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# Technical Feasibility of 400GE Architecture with Stronger FEC

*Tongtong Wang, Wenbin Yang, Xinyuan Wang*

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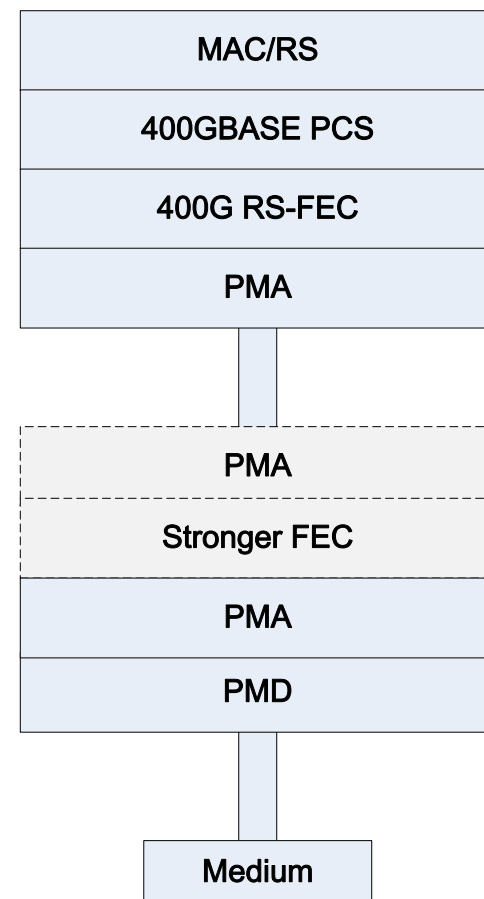HUAWEI TECHNOLOGIES CO., LTD.        IEEE 802.3 400GbE Study Group

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# Motivation

- **High speed Ethernet connections, such as 400GbE, especially with advanced modulations, significantly increase the complexity of PMA and/or optical and electrical PMDs**
  - Stronger FEC than the genericFEC may be needed to satisfy the system performance requirement
- **This contribution includes two parts**
  - Discuss interoperation scenarios between different CDAUI-n
  - Investigate different approaches in 400GbE architecture to support stronger FEC

# 400GE PCS Architecture with Stronger FEC

- One unified PCS architecture with generic FEC is feasible to cover most PMA/PMDs with 25/50/100Gbps lanes per lambda, optical fiber, copper cable, or SerDes lane;

- Stronger FEC could be used for PAM-n/DMT or specific applications.
  - Refer to **zhai_400_01_0713.pdf, takahara_400_01a_0913.pdf, nicholl_400_01_0713.pdf**

- 400GbE PMDs are not defined yet, so we should define the PCS architecture to adapt to possible future options.

| MAC/RS |
| :---: |
| 400GBASE PCS |
| 400G RS-FEC |
| PMA |

| PMA |
| :---: |
| Stronger FEC |

| PMA |
| :---: |
| PMD |

| Medium |
| :---: |

# Generic FEC Possibilities

| FEC code RS(n,k,t,m) | overclcoking | Trans-coding | Effective Gain | Total Area (40nm) | Overall Latency | Total Power |
|---|---|---|---|---|---|---|
| RS(528,514) | 0% | 256b/257b | 4.87dB | 275k | 99.4ns | 101mW |
| RS(544,514) | 3% | 256b/257b | 6.10dB | 516k | 121.5ns | 187mW |
| RS(560,514) | 6% | 256b/257b | 6.39dB | 871k | 110ns | 318mW |

- **Generic FEC can use any one of RS(528/544/560, 514) as mandatory;**

- **Defining different generic FEC for different PMDs increases the complexity and cost of PCS.**

  - We suggest to pick just one algorithm for the generic FEC.

*Refer to FEC_options_gustlin_01_0112

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# Possible Stronger FEC

| | application | Code type | OH (%) | NCG (dB) @1E-5 |
|---|---|---|---|---|
| Medium Strength RSFEC | 100GE-KP4 | RS(544, 514, 15, 10) | 5.84 | 6.85 |
| | ITU-T G.975 / G.709/Y.1331 | RS(255, 239, 8, 8) | 6.69 | 6.20 |
| BCH | ITU-T G.975.1 I.3 | BCH(3860,3824) / BCH(2040,1930) | 6.69 | 8.99 |
| BCH x BCH | 802.3bm FEC discussion * | BCH(92, 70, t=3) x BCH(90, 68, t=3) | | > 11dB |
| | | BCH(180, 132, t=6) x BCH(92, 70, t=3) | | 8.5dB/12dB |

- **Since complex and stronger FEC in optical module significantly increases the cost and constrain 400GE market potential,  ideally, the stronger FEC chosen should have the following properties: moderate complexity, enough code gains, and limited trancoding cost if not being able to avoid it.**

