How to Deliver Optical Network Evolution and Differentiation and Handle the Future Capacity Crunch as an Optical Industry Centre

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Outline

- Facebook Optical Metrics and Bandwidth Drivers
- Facebook Data Centers and Global Optical Network
  - Open Submarine cable systems
  - Optical Network metrics
  - Directions of Optical Technology
  - Towards the Cognitive Optical Network
- Conclusions

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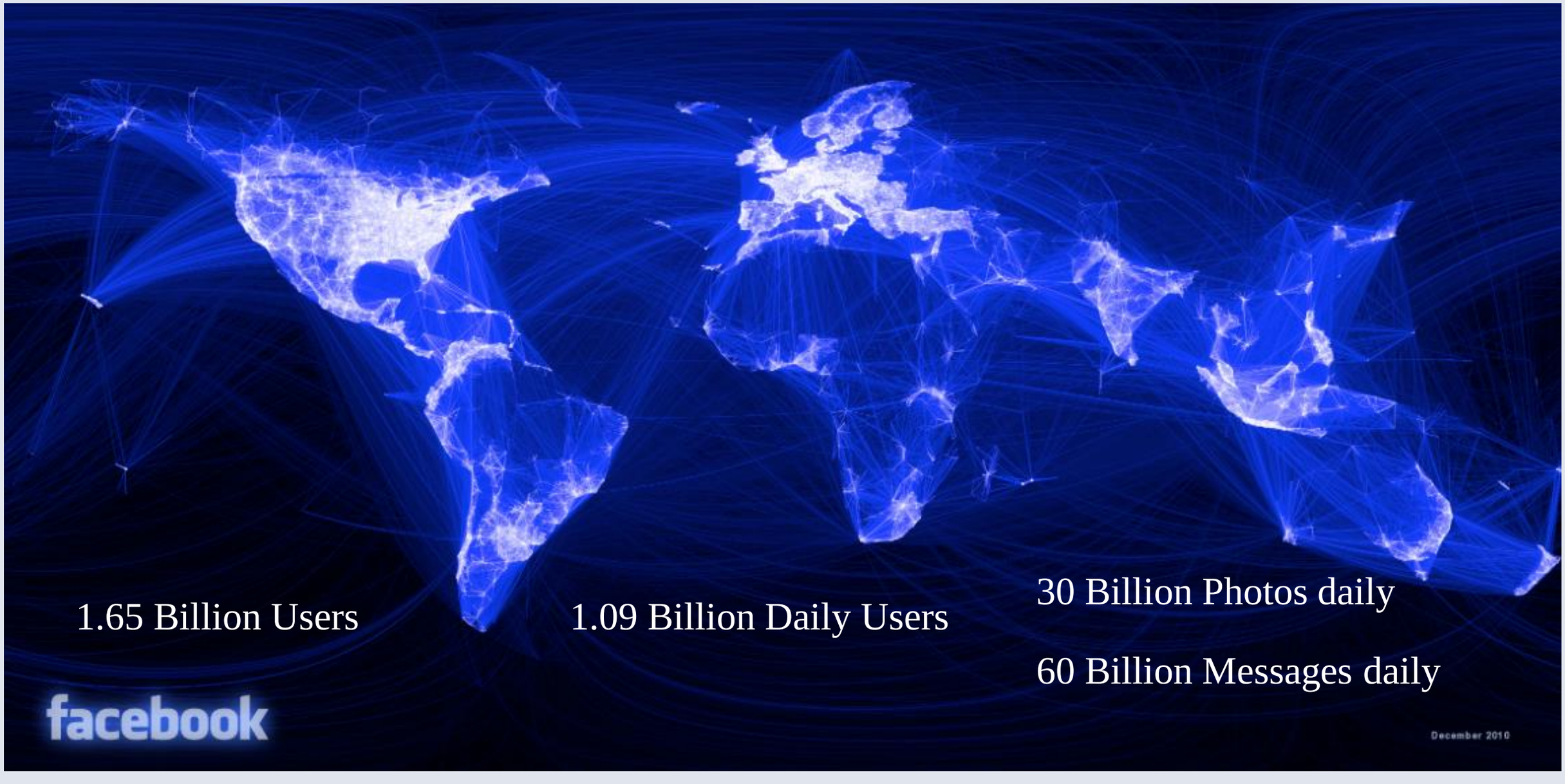
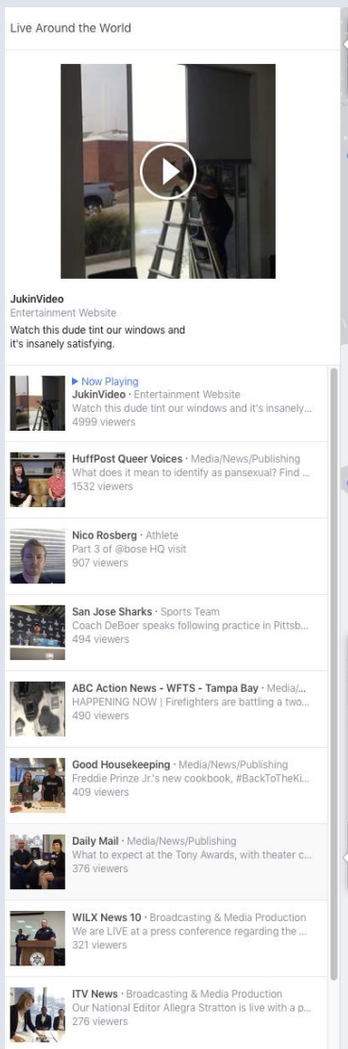
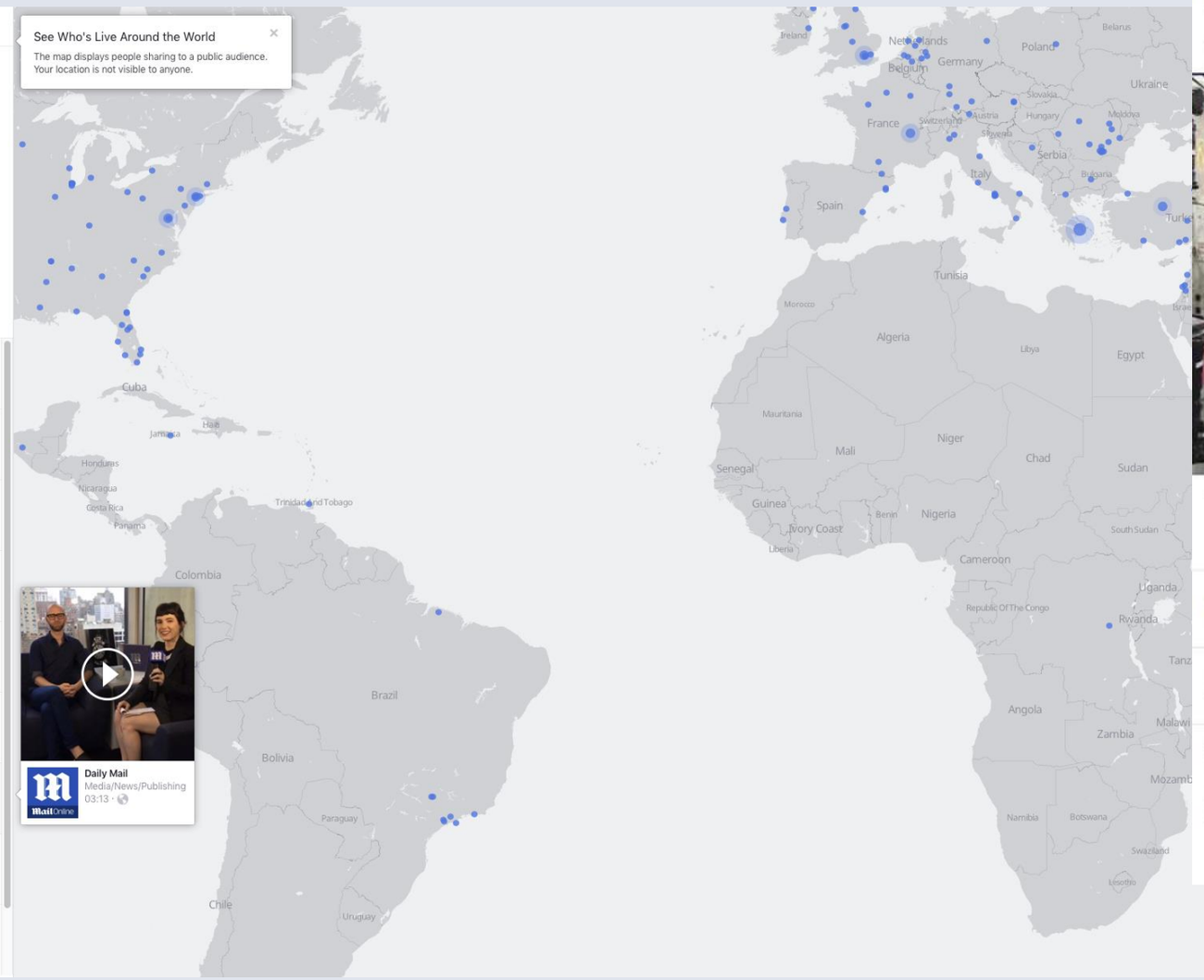
Facebook by the Numbers



