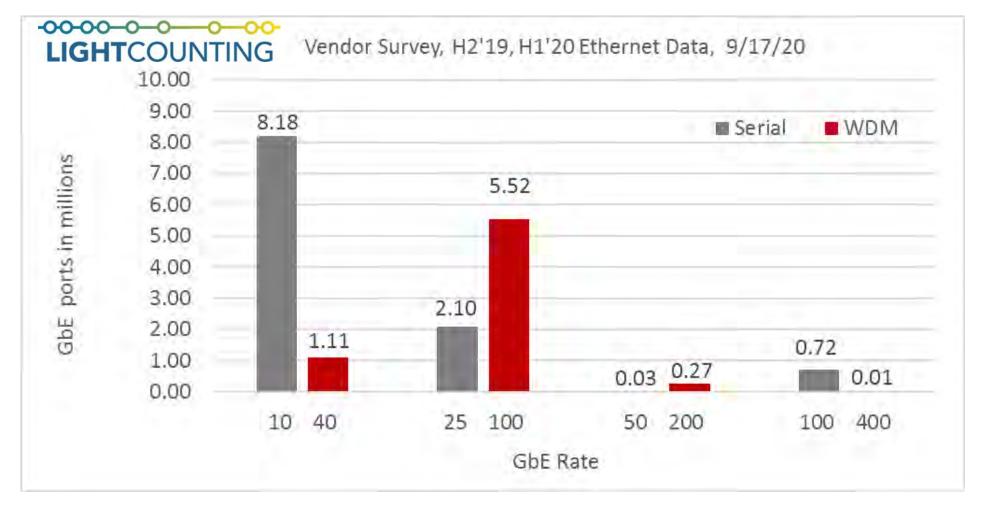
Categorization of 5 Criteria Responses
IEEE 802.3 Beyond 400 Gb/s Study Group
20 March 2021
Chris Cole, II-VI

Introduction

- Great reference on 5 criteria responses by Howard Frazier:
 https://www.ieee802.org/3/100GCU/public/jan11/frazier 01 0111.pdf
- Past 802.3 projects 5 criteria responses fell into different time frame categories
- Blend of past GbE timelines is used to project the 800 & 1600GbE timeline
- >400GbE 5 criteria responses are placed into time frame categories
- Categorization will help industry optimize R&D and Deployment planning
- To maximize timeline projection accuracy:
 - astrology identifies the most favorable moment to predict the future: Vernal Equinox (3/20/21)
 https://exploredeeply.com/live-your-purpose/tag/Ritual
 - o crystal energy aligns internal Chakras for vision clarity



Ethernet Current Annual Port Shipments



Same data plotted as # of λ s instead of GbE ports was sent out to the 802.3 NGECDC reflector last Sept.

Ethernet Milestones

| 1 st | designation | ation ae ba | | | | bs | >400GbE | | |
|-----------------|-------------|-------------|------|------|------|------|---------|------|--|
| 802.3 | GbE Rate | 10 | 40 | 100 | 200 | 400 | 800 | 1600 | |
| Project | start | 1999 | 2007 | 2006 | 2015 | 2013 | 2021 | 2021 | |
| | published | 2002 | 2010 | 2010 | 2017 | 2017 | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

Ethernet >400GbE Milestone Prediction

| designation | ae | b | a | | bs | >400GbE | | |
|-------------|-------------------|------------------------|--|---|--|---|--|--|
| GbE Rate | 10 | 40 | 100 | 200 | 400 | 800 | 1600 | |
| start | 1999 | 2007 | 2006 | 2015 | 2013 | 2021 | 2021 | |
| published | | 2010 | 2010 | 2017 | 2017 | 2025* | 2025* | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | GbE Rate start | GbE Rate 10 start 1999 | GbE Rate 10 40 start 1999 2007 | GbE Rate 10 40 100 start 1999 2007 2006 | GbE Rate 10 40 100 200 start 1999 2007 2006 2015 | GbE Rate 10 40 100 200 400 start 1999 2007 2006 2015 2013 | GbE Rate 10 40 100 200 400 800 start 1999 2007 2006 2015 2013 2021 | |