*Refer to wang_01_0912_optx, wang_01_0113_optx

# FEC Effect on 400GbE Architecture
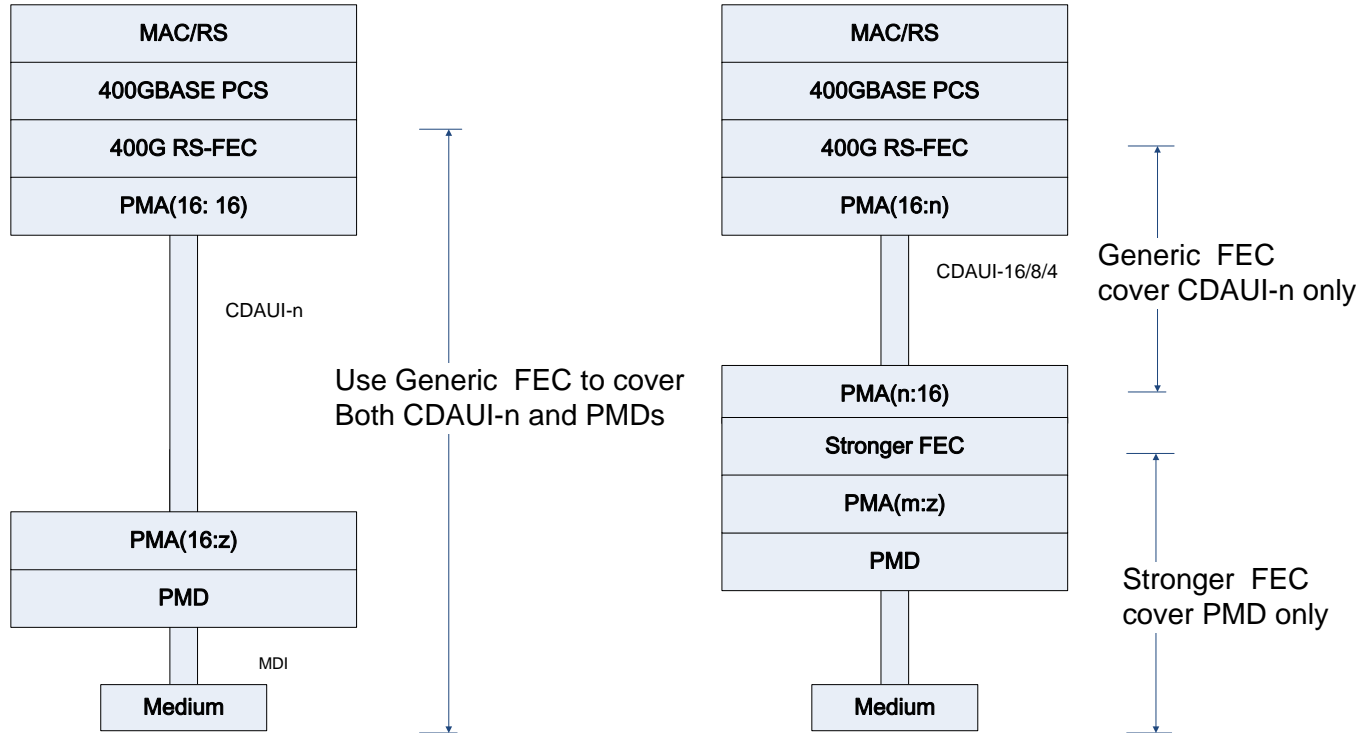


- **In 400GbE early stage, the generic FEC can cover both CDAUI-16 and most PMDs.**
- **For PMDs with advanced modulations, use the generic FEC for CDAUI-n link, and stronger FEC for the PMDs;**
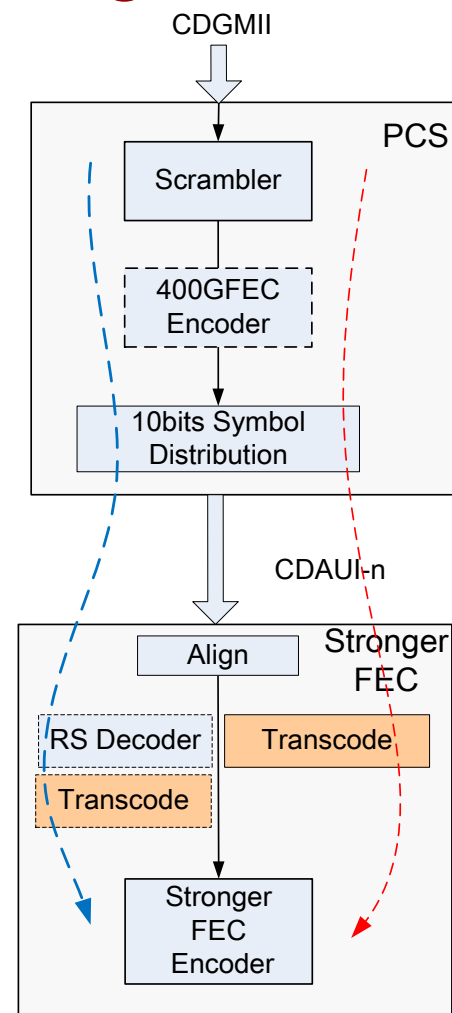- **Keep the same PCS architecture to support CDAUI-n/PMD evolvements.**