Emerging Bandwidth Drivers: Facebook Live





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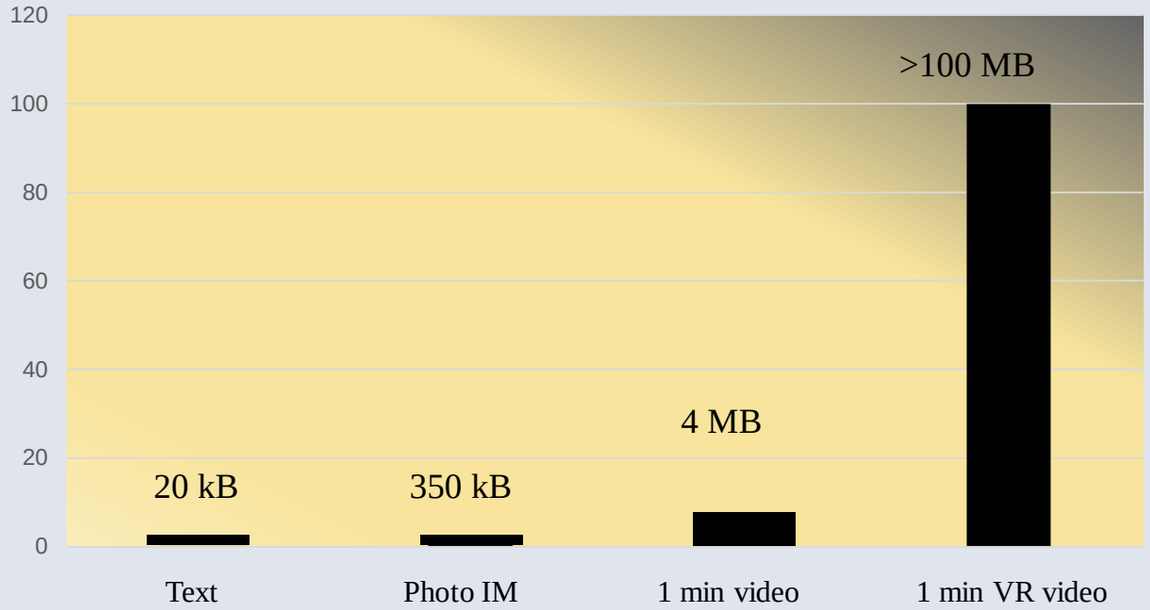
Emerging Bandwidth Drivers: Virtual Reality- Oculus

- Gaming
- VR Video Content
- Video Conferencing
- VR Sports viewing
- Future NGON Conferences ?

