Hvordan redundans og optisk beskyttelsesomkopling øker oppetiden til et optisk nett

Steinar Bjørnstad

Strat. competence and research manager@Tampnet

Senior research scientist@Simula

Adjunct associate professor@NTNU

Raising the Standard

Name

- Company

How can sub-sea fibre networks be designed for high availability?

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Outline

- Motivation for high availability and capacity
- What is availability and security?
  - Availability risk factors
  - Security risk factors
- Methods for increasing availability
- Passive fibre cables and offshore installations
- Tampnet resilient sub-sea cable network

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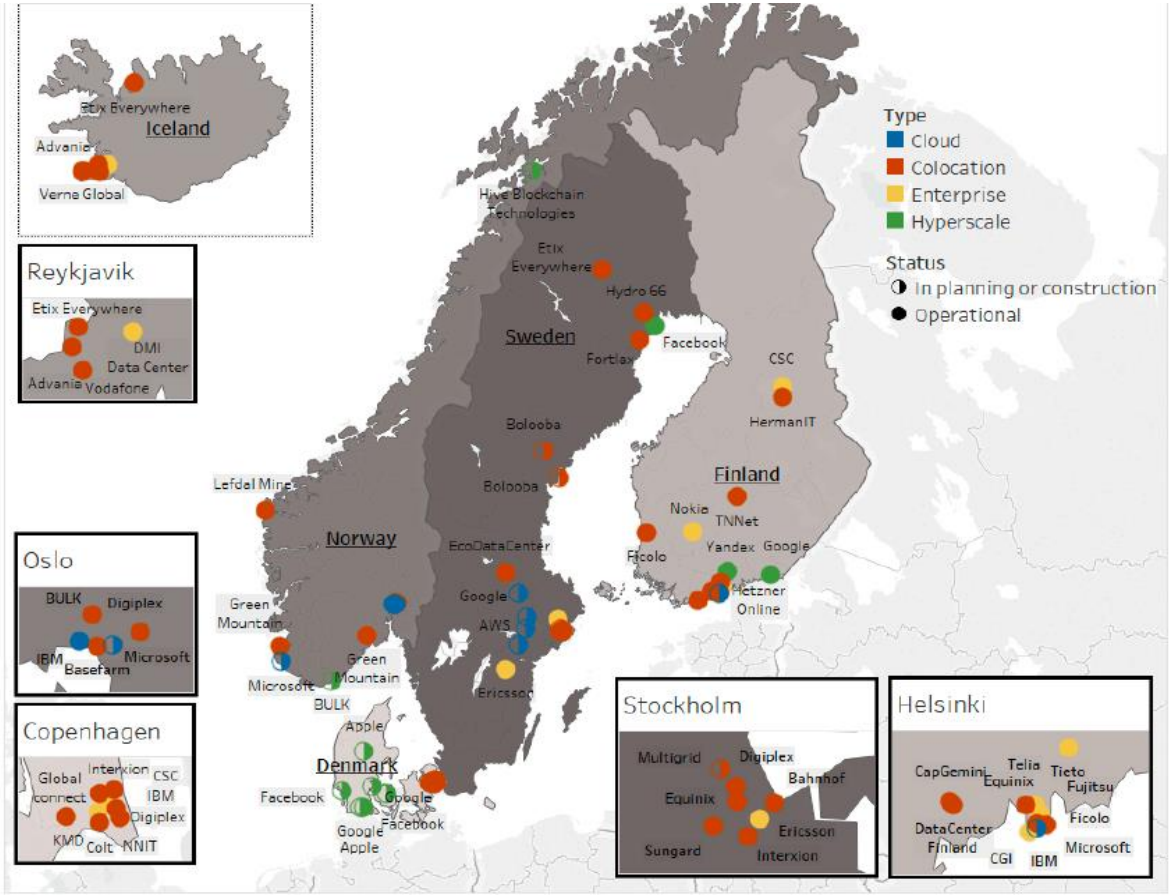
Nordic Data Centres investments



Note: Please note that the Facebook facility near Esbjerg, Denmark is not officially announced.

Source: COWI (public sources).