*Turquoise-blue is used for predictions because on the crystal color energy wheel, Vernal Equinox is the transition from Blue (Trust) to Turquoise (Discovery)

10GbE Milestones

| 1 st | designation | ae |
|-----------------|-------------|----------|
| 802.3 | GbE Rate | 10 |
| Project | start | 1999 |
| | published | 2002 |
| | year | 1998 |
| 4. | type | SONET LR |
| 1st shipment | wavelength | 1x10 |
| Silipilient | I/O | 16x0.622 |
| | form factor | 300-pin |
| | year | 2008 |
| 1st | type | LR |
| million | wavelength | 10 |
| shipment | I/O | 10 |
| | form factor | SFP |

40 & 100GbE Milestones

| 1 st | designation | ae | b | oa e e e e e e e e e e e e e e e e e e e |
|-----------------|-------------|----------|------|--|
| 802.3 | GbE Rate | | 40 | 100 |
| Project | start | 1999 | 2007 | 2006 |
| • | published | 2002 | 2010 | 2010 |
| | year | 1998 | 2009 | 2011 |
| | type | SONET LR | LR4* | OTN LR4 |
| 1st shipment | wavelength | 1x10 | 4x10 | 4x25 |
| Simplifient | I/O | | 4x10 | 10x10 |
| | form factor | 300-pin | CFP | CFP |
| | year | 2008 | 2014 | 2016 |
| 1st | type | LR | LR4 | CWDM4 |
| million | wavelength | | 4x10 | 4x25 |
| shipment | I/O | | 4x10 | 4x25 |
| | form factor | SFP | QSFP | QSFP |

*1st 40G shipped was VSR Serial λ in 16x2.5G I/O 300-pin form factor in 2003

200 & 400GbE Milestones

| 1 st | designation | ae | k |)a | | | bs | | |
|-----------------|-------------|---------------------------------|------------|-------|------|------|-------|--------------|--|
| 802.3 | GbE Rate | 10 | 40 100 200 | | 00 | 4 | 00 | | |
| Project | start | 1999 | 2007 | 2006 | 20 | 15 | 20 | 2013 2017 | |
| | published | 2002 | 2010 | 2010 | 20 | 17 | 20 | | |
| | year | 1998 | 2009 | 2011 | 2017 | 2018 | 2018 | 2019 | |
| | type | SONET LR LR4 OTN LR4 Mobile LR4 | | LR8 | | | | | |
| 1st shipment | wavelength | | | | 4x50 | | 8x50 | | |
| Silipilielit | I/O | 16x0.622 | 4x10 | 10x10 | 8x25 | 4x50 | 16x25 | 8x50 | |
| | form factor | 300-pin | CFP | CFP | CFP | QSFP | CFP8 | QSFP-DD | |
| | year | 2008 | 2014 | 2016 | | | | | |
| 1st | type | LR | LR4 | CWDM4 | | | | | |
| million | wavelength | 10 | 4x10 | 4x25 | | | | | |
| shipment | I/O | 10 | 4x10 | 4x25 | | | | | |
| | form factor | SFP | QSFP | QSFP | | | | | |

| 1 st | designation | ae | b | a | | | bs | | | | |
|-----------------|-------------|----------|------|---------|--------|-------|------|---------|--|--|--|
| 802.3 | GbE Rate | 10 | 40 | 100 | 20 | 00 | 4 | 00 | | | |
| Project | start | 1999 | 2007 | 2006 | 20: | 2015 | | | | | |
| ., | published | 2002 | 2010 | 2010 | 20: | 17 | 20 | 17 | | | |
| | year | 1998 | 2009 | 2011 | 2017 | 2018 | 2018 | 2019 | | | |
| 4. | type | SONET LR | LR4 | OTN LR4 | | e LR4 | | LR8 | | | |
| 1st shipment | wavelength | 1x10 | | 4x25 | 4x50 | | 8x50 | | | | |
| Simplification | I/O | 16x0.622 | | 10x10 | 8x25 | | | 8x50 | | | |
| | form factor | 300-pin | CFP | CFP | CFP | | CFP8 | QSFP-DD | | | |
| | year | 2008 | 2014 | 2016 | 202 | 21 | | | | | |
| 1st | type | LR | LR4 | | FR | FR4 | | | | | |
| million | wavelength | | 4x10 | | 4x50 | | | | | | |
| shipment | I/O | 10 | 4x10 | 4x25 | 2x4x50 | 4x50 | | | | | |
| | form factor | SFP | QSFP | QSFP | OSFP | QSFP | | | | | |