Virtual Reality (VR) Bandwidth Requirements



Why The Internet Pipes Will Burst When Virtual Reality Takes Off

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Valley Voices

CONTRIBUTOR

Voices on technology and change

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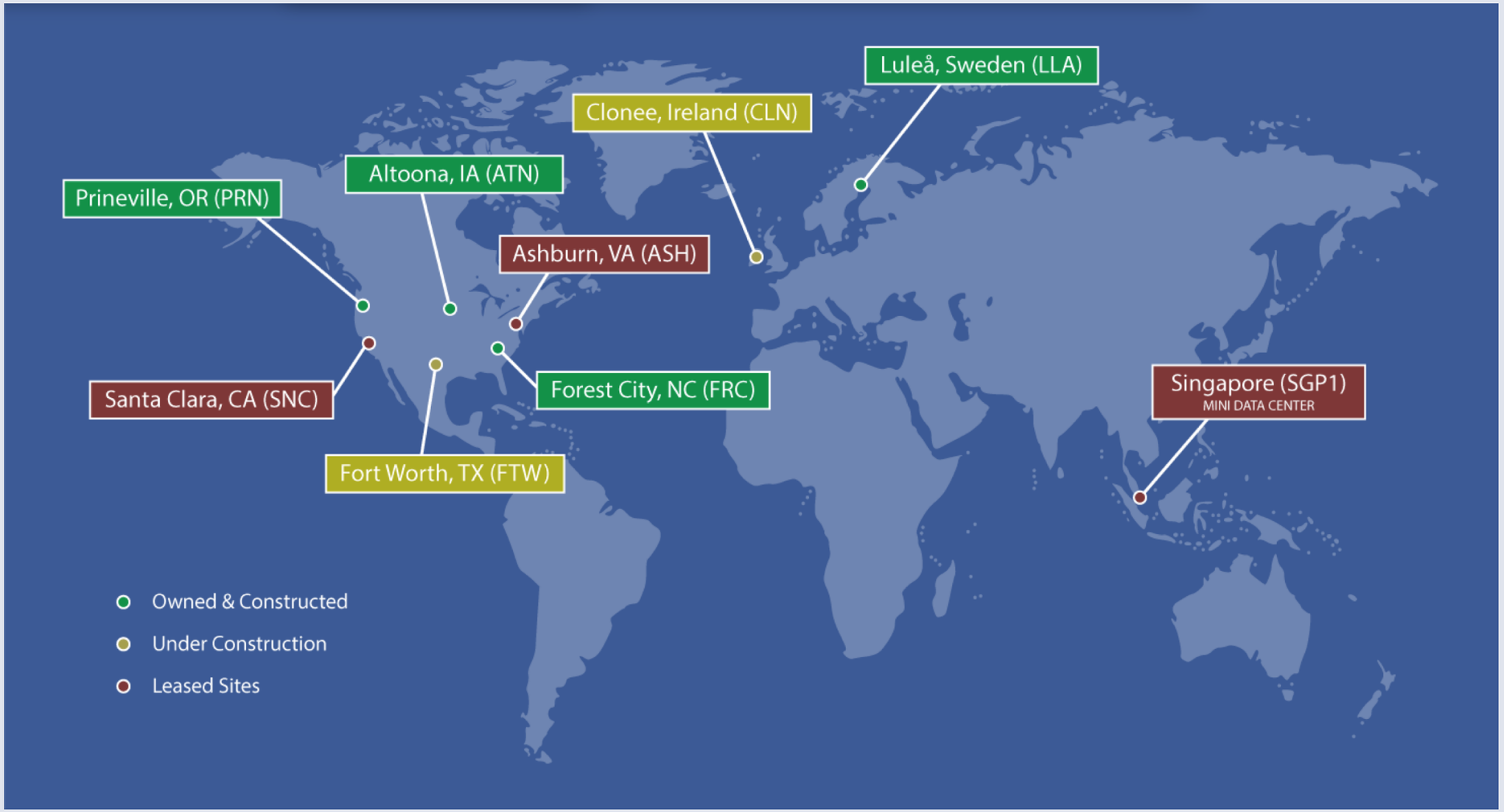
Facebook Global Data Centers