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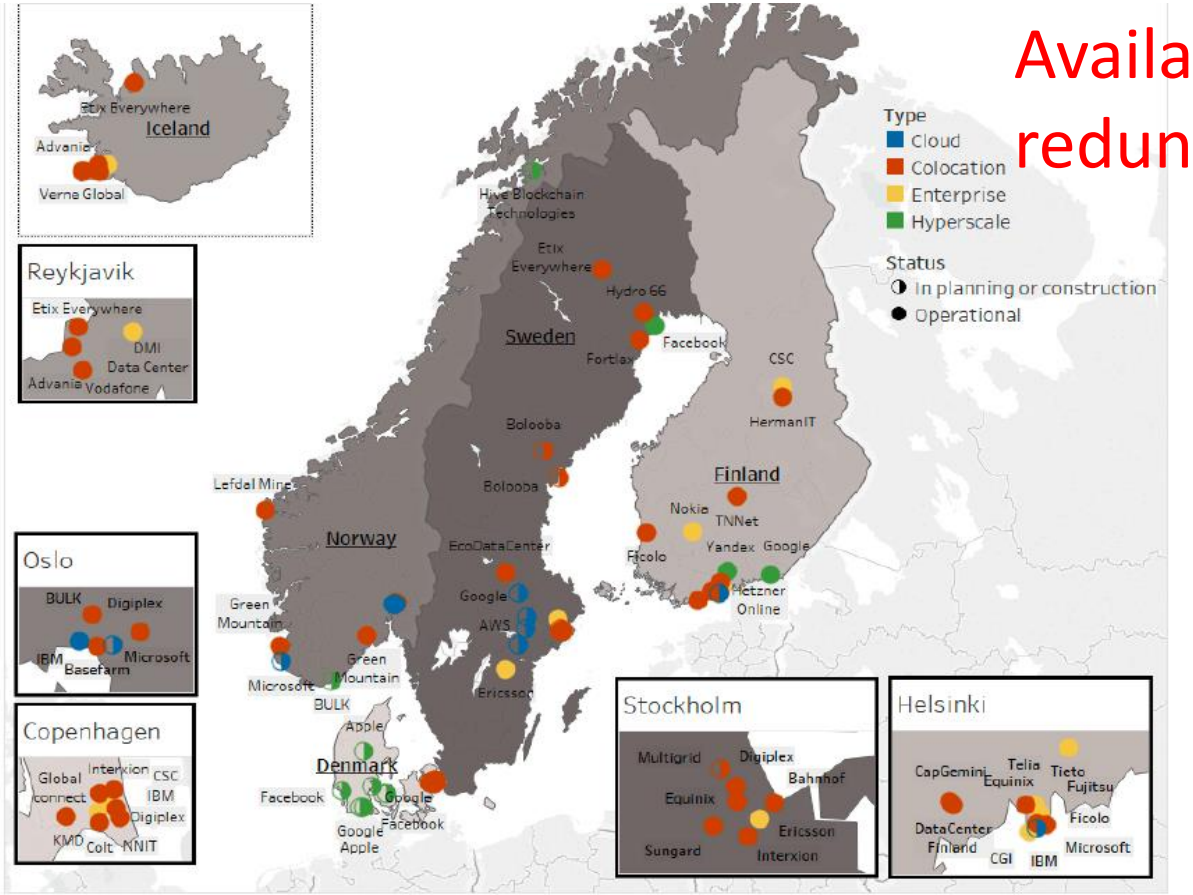
Nordic Data Centres investments

Availability and redundancy is key!



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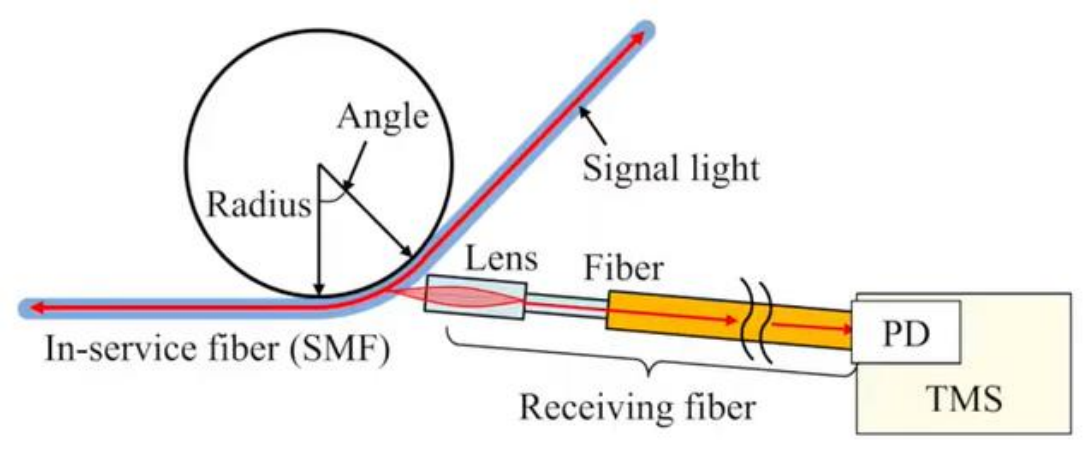
Availability risk factors

- Power failure
- Cable break
- Equipment failure
- Sabotage
  - Mechanical
  - Security breach

Security risk factors

- Eaves dropping
- Sabotage
  - Mechanical
  - Hacker attack



IEEE Photonics Journal
Design of a Temporary optical coupler

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Combating risk factors

- Power failure on landing station
  - Depend on availability of land-based power
  - Generator as backup increases availability
- Power shutdown on offshore installation
  - Very stable power with built in backup power
- Cable break
  - Typically due to fishing and trawls
  - Inform boat crew in advance about the cables
  - Monitor and warn boats approaching the cable
  - Most important: Proper burying of the cable

