

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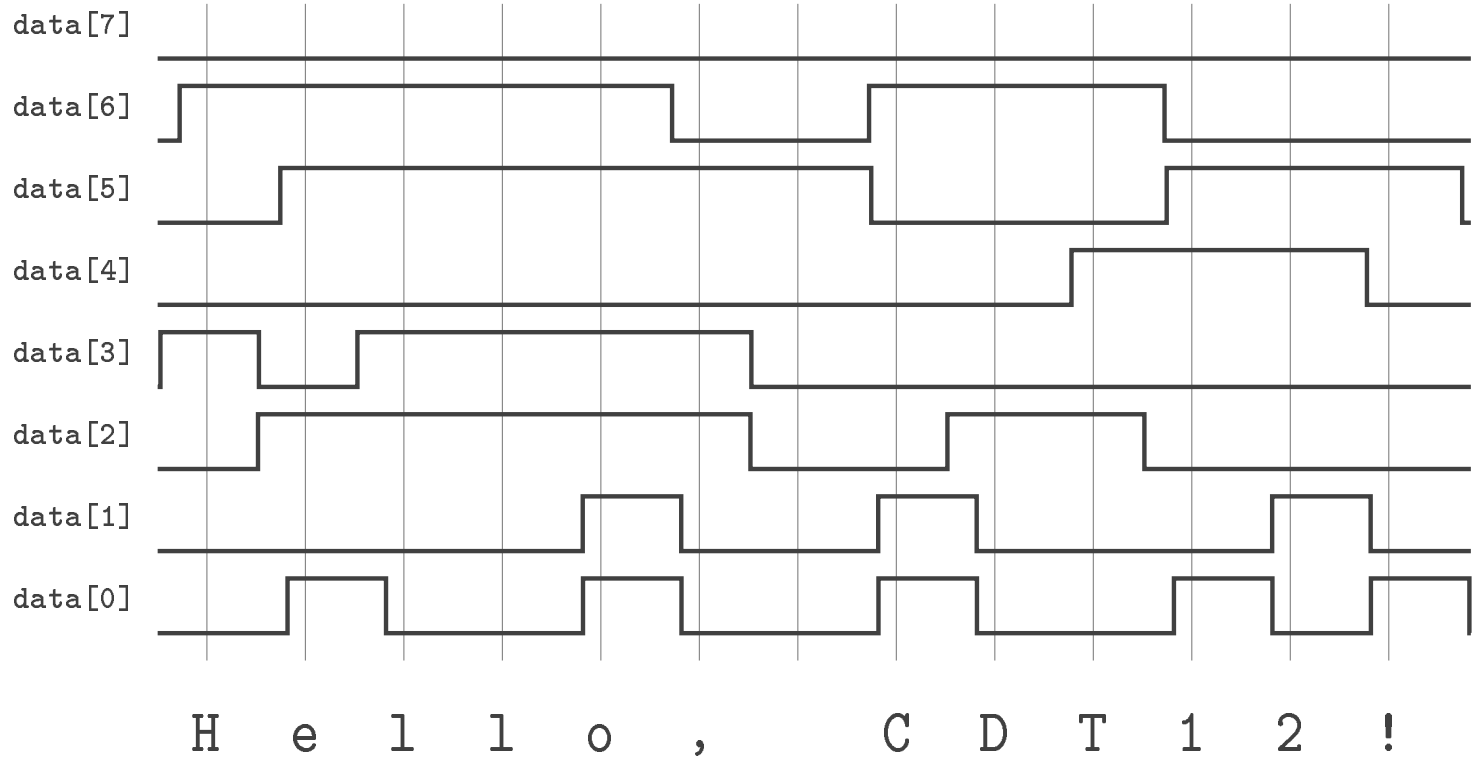

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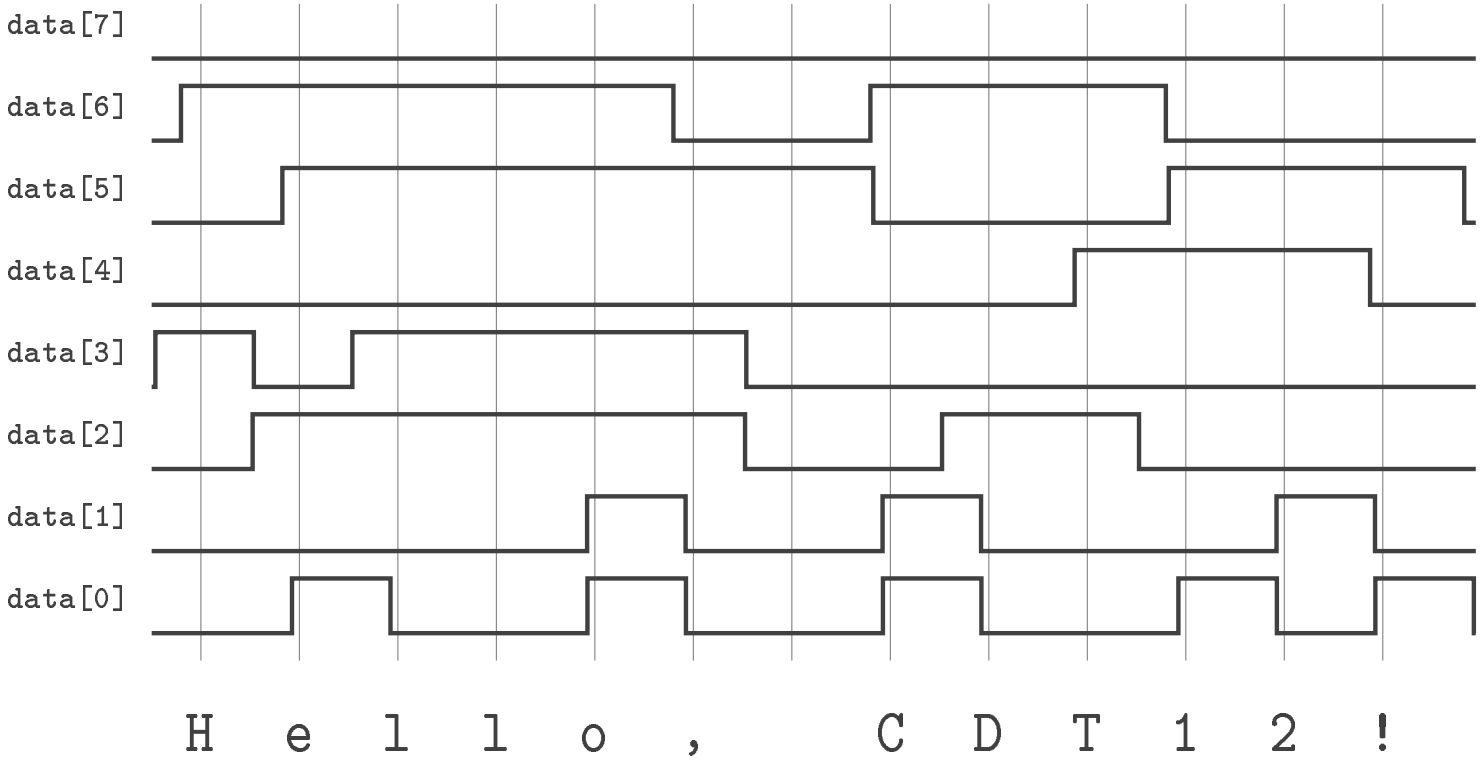