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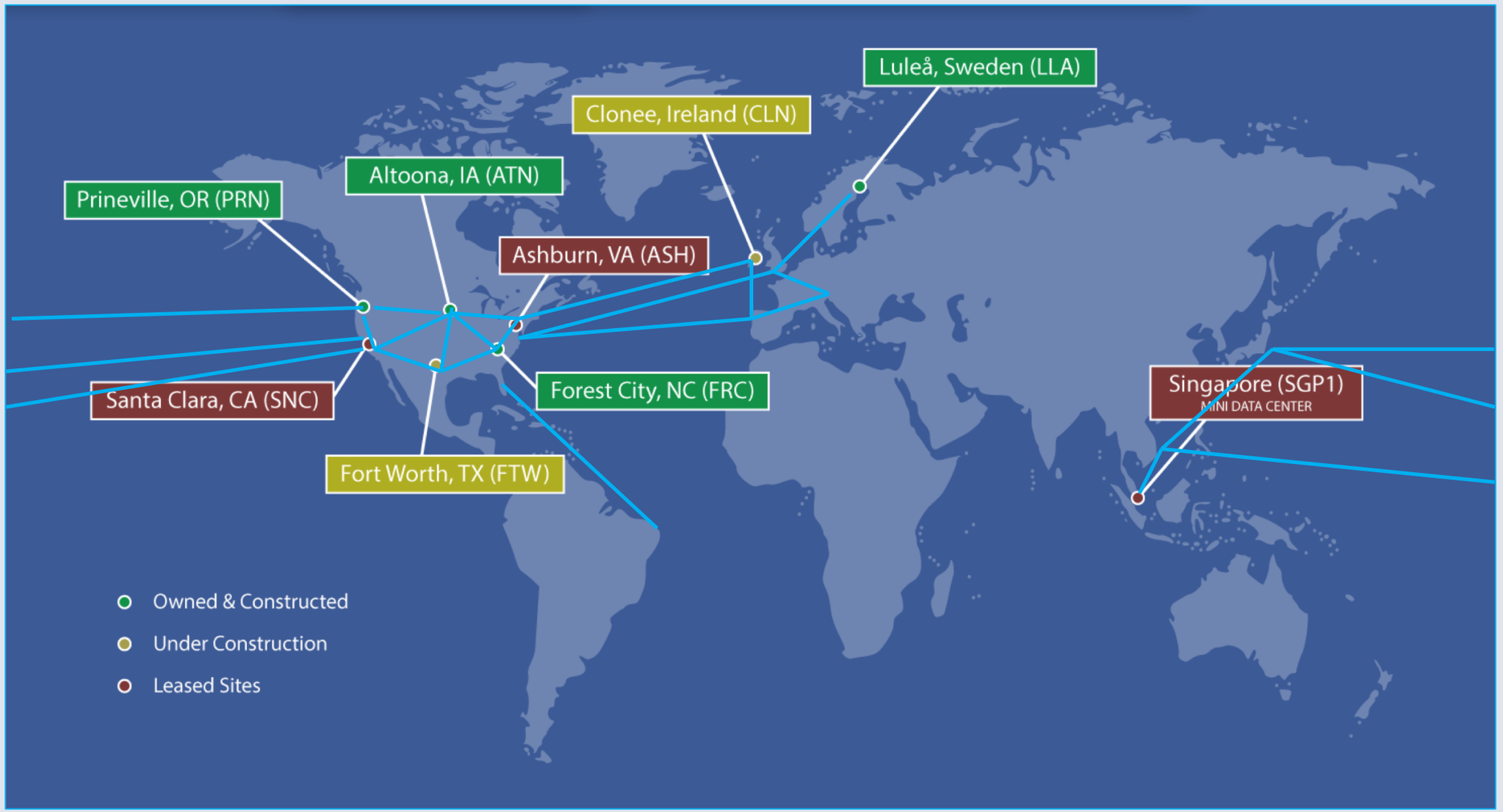
Facebook Global Optical Network



Links shown are schematic and do not represent the extensiveness of the Facebook Global Network