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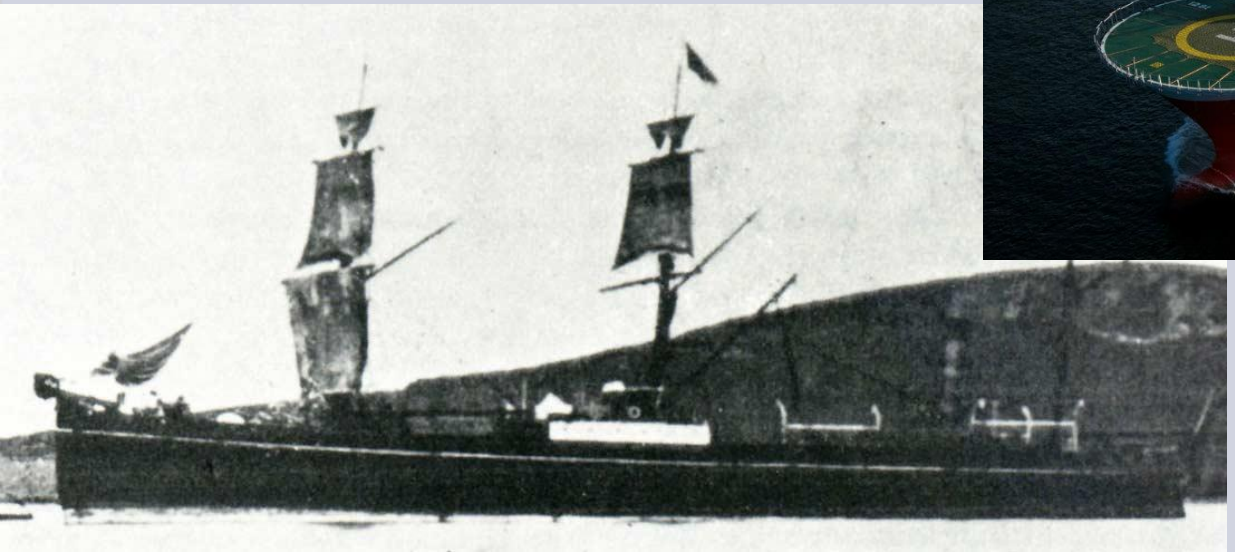
Burying the sea-cable

«Global Symphony» Egersund-Ula 2019

«La Plata»: Egersund-Peterhead in 1869



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Burying the sea-cable

- Ploughing or trenching are the most commonly used methods
- If burying is not achievable: Concrete mattresses, rock dumping on top or similar.
- Telegraph cable laid in 1869 between Egersund and Peterhead, Scotland was laid in 48 hours
- Tampnet spent almost 2 months laying Egersund-Scotland cable this summer.

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Combating equipment failure

- Long repair time and costly for active sub-sea cables
  - Redundant components
- Replaceable within hours/day on offshore installation
  - Failures may be predictable using machine learning: Proactive replacement

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Preventing sabotage

- Mechanical
  - Cutting the cable or destroying equipment
  - Ensure strict access control
- Security breach
  - Remote attack through e.g. accessing network management system bringing down or slowing the system
  - Ensure proper security systems

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Security risk factors

- Eaves dropping
  - Complex to access sub-sea for tapping a fibrecable
  - Tapping in the landing station if access and a proper device
  - Tapping on offshore installation: Complex access and strict security. Difficult to transport eaves-dropped data
- Sabotage as discussed for availability

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Redundant routes and protection switching

- If a cable route is unavailable it is comparable with a roadblock
- Imagine a roadblock in “Oslofjordtunnelen”
- The cars are then rerouted through roads in and around Oslo
- Probability of all roads being closed is very low
  - Typically much lower than any attempts improving availability of oslofjordtunnelen could give.