| 1 st | designation | ae | b | a | | bs | |
|-----------------|-------------|----------|------|---------|-------------|---------------|--|
| 802.3 | GbE Rate | 10 | 40 | 100 | 200 | 400 | |
| Project | start | 1999 | 2007 | 2006 | 2015 | 2013 | |
| | published | 2002 | 2010 | 2010 | 2017 | 2017 | |
| | year | 1998 | 2009 | 2011 | 2017 2018 | 2018 2019 | |
| | type | SONET LR | LR4 | OTN LR4 | Mobile LR4 | LR8 | |
| 1st shipment - | wavelength | 1x10 | 4x10 | 4x25 | 4x50 | 8x50 | |
| Silipilielit | I/O | 16x0.622 | 4x10 | | 8x25 4x50 | 16x25 8x50 | |
| | form factor | 300-pin | CFP | CFP | CFP QSFP | CFP8 QSFP-DD | |
| | year | 2008 | 2014 | 2016 | 2021 | 2023* | |
| 1st | type | LR | LR4 | CWDM4 | FR4 | FR4 | |
| million | wavelength | 10 | 4x10 | 4x25 | 4x50 | 4x100 | |
| shipment | I/O | 10 | 4x10 | 4x25 | 2x4x50 4x50 | 2x4x100 4x100 | |
| | form factor | SFP | QSFP | QSFP | OSFP QSFP | OSFP QSFP | |

^{*}Requires annual volume to quadruple for the next 3 years, which is very aggressive

800GbE 1st Shipment Milestone Prediction

| 1 st | designation | ae | b | a | | | bs | | >400GbE | | | |
|-----------------|-------------|----------|------|---------|------------|---------------------|-------|------------|---------|---------|--|---|
| 802.3 | GbE Rate | 10 | 40 | | 20 | 00 | 40 | | 800 | | | |
| Project | start | 1999 | 2007 | | 20 | 15 | 2013 | | 2021 | | | |
| ., | published | 2002 | 2010 | 2010 | 20 | | 2017 | | | | | 5 |
| | year | 1998 | 2009 | 2011 | 2017 | 2017 2018 2018 2019 | | 2019 | 2023/24 | | | |
| 4.1 | type | SONET LR | LR4 | OTN LR4 | Mobile LR4 | | LR8 | | LR8 | | | |
| 1st shipment | wavelength | 1x10 | 4x10 | 4x25 | 4x50 | | 8x50 | | 8x100 | | | |
| Simplification | I/O | 16x0.622 | 4x10 | | 8x25 | 4x50 | 16x25 | 8x50 | 8x: | 100 | | |
| | form factor | 300-pin | CFP | CFP | CFP | QSFP | CFP8 | QSFP-DD | OSFP | QSFP-DD | | |
| | year | 2008 | 2014 | 2016 | 20 | | | 2 3 | | | | |
| 1st | type | LR | LR4 | | FR4 | | FR4 | | | | | |
| million | wavelength | 10 | 4x10 | 4x25 | | | | 100 | | | | |
| shipment | I/O | 10 | | | 2x4x50 | | | 4x100 | | | | |
| | form factor | SFP | QSFP | QSFP | OSFP | | | QSFP | | | | |