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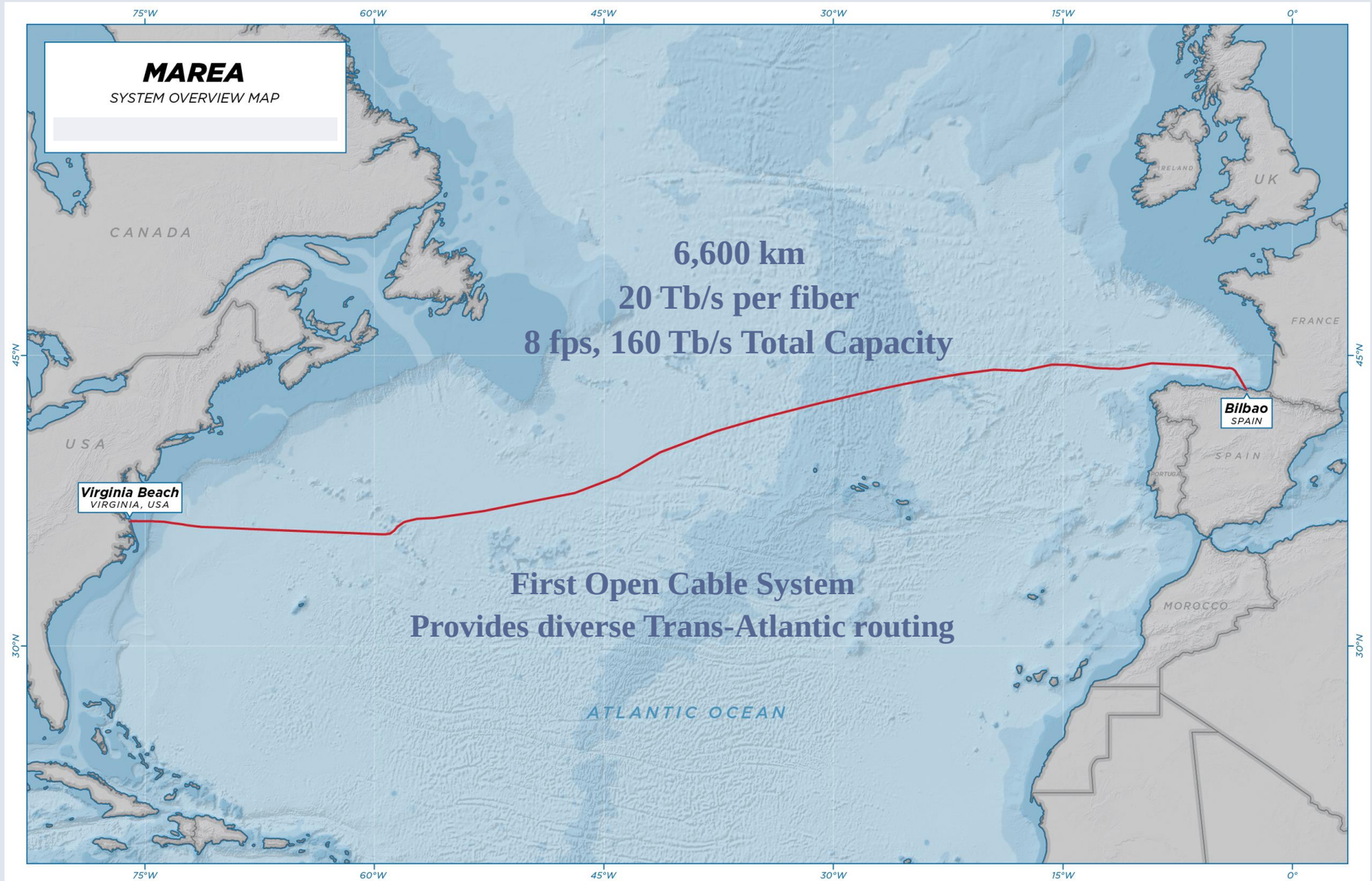
MAREA Submarine Cable



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Why Buy Open Submarine Cables ?