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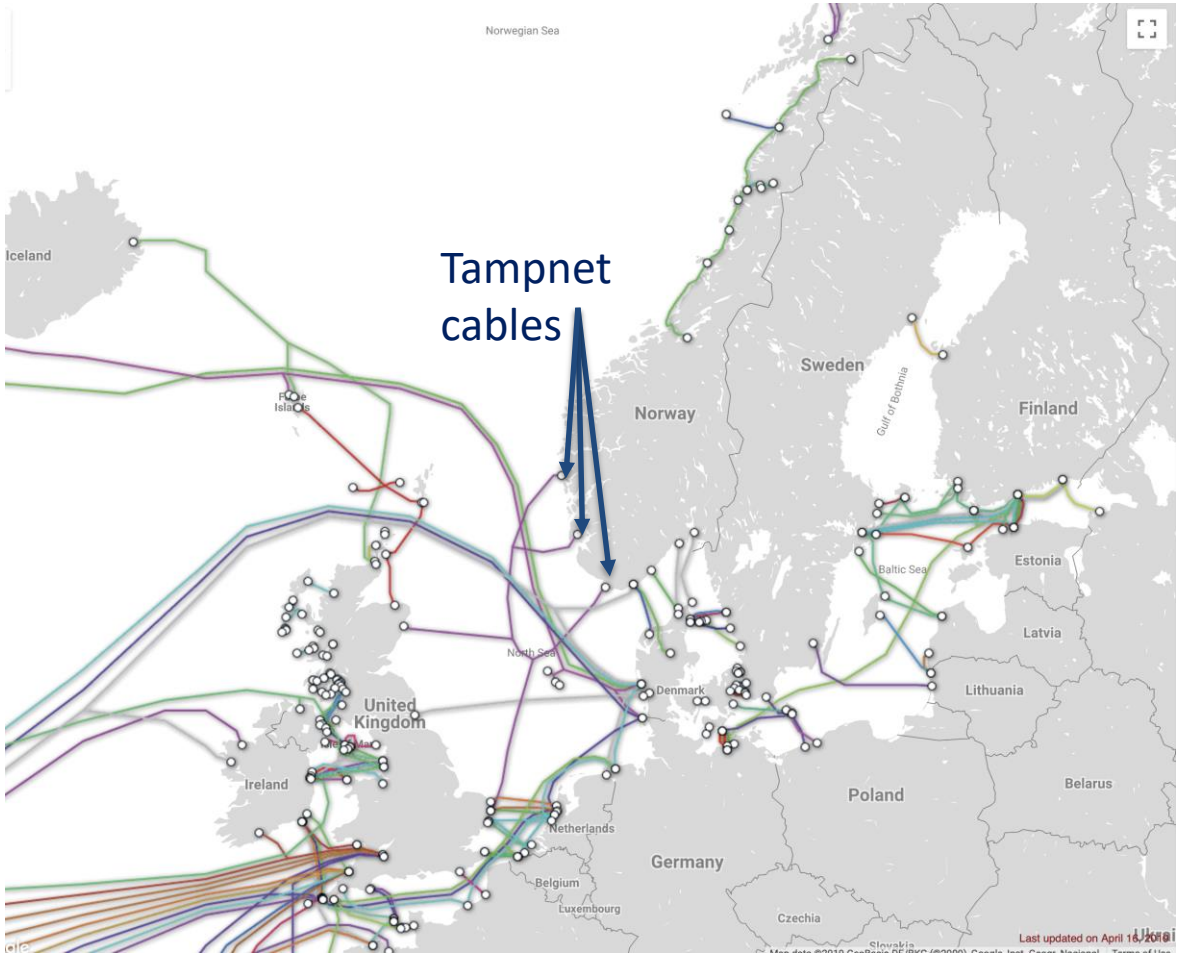
Redundant fibre connectivity is key



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What is optical protection switching?

- Electronics are not involved in the data-path
- Switching the light through an optical switch
  - All wavelengths in a fibre
  - A spectrum of wavelengths
  - Individual wavelengths
- Switching is transparent to type of data (protocols), modulation format and bitrate

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Transparent optical protection switching

- Optical switching enables full data transparency
- Protected service offerings
  - Fibre
  - Wavelength spectrum
  - Wavelength

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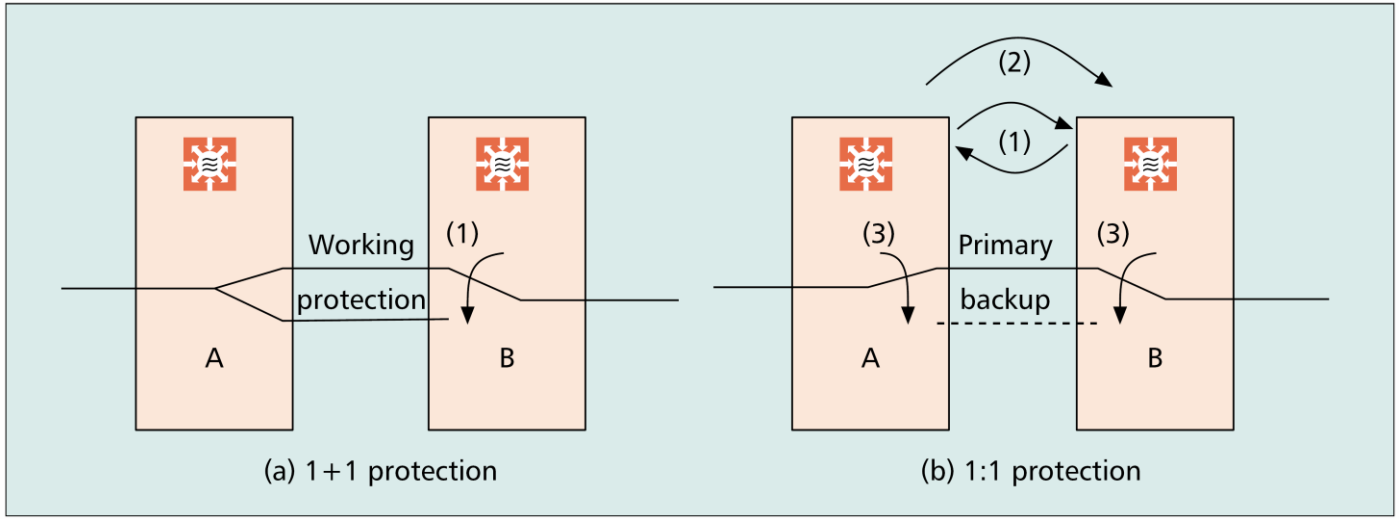
Protection switching