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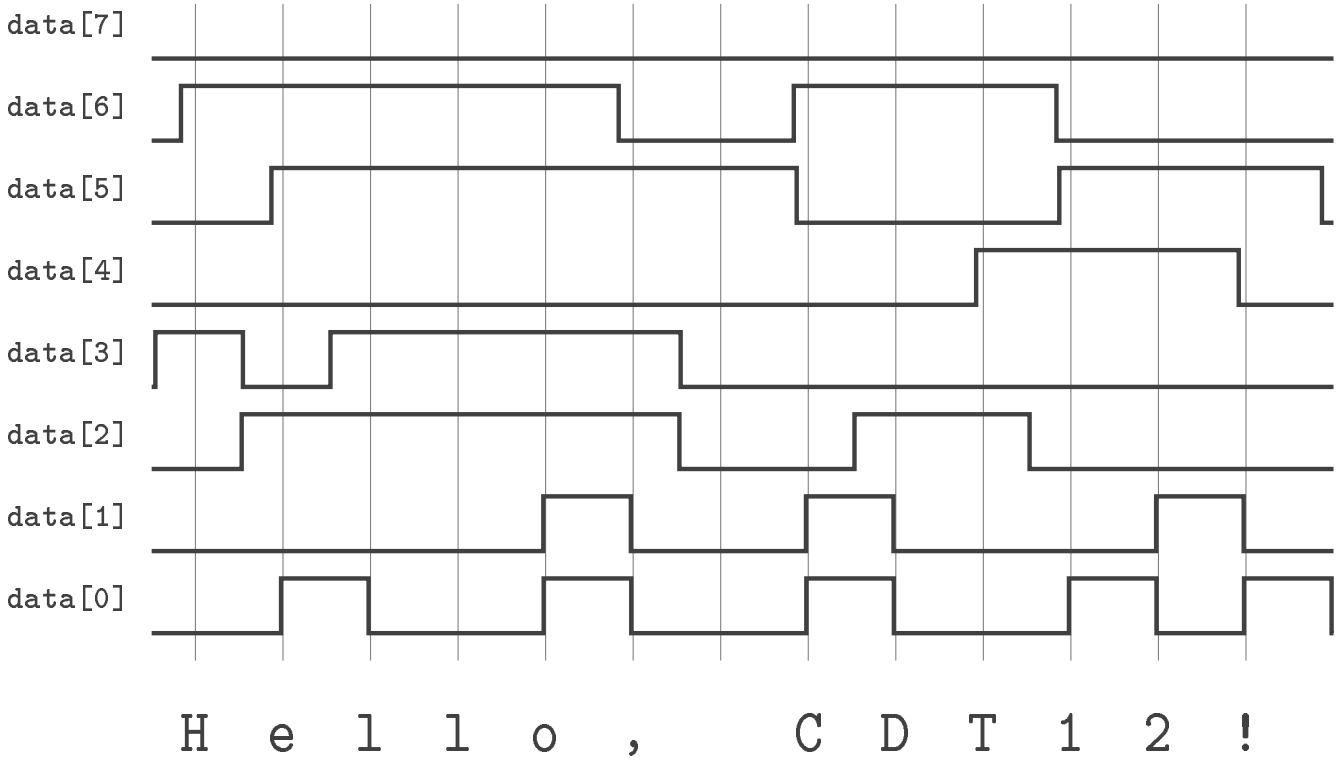

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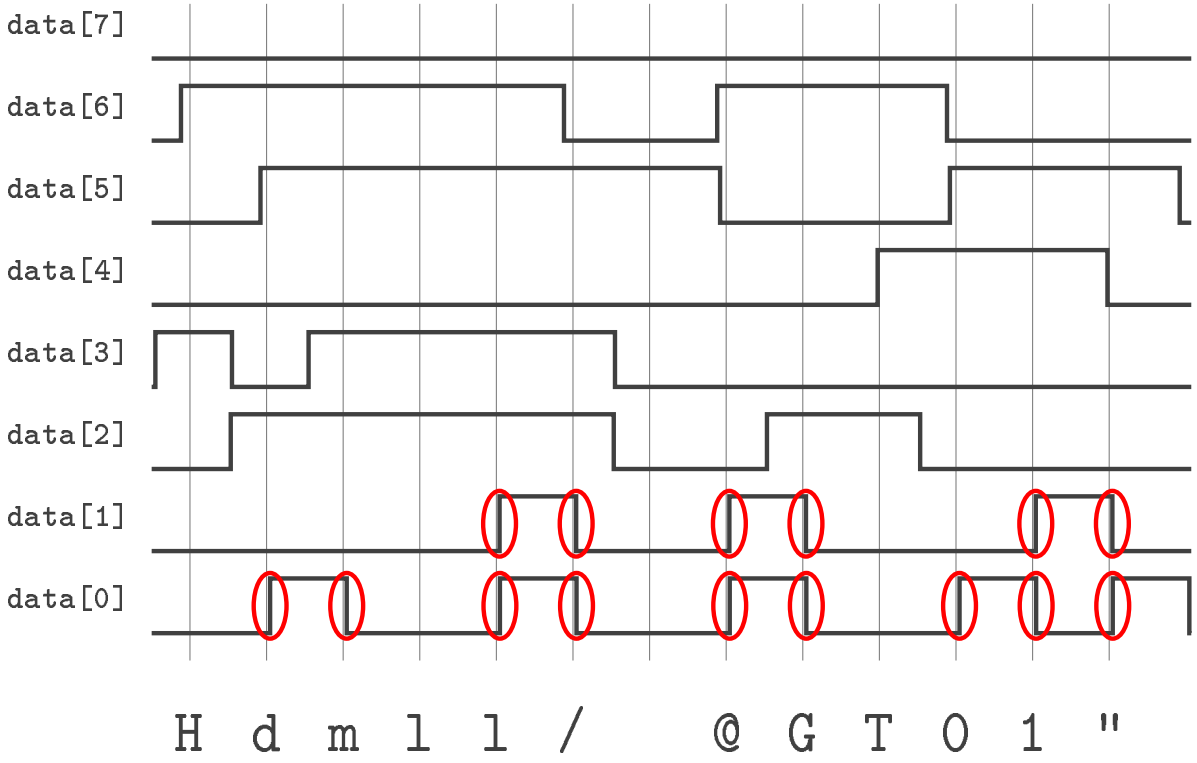

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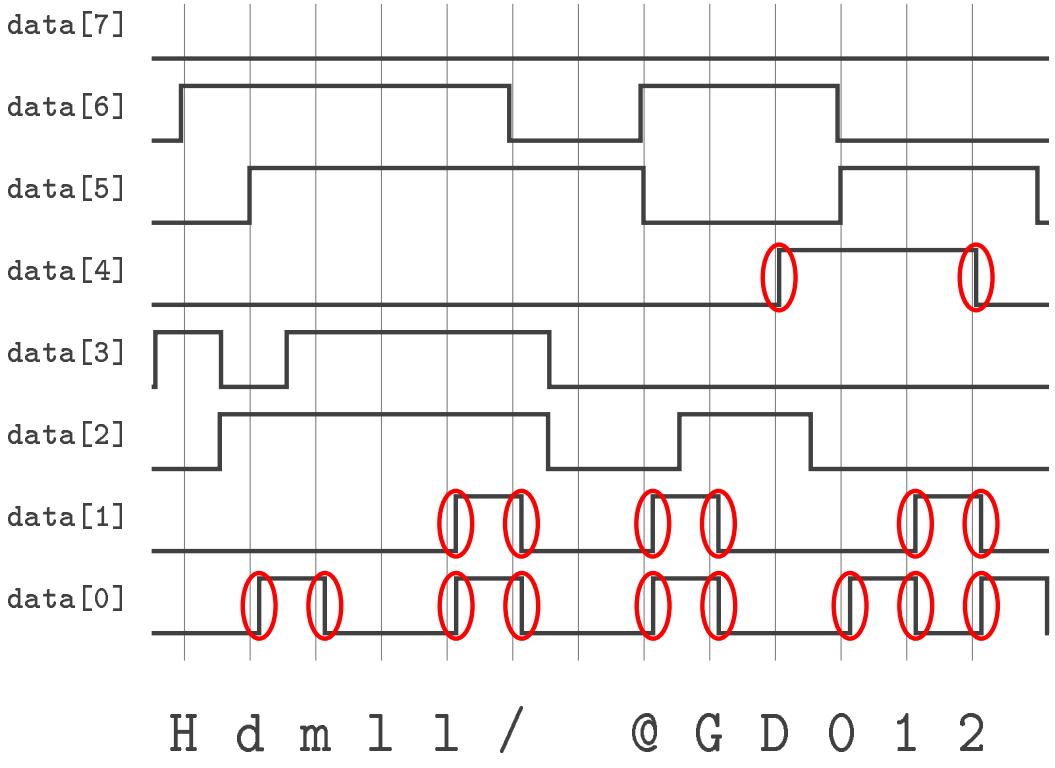

