InterPacket Gap and Start of Packet Lane Alignment

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Inter Packet Gap

- Frazier et. al. proposal for XGMII:
  - Minimum transmit IPG of 12 byte times (specified by MAC)
  - Minimum receive IPG of 4 byte times
  - Lane alignment: All packets start on lane 0.
- MAC constraints:
  - MAC transmitter is specified as a byte wide device
    - Technically specified as a bit wide device, but never transmits partial octets.
  - Has no knowledge of 4 byte lane alignment restrictions.
    - Therefore will not generate a packet stream where all packets naturally begin on lane 0 of the XGMII.

Options for Maintaining Lane Alignment

- 1) Change the MAC
  - Make it aware of physical layer packet alignment restrictions.
  - Round each IPG up to get 4 byte alignment for next packet.
- 2) Allow preamble compression
  - When a frame from the MAC transmitter would “naturally” begin on a lane other than lane 0, delete preamble bytes until the packet can begin on lane 0.
- 3) Allow variation in the minimum IPG at the XGMII
  - Allow packets to be held back until the next lane 0 alignment, and make up by shrinking a subsequent IPG. The minimum IPG observed at the XGMII would “dither” between 9 and 15 bytes, but would average 12. The minimum IPG “observed” at the MAC would always be 12.

Precedent from Gigabit Ethernet

- Same issue arose because the two symbol 8B/10B idle sequence imposed a two byte alignment restriction.
- Decision was made not to modify the MAC.
- Preamble compression was chosen over IPG variation:
  - The IPG variation, combined with potential IPG shrinkage in repeaters, could result in a IPG short enough to affect fairness in half-duplex operation.
  - This is not a concern in 10 Gigabit Ethernet, so either preamble compression or IPG variation could be chosen.

Recommendation for 10 Gigabit Ethernet

- No change to the MAC
  - Making the MAC aware of 4 byte alignment restriction at a particular speed is contrary to the goal of a speed independent MAC.
  - Makes 10GE < 10 * GE packet rates for odd packet sizes.
- No preamble compression
  - Preamble compression would allow SOP to be aligned to lane 0, but SFD would not be. This eliminates any simplicity achieved by the lane alignment restriction in the first place.
- Pick IPG variation
  - MAC always generates 12 byte minimum IPG. The packet can “slide” forward or backward to meet lane alignment while maintaining 12 byte average.

Impact

- Impact on specification:
  - No change to MAC, min IPG remains 12 bytes (96 bits)
  - XGMII specs minimum of two full columns of Idle following the “T” column (min IPG of 9 bytes at XGMII while MAC assures an avg min of 12 bytes).
- No impact on implementations:
  - No change to required tolerance on received IPG.
  - Transmitters allowed to always round up minimum IPG to next lane alignment if simpler for wide MAC implementations.

Example

- Packet flow from MAC with 12 byte IPG and no knowledge of 4 byte alignment restrictions:

```
d d d I I I d d d d d d d d d d d d d d d d d I I I d d d
d d d I I I d d d d d d d d d d d d d d d d d I I I d d d
d d d I I I d d d d d d d d d d d d d d d d d I I I d d d
d d I I I d d d d d d d d d d d d d d d d d d I I I d d d
```

- RS Aligns by “sliding” packet forward within the window between previous and subsequent packets:

```
d d d I I I S d d d d d d d d d d d d d d d d d I I S d d
d d d I I I d d d d d d d d d d d d d d d d d T I I d d d
d d d I I I d d d d d d d d d d d d d d d d d I I I d d d
d d T I I I d d d d d d d d d d d d d d d d d I I I d d d
```

IPG Length Table

Packet Length Modulo 4 \ RS delay at end of packet (in bytes)	**0**	**1**	**2**	**3**
n + 0	12 / 0	12 / 1	12 / 2	12 / 3
n + 1	15 / 3	11 / 0	11 / 1	11 / 2
n + 2	14 / 2	14 / 3	10 / 0	10 / 1
n + 3	13 / 1	13 / 2	13 / 3	9 / 0

IPG Length / RS delay at end of IPG

RS delay at end of packet (in bytes)

Thank you!

IPG cases

- 2 column cases (9-12 byte IPG):

d T A R S	d d A R S	d d A R S	d d A R S
d K A R d	d T A R d	d d A R d	d d A R d
d K A R d	d K A R d	d T A R d	d d A R d
d K A R d	d K A R d	d K A R d	d T A R d

- 3 column cases (13-16 byte IPG):

d T A R K S	d d A R K S	d d A R K S	d d A R K S
d K A R K d	d T A R K d	d d A R K d	d d A R K d
d K A R K d	d K A R K d	d T A R K d	d d A R K d
d K A R K d	d K A R K d	d K A R K d	d T A R K d