Protection mechanisms:

- 1+1 protection: simultaneous transmission of data on two different paths.
- 1:1 protection: Pre-allocated back-up path

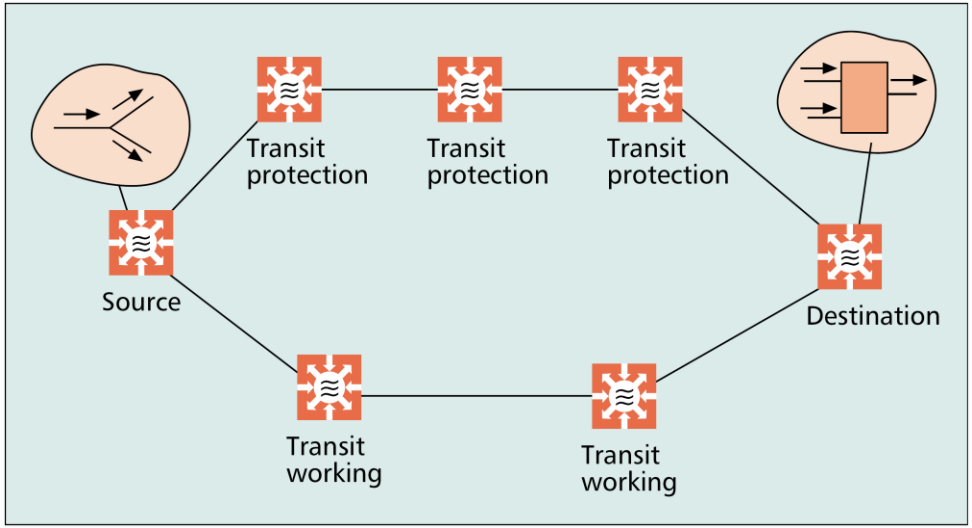


Banerjee et.al.

"Generalized Multiprotocol Label Switching: An Overview of Signaling Enhancements and Recovery Techniques"

1+1 protection switching

- 1+1 Path protection (disjoint paths):



Banerjee et.al.
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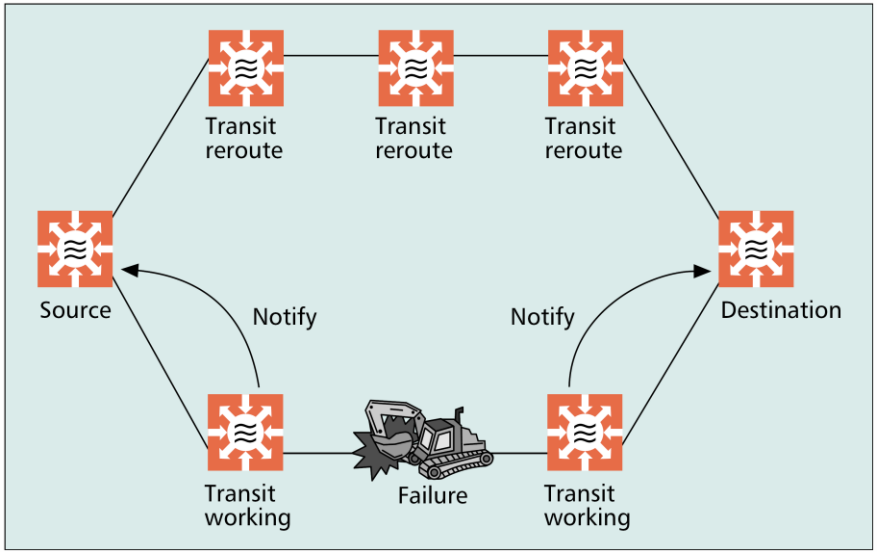
1:1 path protection

- Signaling in the network of a failure condition
- Automatic or manual switching through network management system



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"Generalized Multiprotocol Label Switching: An Overview of Signaling Enhancements and Recovery Techniques"

- Switching optically at source and destination nodes

Availability with redundant routes and protection switching

- P(failure) = F
  - P(double failure) = F X F = F^2 = DF
  - P(triple failure) = F X F X F = F^3 = TF
  - P(working) = 1-P(failure) = 1 – F = W
  - P(working redundant system) = 1 – P(double failure) = 1 – DF
  - P(working trippel redundancy system) = 1 – P(trippel failure) = 1 – TF
  - Probability for outage decreases exponentially

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Example: Redundant routes and protection switching

- Example for cables with uptime 99.99 % each
  - P(failure) = 0.01
  - P(working dual system) = Uptime = 99.9999 %
  - P(working triple redundancy system) =99.999999%

Achievable uptime using redundant routes and optical switching is superior to using a single cable

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Passive subsea cables availability