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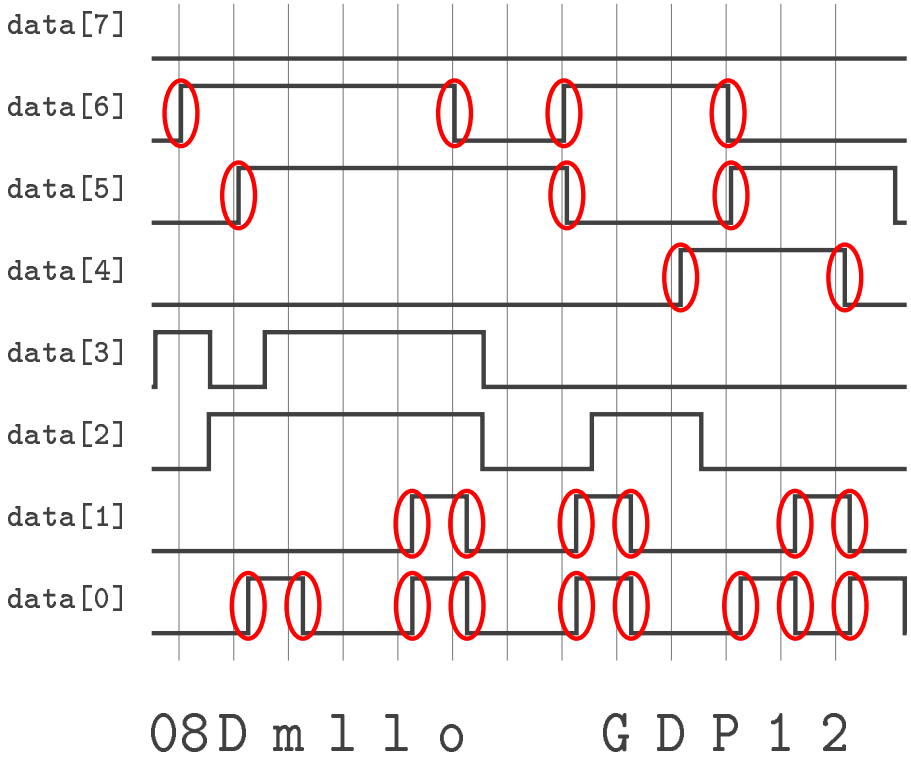

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Serial Transmission

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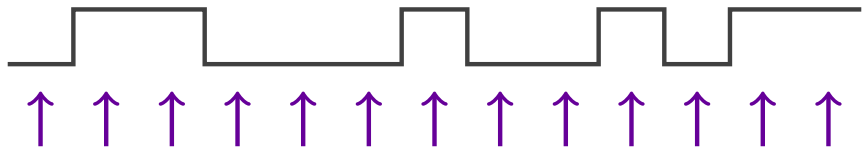
Sampling the Signal



- **Midpoint** between transitions
- **Phase detector** can find this…
- …but requires **frequent transitions**

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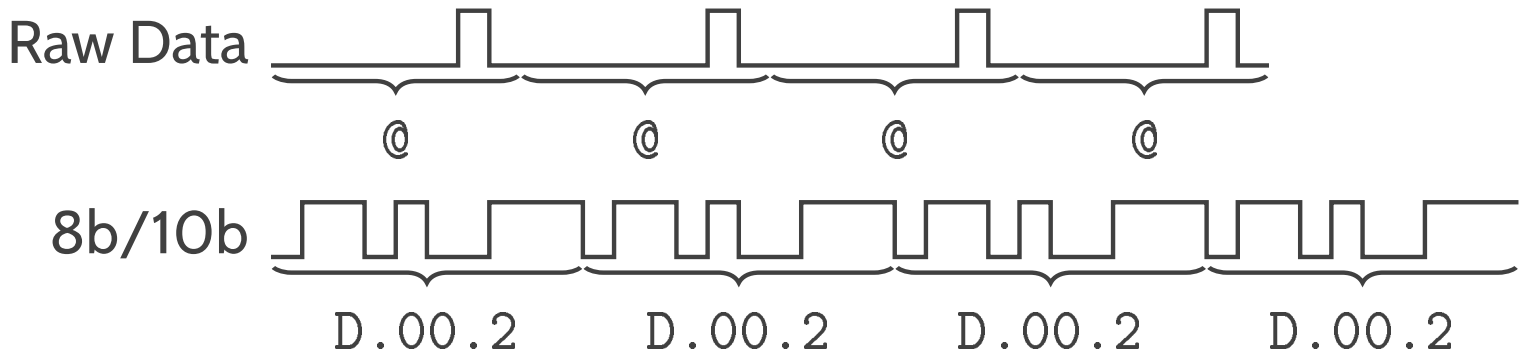
8b/10b Coding



- Encodes 8-bit bytes into 10-bit symbols
- Transitions at least every 5 bits
- 256 ‘data’ + 8 ‘special’ codes = 264 valid values

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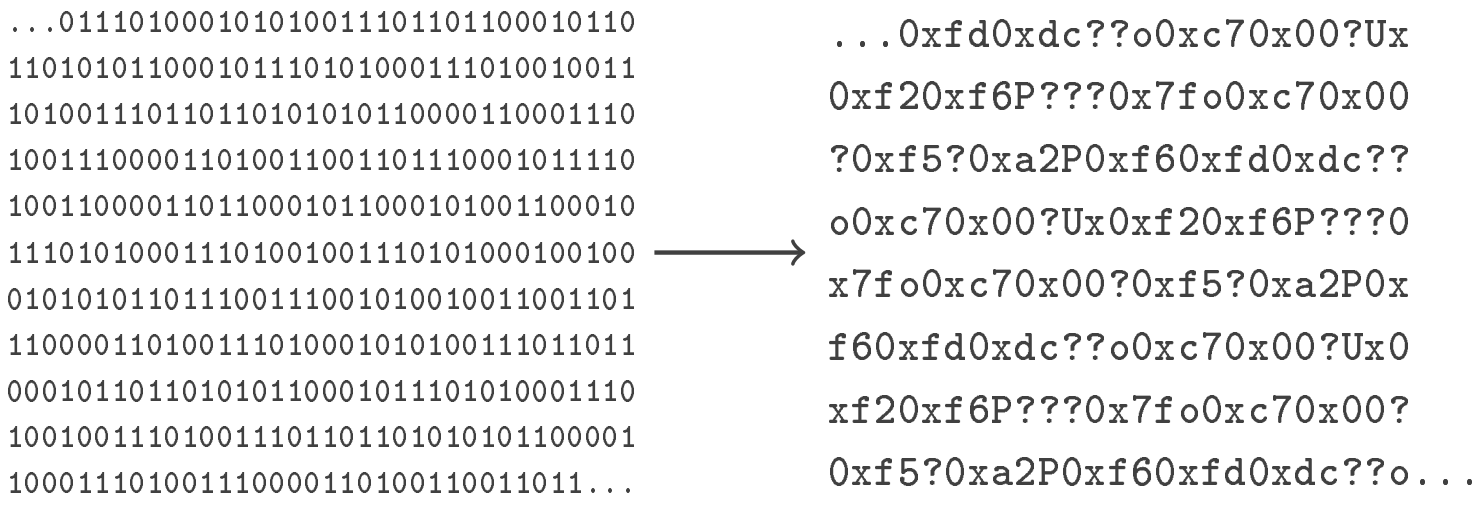
From Bits to Bytes



- Where does one byte start and another begin?

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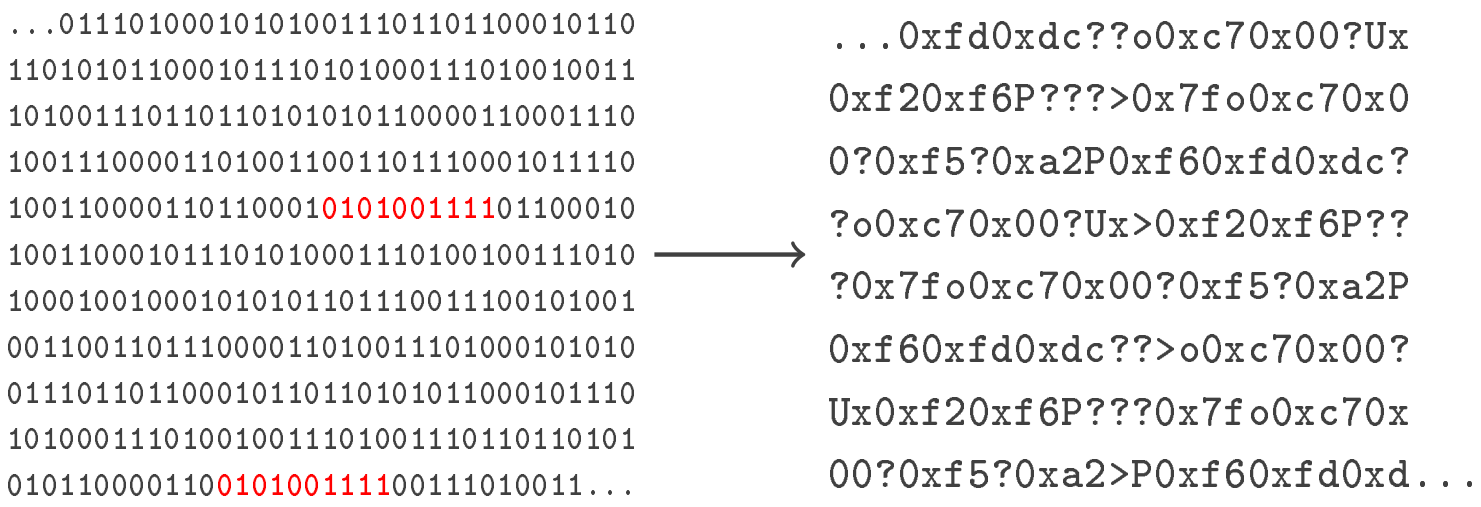