- Best of breed in Wet plant and SLTE
  - Drive wet plant vendors to higher capacity, lower cost, faster deployments
  - Drive SLTE vendors to higher rates/capacities, lower cost per bit, flexible line card
- Designs incorporating Submarine links are now almost always POP to POP or DC to DC, need to separate out wet plant specifications
  - Need to specify performance independent of a specific suppliers transponder
- Ability to commit to SLTE at later date than at beginning of longer wet plant build cycle--- critical with fast moving technology changes in SLTE
- Desire to fully integrate submarine and terrestrial network management- demarcations are blurring
- Ability to move fast with like-minded partners, often in new geographically diverse routes- drive aggressive systems specifications

TELECOM INFRA PROJECT

Facebook is driving this paradigm in our entire network

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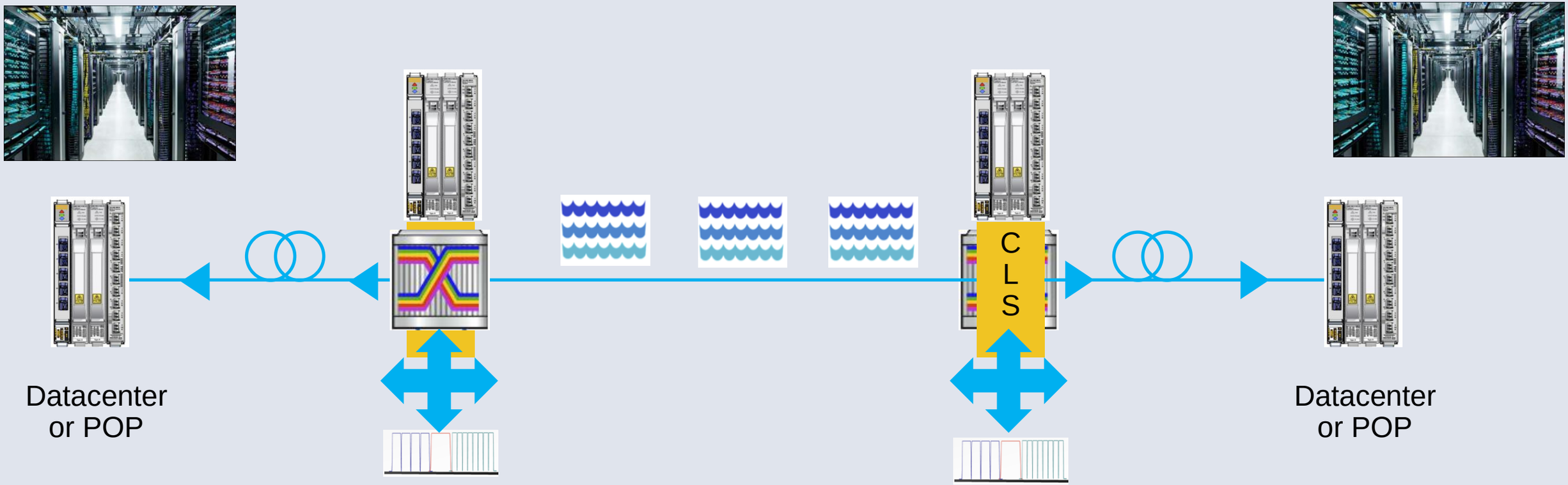
New Paradigm for Submarine Cable Connections



- Demarcations between Submarine and Terrestrial Networks are blurring
- Facebook is building One Global Integrated Network

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Facebook Optical Network Metrics

- **Capacity / Scaling**
  - Low cost and power per bit, high density, near continuous tuning of card capacity, reach
- **Speed of Service**
  - Automated turn up and provisioning, network optimization
- **Agility**
  - Modular ROADM (CD to CDC), add degrees, extend network
- **Flexibility**
  - Flex modulation, flexgrid, flex clients (FlexEthernet)
  - Open API, SDN/NFV, support for 3rd party wavelength management
- **Resiliency and Redundancy**
  - Facebook deploys multiple paths between data centers- 3 or 4