- Fibre cable only – no power
- Long lifetime - 35 years+
  - Lower complexity and cost: No active equipment on seafloor
  - No failures in electronics
  - Experience: No added attenuation after 20 year in the sea
  - No active equipment getting outdated

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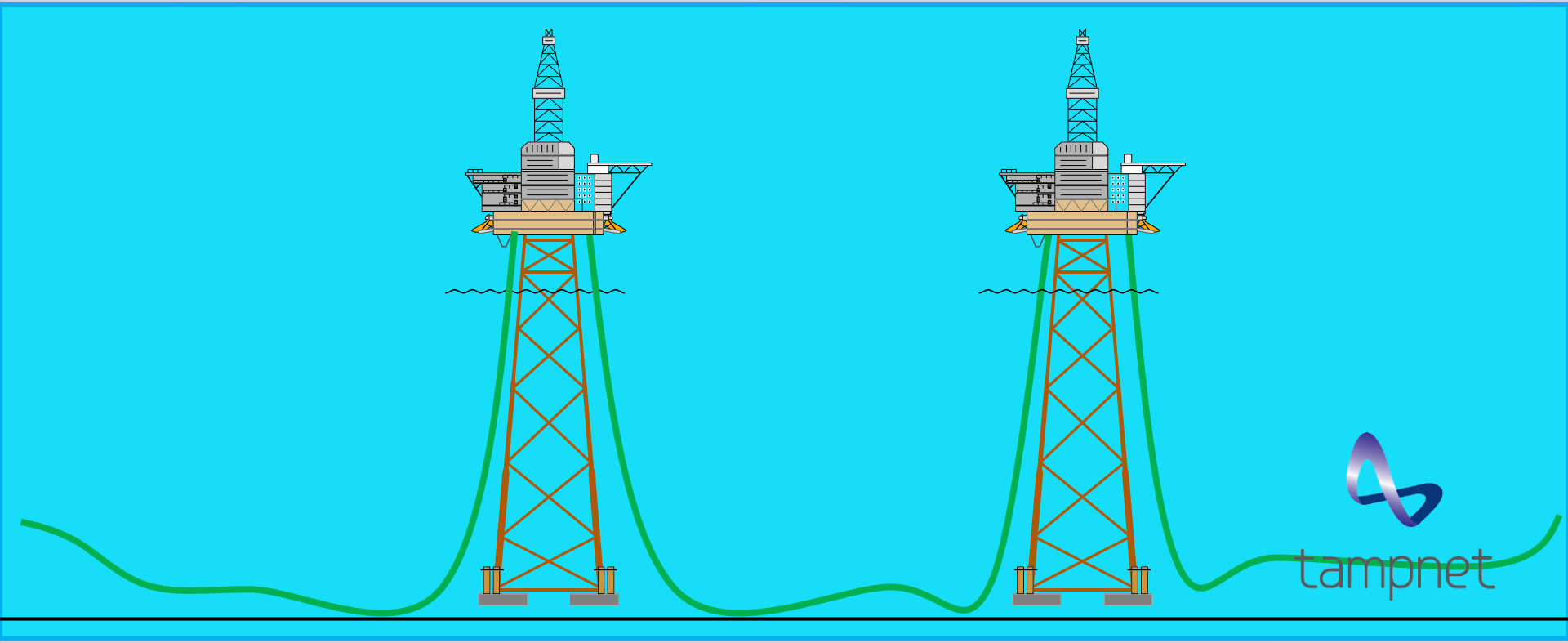
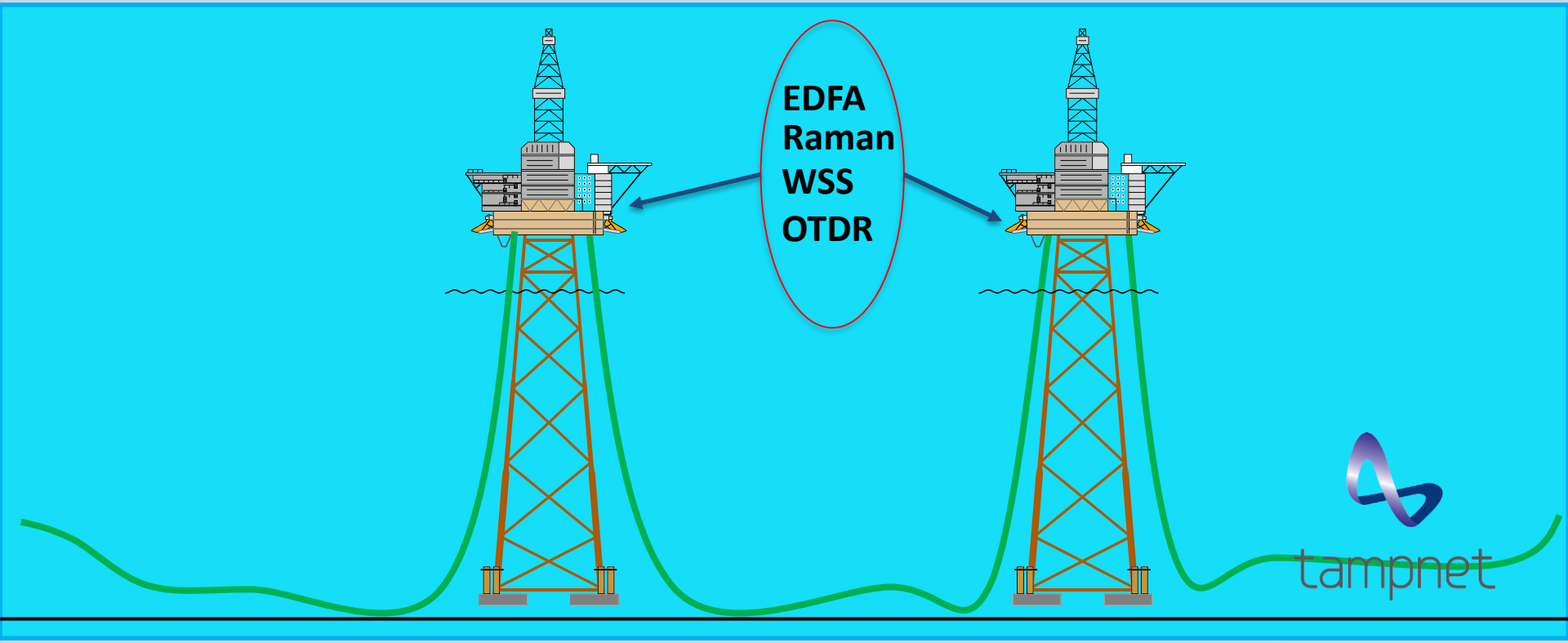
Passive cables + offshore installations