- Where does one byte start and another begin?
- Special **'comma'** code in 8b/10b inserted periodically

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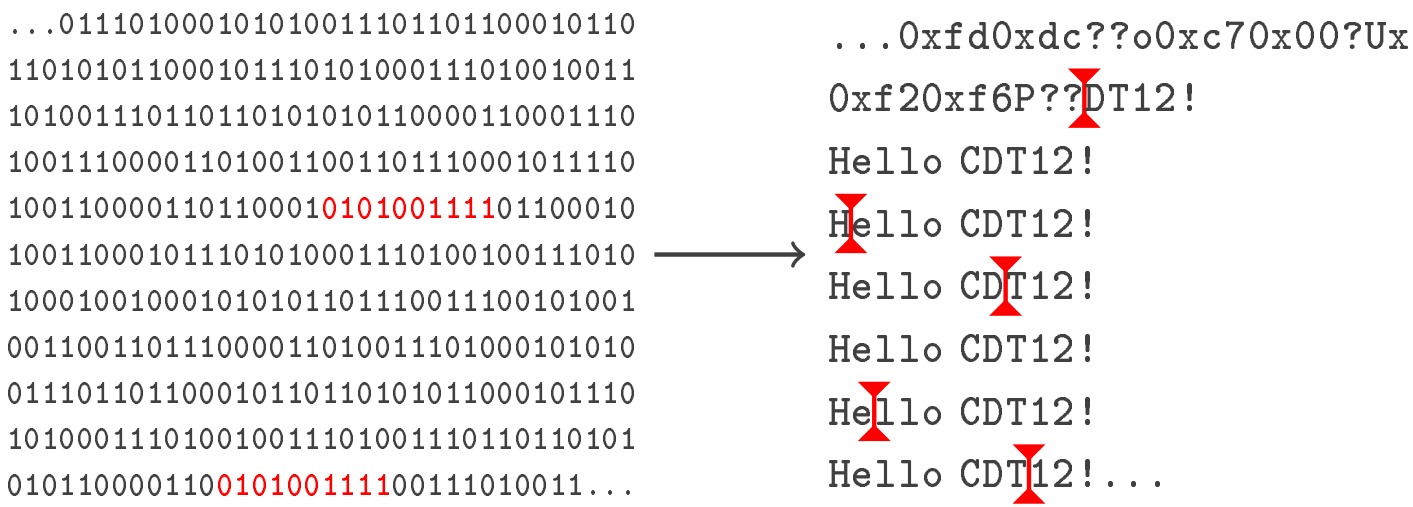

- Where does one byte start and another begin?
- Special **'comma'** code in 8b/10b inserted periodically
- When a comma is found, align bits

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Differing Transmission Rates

- Clock accuracy $\approx \pm 300$ parts-per-million (ppm)
- Off-by-one every 1666 bits
- At 16 GHz, up to **1MB extra sent/received per second**
- Solved by inserting extra **'skip packets'**

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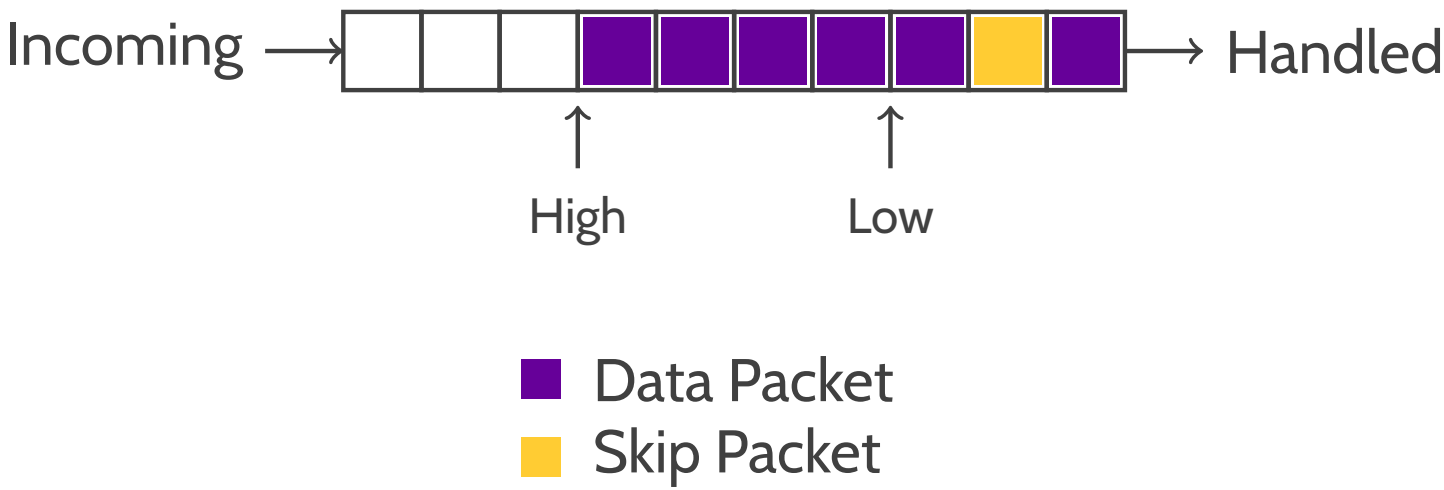
Skip Packets Example: Sender Faster

- Fills faster than empties
- Eventually falls above 'high' mark
- Skip packets **skipped to empty buffer faster**



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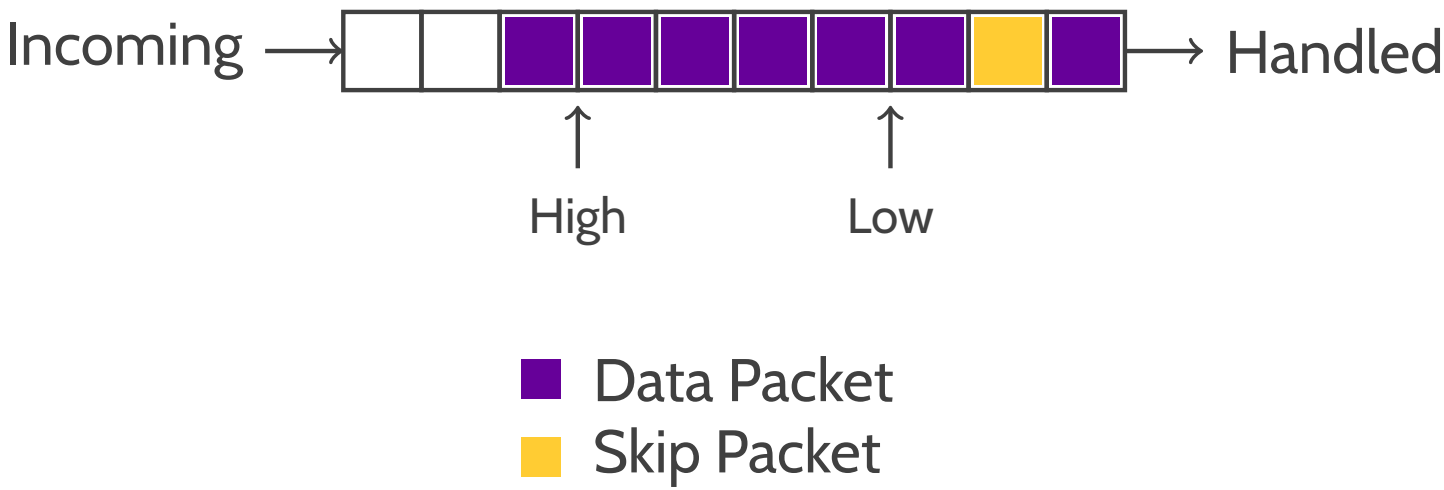