11

| 1 st | designation | ae | k | a | | | bs | os | | >400GbE | |
|---|-------------|----------|------|---------|-------------|-------|---------|---------|---------|---------|------|
| 802.3 | GbE Rate | 10 | 40 | | 20 | 00 | | | 800 | | |
| Project | start | 1999 | 2007 | | 20 | 15 | 20 | 13 | 2021 | | 2021 |
| ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, | published | 2002 | 2010 | 2010 | 20 | 17 | 20 | 2017 | | 25 | 2025 |
| | year | 1998 | 2009 | 2011 | 2017 | 2018 | 2018 | 2019 | 2023/24 | | |
| | type | SONET LR | LR4 | OTN LR4 | Mobil | e LR4 | LR8 | | LR8 | | |
| 1st shipment | wavelength | | | | 4x50 | | 8x50 | | 8x100 | | |
| Simplification | I/O | 16x0.622 | 4x10 | 10x10 | 8x25 | | 16x25 | 8x50 | 8x100 | | |
| | form factor | 300-pin | CFP | CFP | CFP | | CFP8 | QSFP-DD | OSFP | QSFP-DD | |
| | year | 2008 | 2014 | 2016 | 20 | 21 | 20 | 23 | 2029 | | |
| 1st | type | LR | LR4 | | FR4 4x50 | | | R4 | FR | 4 | |
| million | wavelength | | 4x10 | | | | | | 4x2 | 00 | |
| shipment | I/O | 10 | 4x10 | 4x25 | 2x4x50 | 4x50 | 2x4x100 | 4x100 | 2x4x200 | 4x200 | |
| | form factor | SFP | QSFP | QSFP | OSFP | QSFP | OSFP | QSFP | OSFP | QSFP | |

1600GbE 1st Shipment Milestone Prediction

| 1 st | designation | ae | k | oa | | | bs | | | >400GbE | | |
|-----------------|-------------|----------|------|---------|------------|----------------|-------|---------|---------|---------|----------------|----------------|
| 802.3 | GbE Rate | 10 | 40 | 100 | 20 | | 40 | 00 | 800 | | 1600 | |
| Project | start | | | 2006 | 20 | | 20 | 13 | 2021 | | 2 | 021 |
| , | published | 2002 | 2010 | 2010 | 20 | | 2017 | | 2025 | | 2 | 025 |
| | year | 1998 | 2009 | 2011 | 2017 | 2018 | 2018 | 2019 | 2023/24 | | 202 | 26/27 |
| 4. | type | SONET LR | LR4 | OTN LR4 | Mobile LR4 | | LR8 | LR8 | LR | .8 | LR8 | |
| 1st shipment | wavelength | 1x10 | 4x10 | 4x25 | 4x | 4x50 8x50 8x50 | | 8x100 | | 8> | <200 | |
| Silipilicit | I/O | 16x0.622 | | 10x10 | 8x25 | | 16x25 | 8x50 | 8x100 | | 8> | <200 |
| | form factor | 300-pin | CFP | CFP | CFP | QSFP | CFP8 | QSFP-DD | OSFP | QSFP-DD | OSFP | QSFP-DD |
| | year | 2008 | 2014 | | 20 | 2021 | | | | 2029 | | |
| 1st | type | LR | LR4 | | FF | | FR4 | | FR4 | | | |
| million | wavelength | | | | | | | | | | | |
| shipment | I/O | 10 | 4x10 | | 2x4x50 | 4x50 | | 4x100 | 2x4x200 | 4x200 | | |
| | form factor | SFP | QSFP | | OSFP | QSFP | | QSFP | OSFP | QSFP | | |

| 1 st | designation | ae | b | a | | bs | >400 | GbE |
|-----------------|-------------|----------|----------------|---------|-------------|---------------|---------------|---------|
| 802.3 | GbE Rate | 10 | 40 | 100 | 200 | 400 | 800 | 1600 |
| Project | start | 1999 | | 2006 | 2015 | 2013 | 2021 | 2021 |
| ., | published | 2002 | 2010 | 2010 | 2017 | 2017 | 2025 | 2025 |
| | year | 1998 | 2009 | | 2017 2018 | 2018 2019 | 2023/24 | 2026/27 |
| | type | SONET LR | LR4 | OTN LR4 | Mobile LR4 | LR8 | | LR8 |
| 1st shipment | wavelength | 1x10 | 4x10 | | 4x50 | 8x50 | 8x100 | 8x200 |
| Silipilielit | I/O | 16x0.622 | | | 8x25 4x50 | 16x25 8x50 | 8x100 | 8x200 |
| | form factor | 300-pin | CFP | | CFP QSFP | CFP8 QSFP-DD | OSFP QSFP-DD | OSFP |
| | year | 2008 | | 2016 | 2021 2023 | | 2029 | 2031 |
| 1st | type | LR | LR4 | CWDM4 | FR4 | FR4 | FR4 | FR8* |
| million | wavelength | 10 | 4x10 | 4x25 | 4x50 | 4x100 | 4x200 | 8x200 |
| shipment | I/O | 10 | 4x10 | 4x25 | 2x4x50 4x50 | 2x4x100 4x100 | 2x4x200 4x200 | 8x200 |
| | form factor | SFP | QSFP QSFP QSFP | | OSFP QSFP | OSFP QSFP | OSFP QSFP | OSFP |