Passive cables + offshore installations



Passive cables + offshore installations

- Active equipment located in dry rooms at offshore installation
  - Deployment of up to date equipment when needed
  - Replaceable and upgradable active equipment
  - Limited span length enables capacity > 20 Tb/s per fibre pair
- Offshore installations have long lifetime
  - 35 years +
  - Floating installations may replace fixed installations
- Highly reliable power sources
  - Oil and gas are mission critical operations
  - Experience from Tampnet: Approx. 5 hours outage in 4 years

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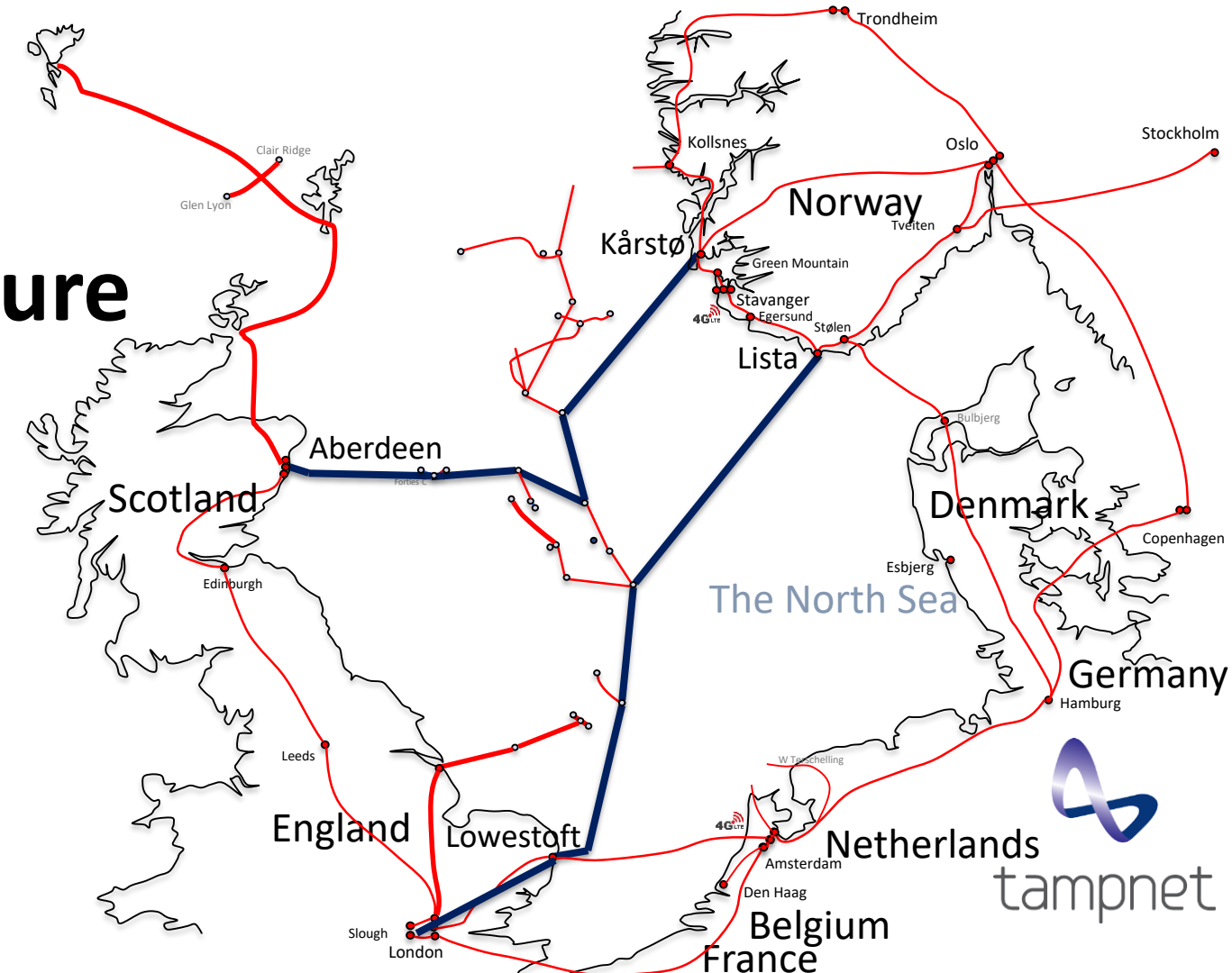
Tampnet Fibre Infrastructure