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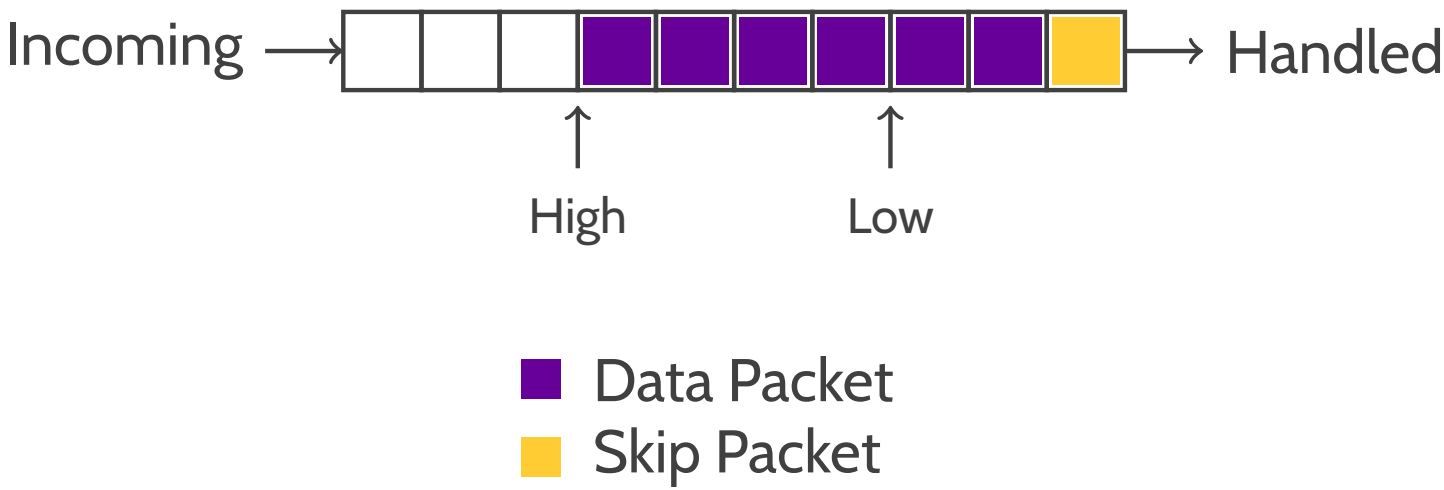

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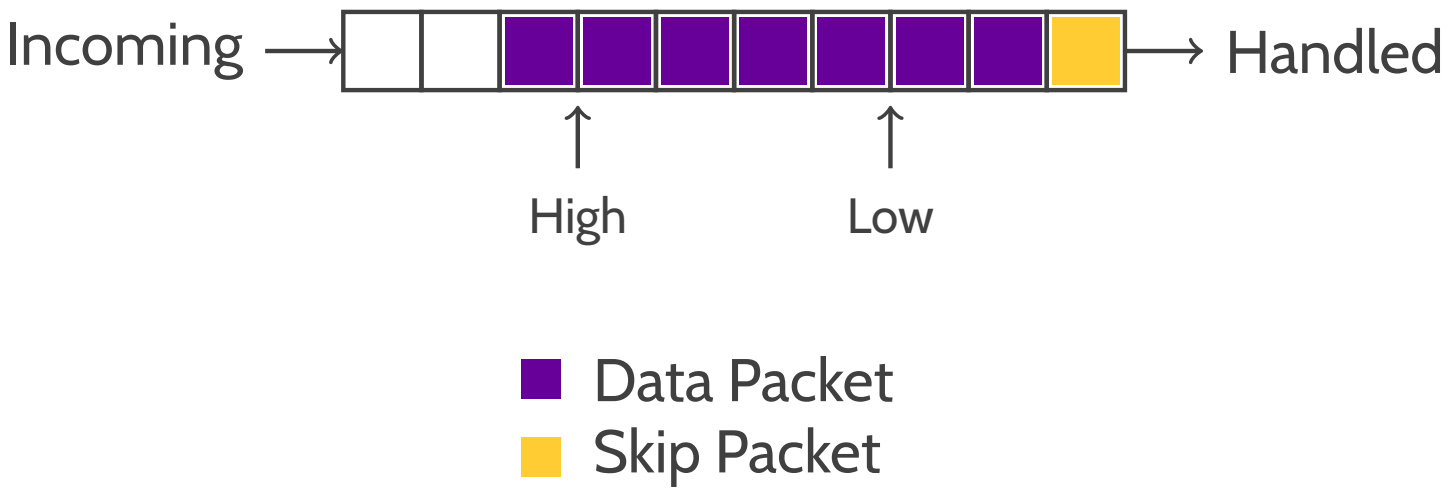

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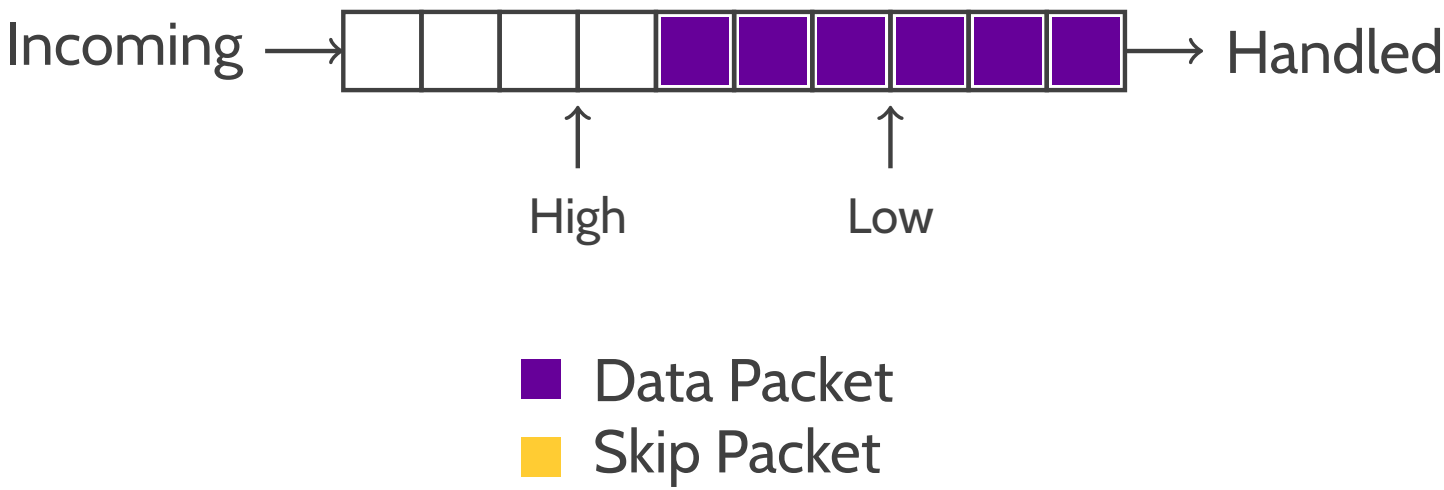

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Skip Packets Example: Receiver Faster