# 400GbE Interoperation Between Different CDAUI-n

- **Define one PCS/FEC architecture to support CDAUI-16/8/4 interoperation.**
- **The generic FEC should be identical with or without stronger FEC.**
- **Additional stronger FEC on both sides does not affect the interoperation.**
- **Symbol based Mux/demux is essential for this scenario.**
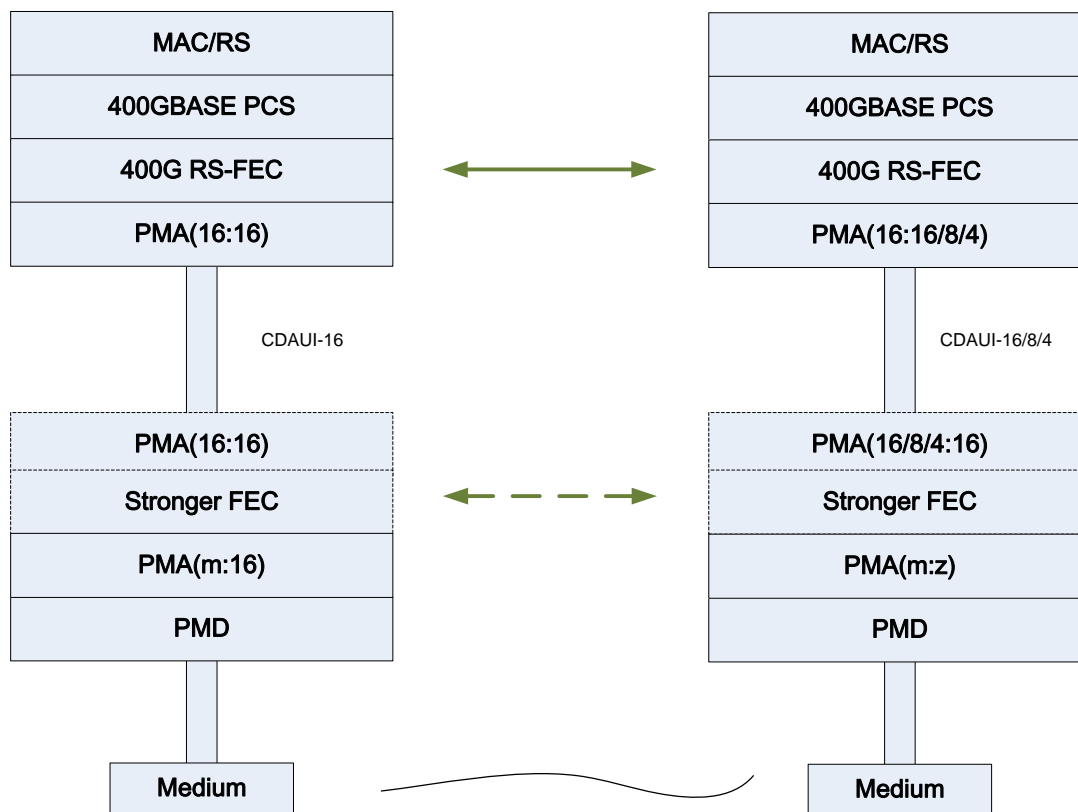
# Generic FEC & Stronger FEC Configuration

- **Bypass the generic FEC to reduce latency and power consumption , use stronger FEC to compensate link budget on PMDs.**

- **Enable the generic FEC for CDAUI-n protection.**

- **Two approaches in 400GE with stronger FEC**
    - Generic FEC enabled (blue data path)
    - Generic FEC disabled (red data path)

- **Process on Stronger FEC layer**
    - Decode the generic FEC or not
        - Yes: encode stronger FEC
        - No: just wrap stronger FEC checksum on
            - Skip decode step for lower latency
            - May induce overclocking and extra overhead issues
            - No additional coding gain.



CDGMII

PCS

Scrambler

400GFEC Encoder

10bits Symbol Distribution

CDAUI-n

Stronger FEC

Align

RS Decoder      Transcode

Transcode

Stronger FEC Encoder

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# TC Considerations For Stronger FEC

|  | 256b/257b based Stronger RS-FEC | Other RS FEC options |
|---|---|---|
| 64b/66b PCS coding | Transcode needed | transcode is always needed for higher coding efficiency. |
| 256b/257b PCS coding | No transcode needed | Perhaps no transcode needed when coding efficiency is good enough for PMD overhead limitation. |

- **256b/257b coding is suitable for stronger RS-FEC or other FEC algorithm, from the prospective of coding efficiency .**
- **Better use 256b/257b DC PCS coding to have hamming distance across PMA interface and save transcoding on stronger FEC layer, when the generic FEC is bypassed.**

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# Summary

- **Define one PCS/FEC architecture to support a generic FEC and future stronger FEC.**

- **Interoperation between CDAUI-16/8/4 is feasible with symbol based multiplexing/de-multiplexing.**

- **The generic FEC can be bypassed to save latency and power.**

- **Use 256b/257b direct coding to simplify coding procedures for stronger FEC process.**

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# Thank you

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