*If 4x400G PAMn or Coherent, 1st M will be later than 2031 (for pros & cons see: https://www.ofcconference.org/en-us/home/program-speakers/rump-session/

14

Categorization of 5 Criteria Responses

Ethernet Milestones

| 1 st | designation | ae | b | a | | | bs | | >400GbE | | | |
|---|-------------|---------------------|------|---------------------------------------|--------|----------------|---------|-------------|--------------|---------|-------|---------|
| 802.3 | GbE Rate | 10 | 40 | 100 | 200 | | 400 | | 800 | | 1600 | |
| Project | start | 1999 2007 2006 2015 | | 20 | 13 | 2021 | | 2021 | | | | |
| ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,, | published | 2002 | 2010 | 2010 | 20 | 17 | 20 | 17 | 2025 | | 2 | 025 |
| | year | 1998 | 2009 | 2011 | 2017 | 2018 | 2018 | 2019 | 202 3 | 2023/24 | | 26/27 |
| 4. | type | SONET LR | LR4 | OTN LR4 | Mobil | Mobile LR4 LR8 | | LR8 | | LR8 | | |
| 1st shipment | wavelength | 1x10 | 4x10 | 4x25 | 4x50 | | 8x50 | | 8x100 | | 8x200 | |
| Silipilielit | I/O | 16x0.622 | 4x10 | 4x10 10x10 8x25 4x50 16x25 8x50 8x100 | 00 | 8x200 | | | | | | |
| | form factor | 300-pin | CFP | CFP | CFP | QSFP | CFP8 | QSFP-DD | OSFP | QSFP-DD | OSFP | QSFP-DD |
| | year | 2008 | 2014 | 2016 | 20 | 21 | 20 | 23 | 202 | 29 | 2 | 031 |
| 1st | type | LR | LR4 | CWDM4 | FF | R4 | FF | R4 | FR4 | | FR8 | |
| million | wavelength | 10 | 4x10 | 4x25 | 4x | 50 | 4x1 | L 00 | 4x2 | 00 | 8x20 | |
| shipment | I/O | 10 | 4x10 | 4x25 | 2x4x50 | 4x50 | 2x4x100 | 4x100 | 2x4x200 | 4x200 | 8 | k200 |
| | form factor | SFP | QSFP | QSFP | OSFP | QSFP | OSFP | QSFP | OSFP | QSFP | O | SFP |

15

Categorization of 5 Criteria Responses

| 1 st 802.3 Project | designation | ae | b | ba | | | bs | | >400GbE | |
|-------------------------------------|-------------------------|---------|------|------|------|------|------|------|---------|---------|
| | GbE Rate | 10 | 40 | 100 | 200 | | 400 | | 800 | 1600 |
| | start | 1999 | 2007 | 2006 | 2015 | | 2013 | | 2021 | 2021 |
| | published | 2002 | 2010 | 2010 | 2017 | | 2017 | | 2025 | 2025 |
| Shipment | 1st | 1998 | 2009 | 2011 | 2017 | 2018 | 2018 | 2019 | 2023/24 | 2026/27 |
| | 1 st million | 2008 | 2014 | 2016 | 2021 | | 2023 | | 2029 | 2031 |
| Broad Market Potential | | ST → LT | MT | LT | MT | | LT | | MT | LT |
| Technical Feasibility | | ST | ST | MT | ST | | LT | | MT | LT |

ST: Short Term

MT: Medium Term

LT: Long Term

Categorization of 5 Criteria Responses

Thank you

17