- Empties faster than fills
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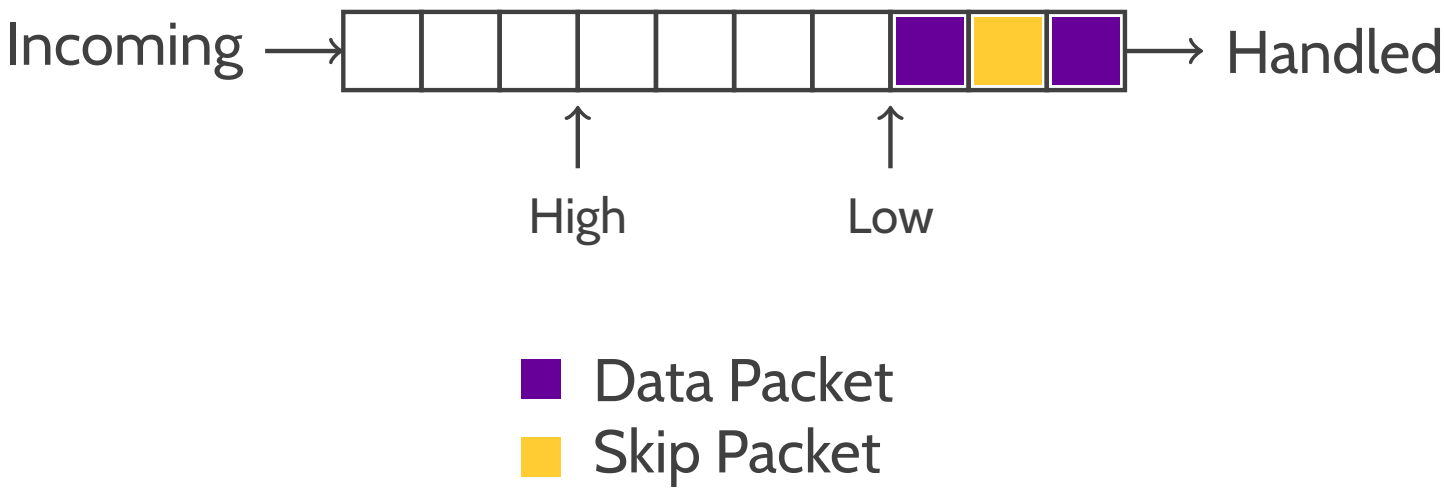
- Skip packets **duplicated to refill buffer**



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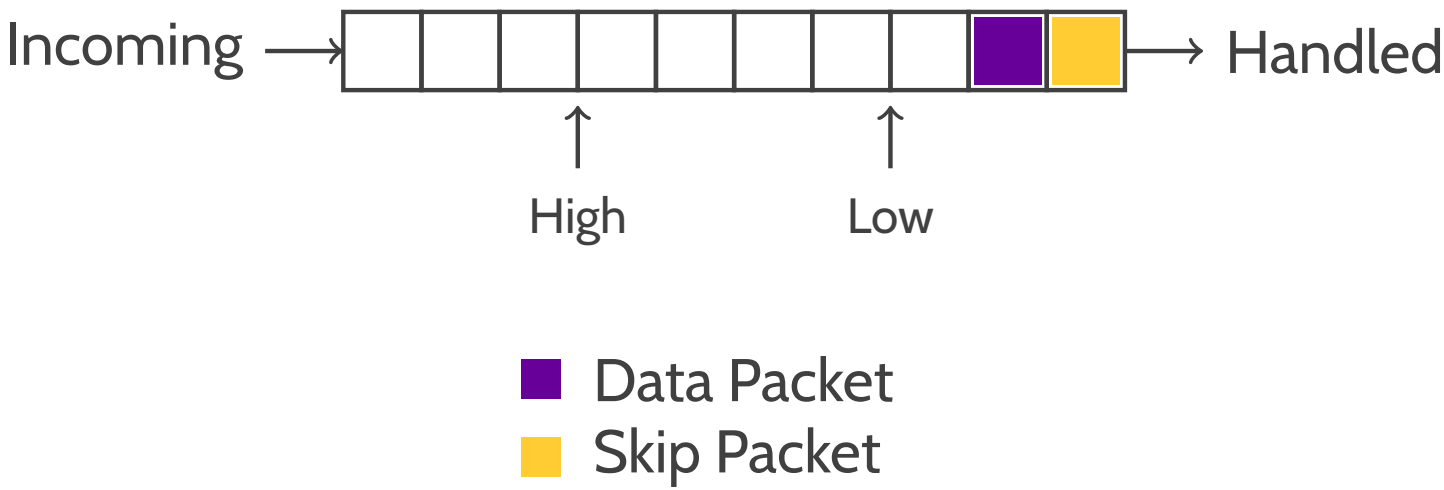

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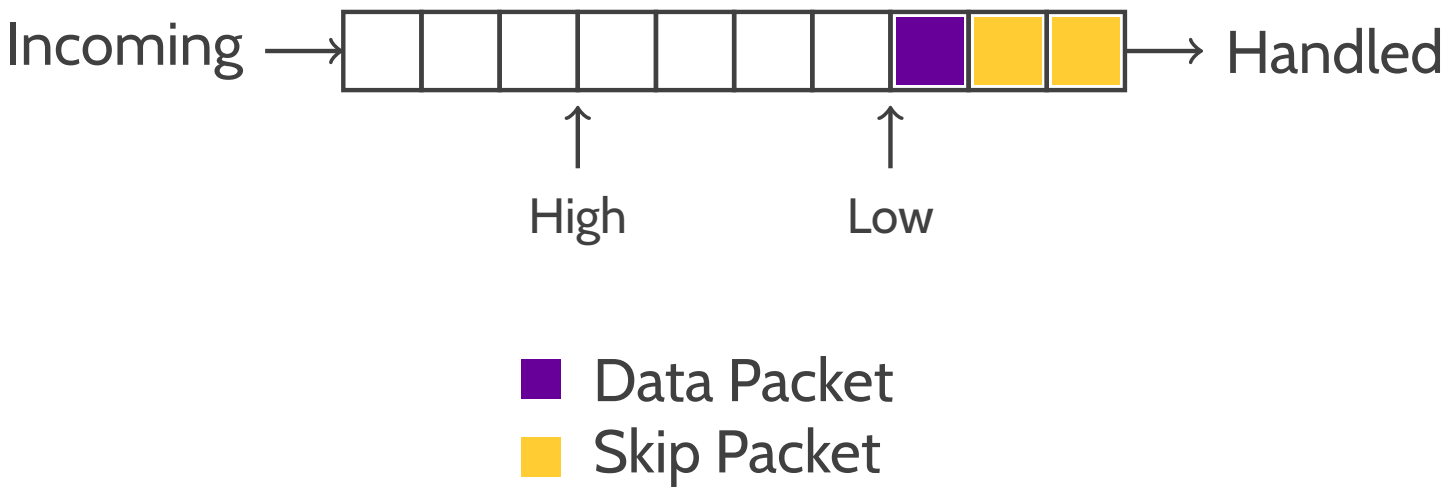

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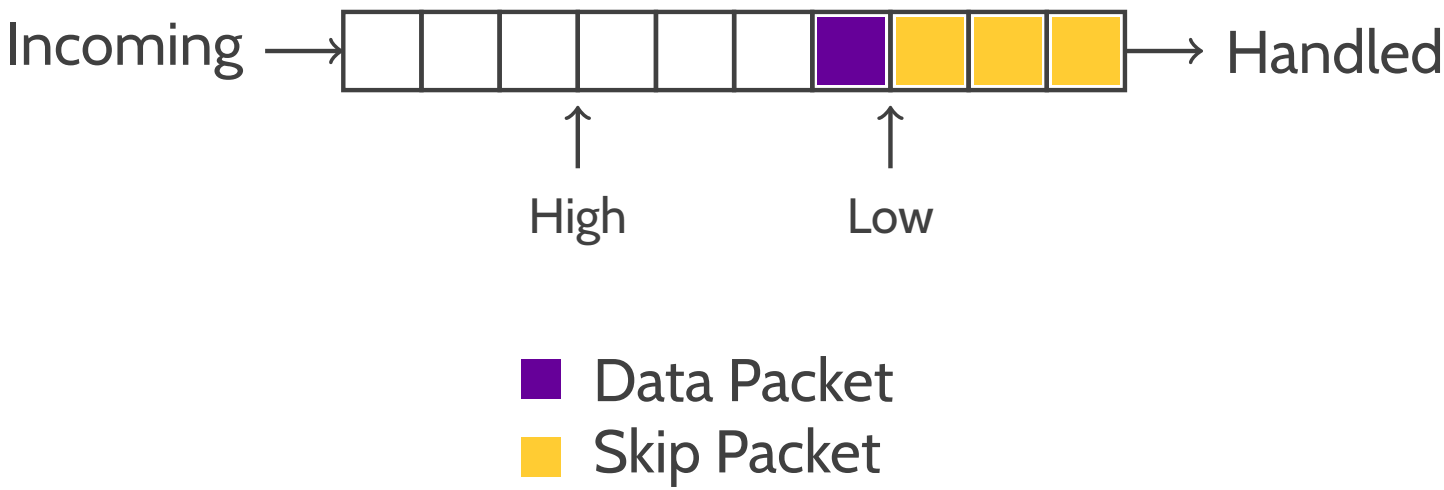