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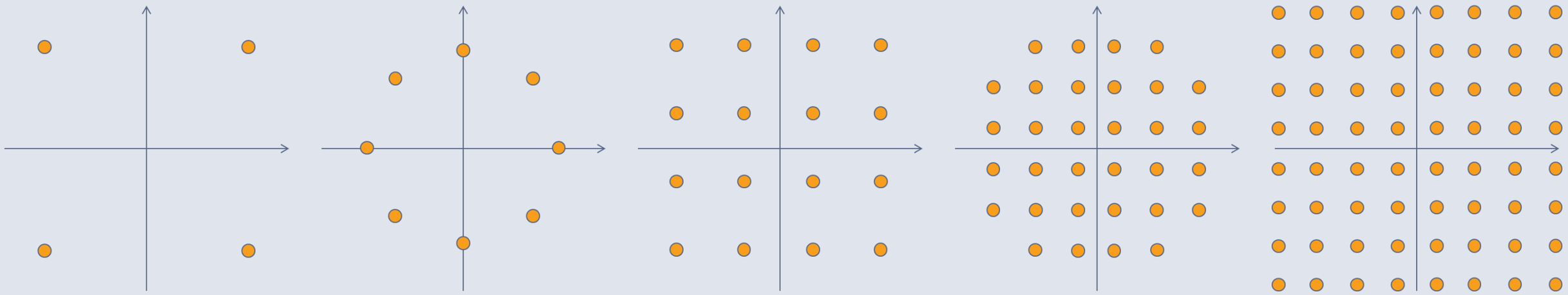
Generations of Coherent Technology

- First Generation
  - 40 Gb/s Coherent, high PMD and CD Tolerance, HD-FEC
- Second Generation Coherent
  - 100 Gb/s, SD-FEC, high PMD/CD tolerance, QPSK, BPSK
- Third Generation Coherent
  - 100G-400G, additional modulation formats (8/16 QAM), high CD tolerance (280K psec/nm), cycle slip tolerance, improved SD-FEC, ability to compensate for high polarization rotation rates
- **Fourth Generation Coherent**
  - 100 Gb/s- X Gb/s ? , more granular modulation formats, variable baud rate, variable FEC, variable grid spacing, higher NCG FEC, improved coherent algorithms

Relative Capacity, Reach and OSNR versus Modulation Format- the Log term of Shannon



	QPSK	8QAM	16QAM	32 QAM	64QAM
Relative Capacity	1	1.5	2	3	4
Relative Reach	1.0	0.5	.20	.08	.03
OSNR Required	12 dB	16 dB	19 dB	23 dB	28 dB

Large jumps in reach and required OSNR, more continuous variation desirable

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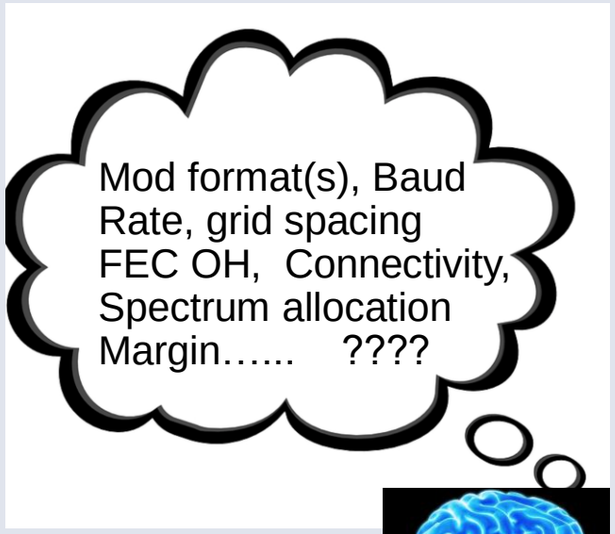
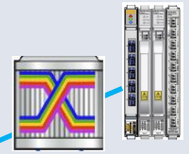
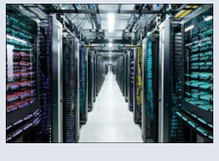
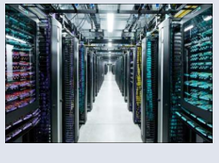
Towards the “Cognitive” Optical Network









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Conclusions

- Facebook Optical Network Metrics
  - Capacity / Scaling
    - Low cost and power per bit, high density
  - Speed of Service
  - Agility
  - Flexibility - grid and line rate
  - Resiliency and Redundancy
- Open Cable Submarine Systems, new paradigm to maximize performance of Submarine Cables
  - Facebook will extend this paradigm to the entire network
- Cognitive Optical Networks
  - Next generation line cards to get improved bandwidth utilization and lower cost per bit, mine “excess” margin in network

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