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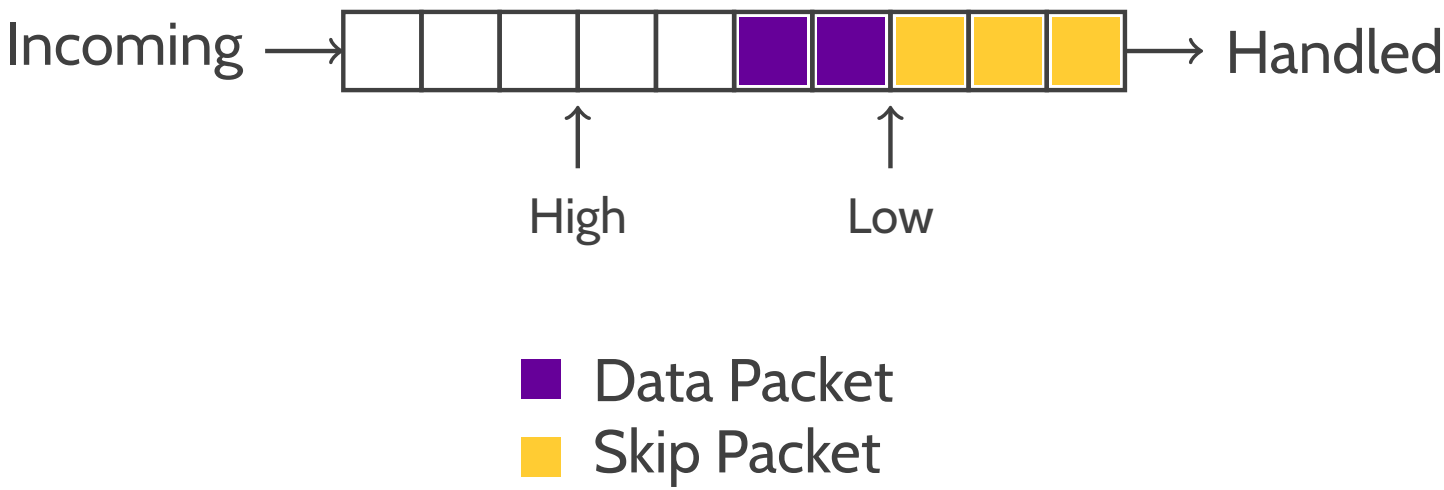

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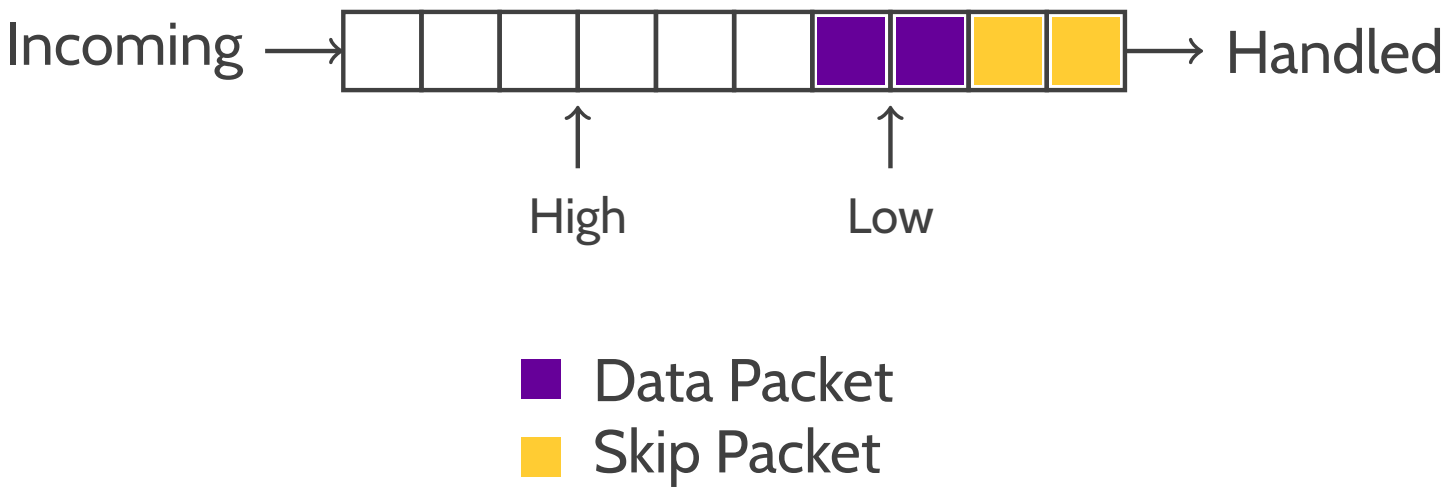

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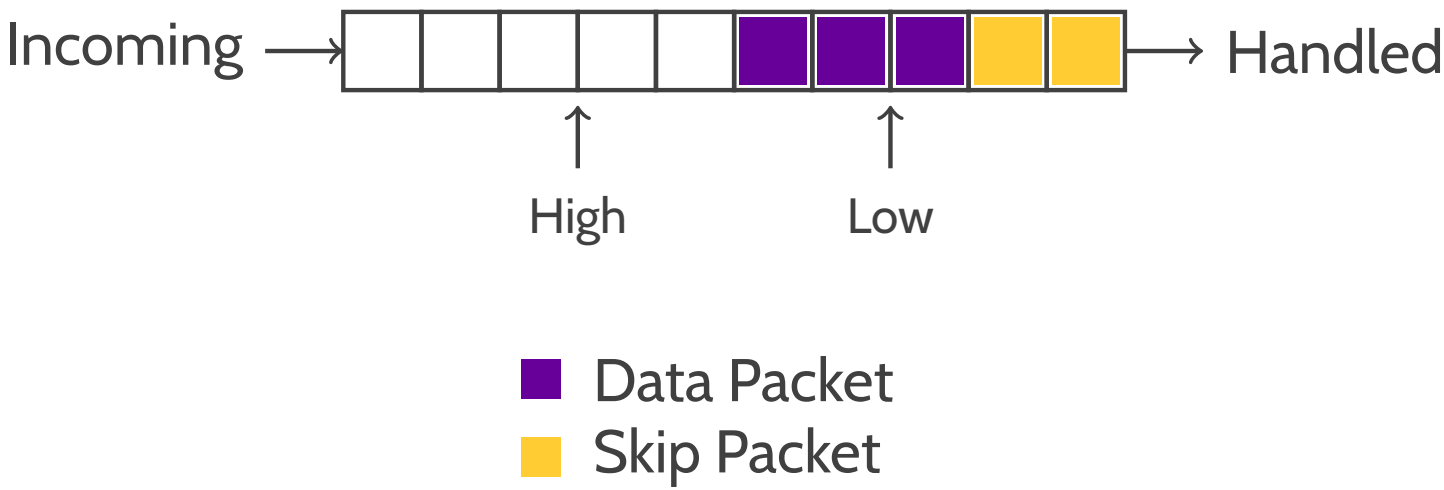

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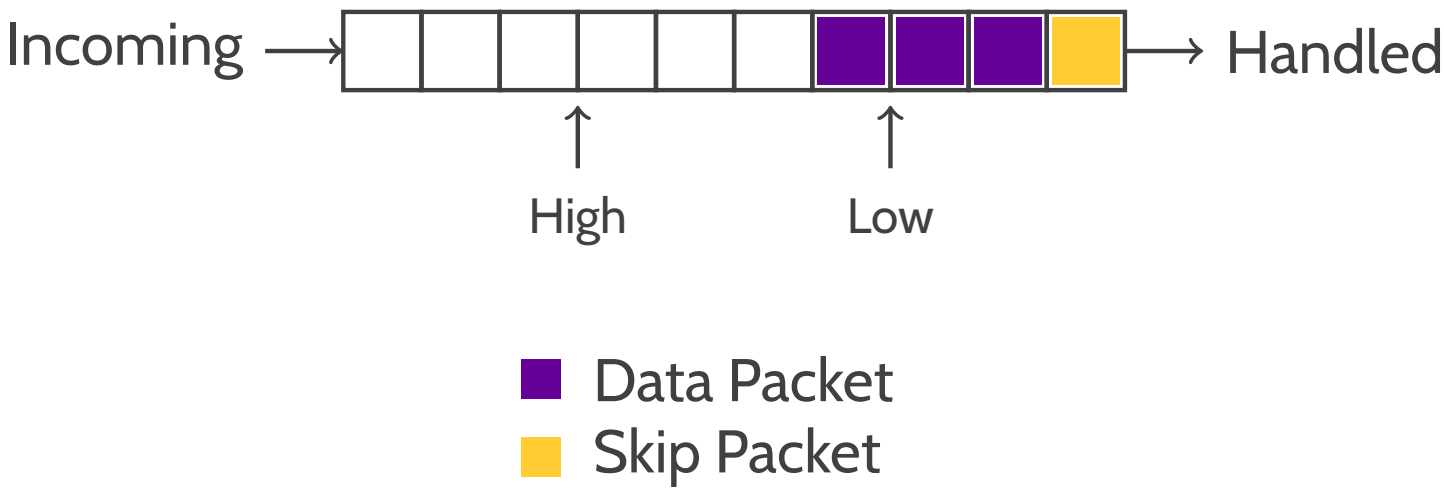

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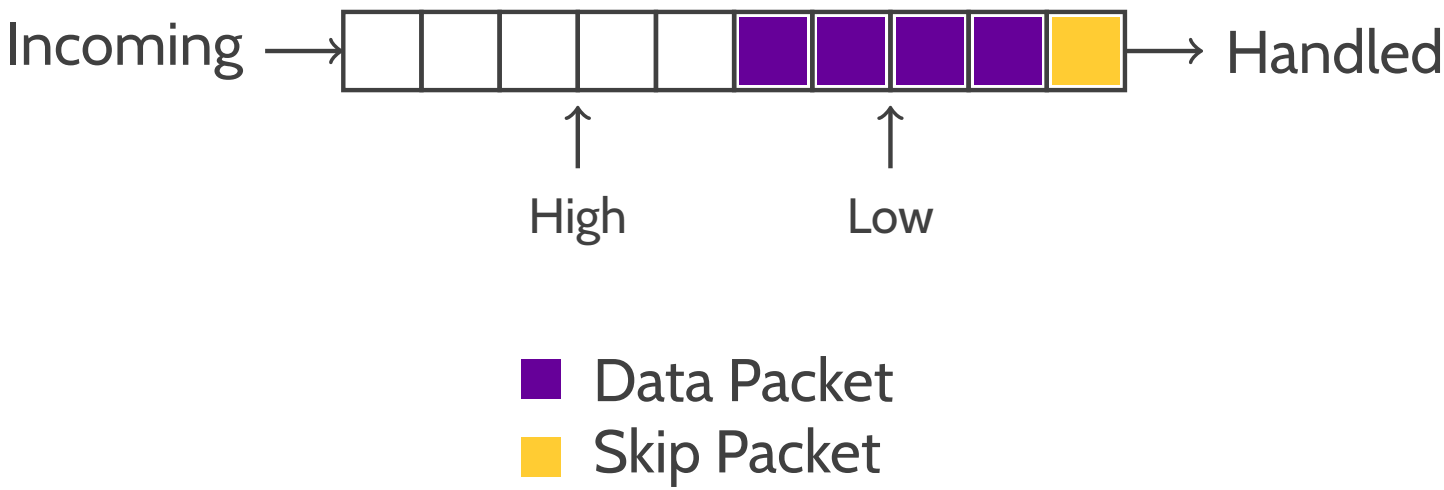

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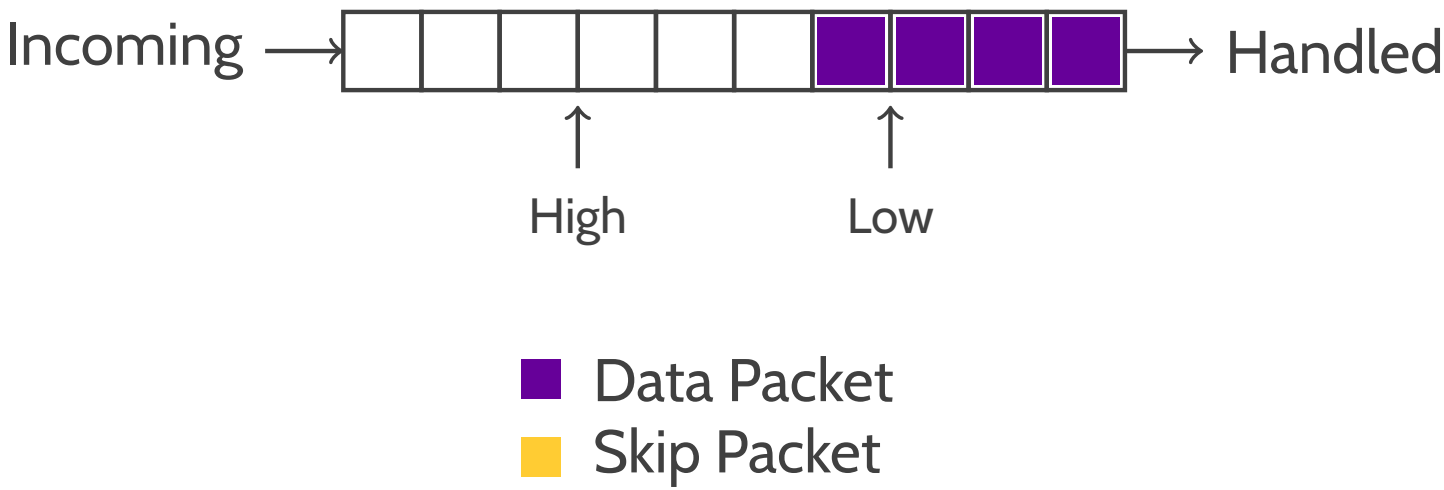

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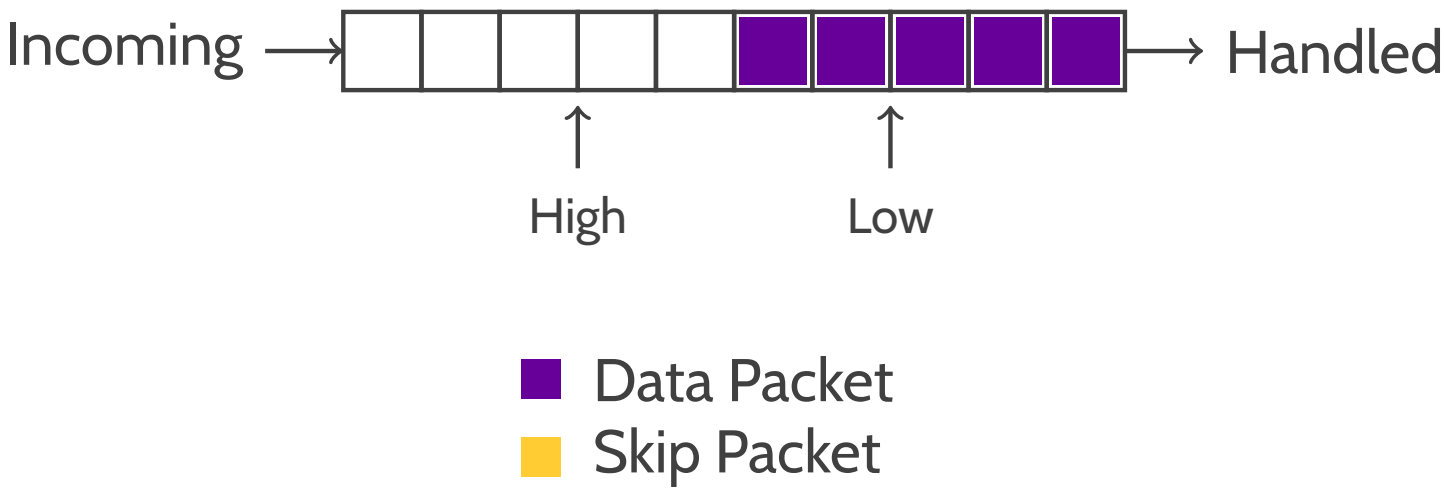

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Where Is All This Going?

- No Idea.

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Where Is All This Going?

- So…We have a fast link, now what?
- Take some ideas forward to ‘SpiNNaker 2’

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Summary

- SpiNNaker needs a fast link to the outside world
- Simple parallel links limit speed due to skew
- Avoid skew problems using **serial**
- Frequent transitions for **phase detection** with **8b/10b**
- Find the start of bytes using **commas**
- Compensate for speed differences using **skip packets**

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