Routes across the North-sea

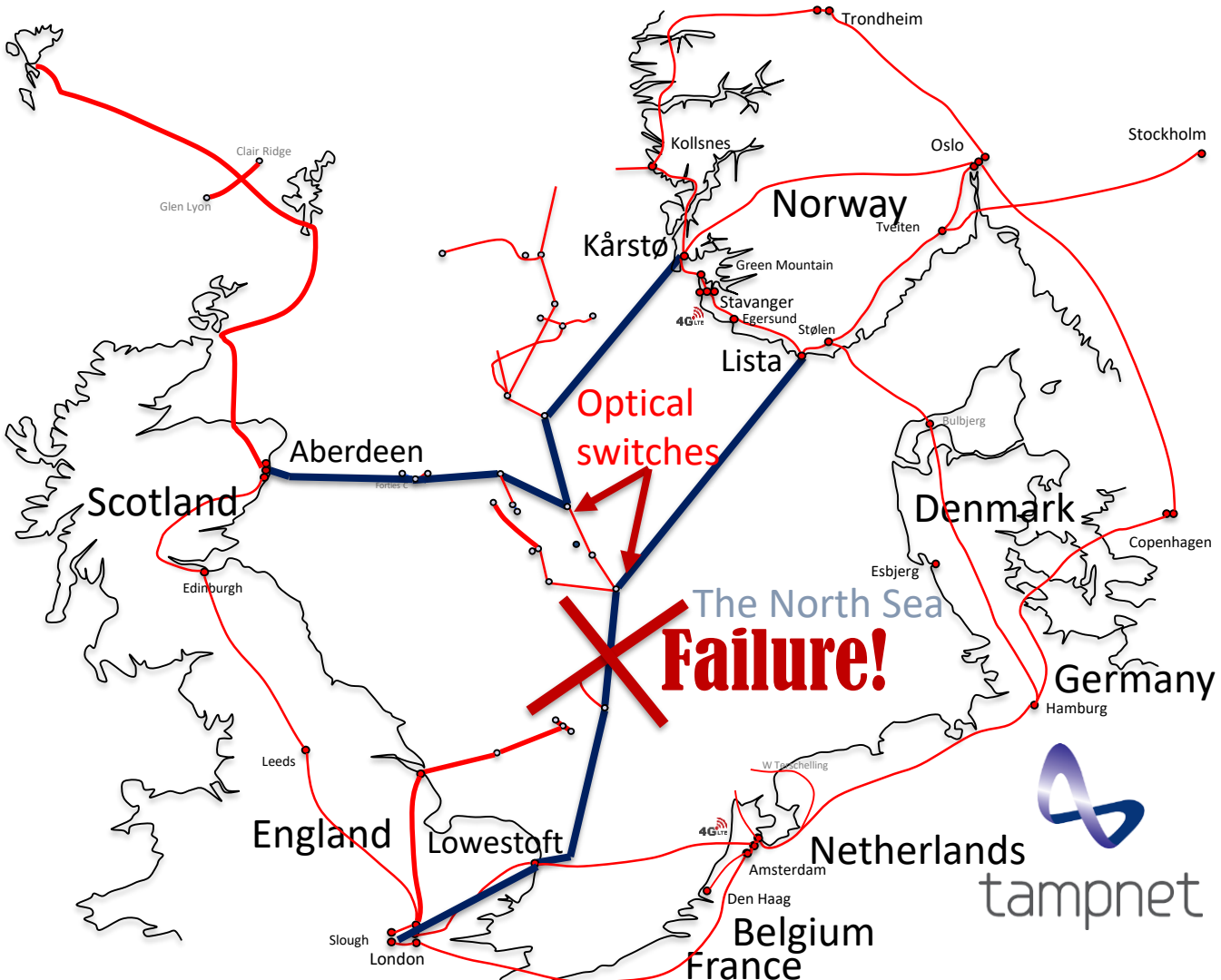


Protection switching off-shore

Routes across the North-sea

Protection switching off-shore

Routes across the North-sea



Protection switching off-shore

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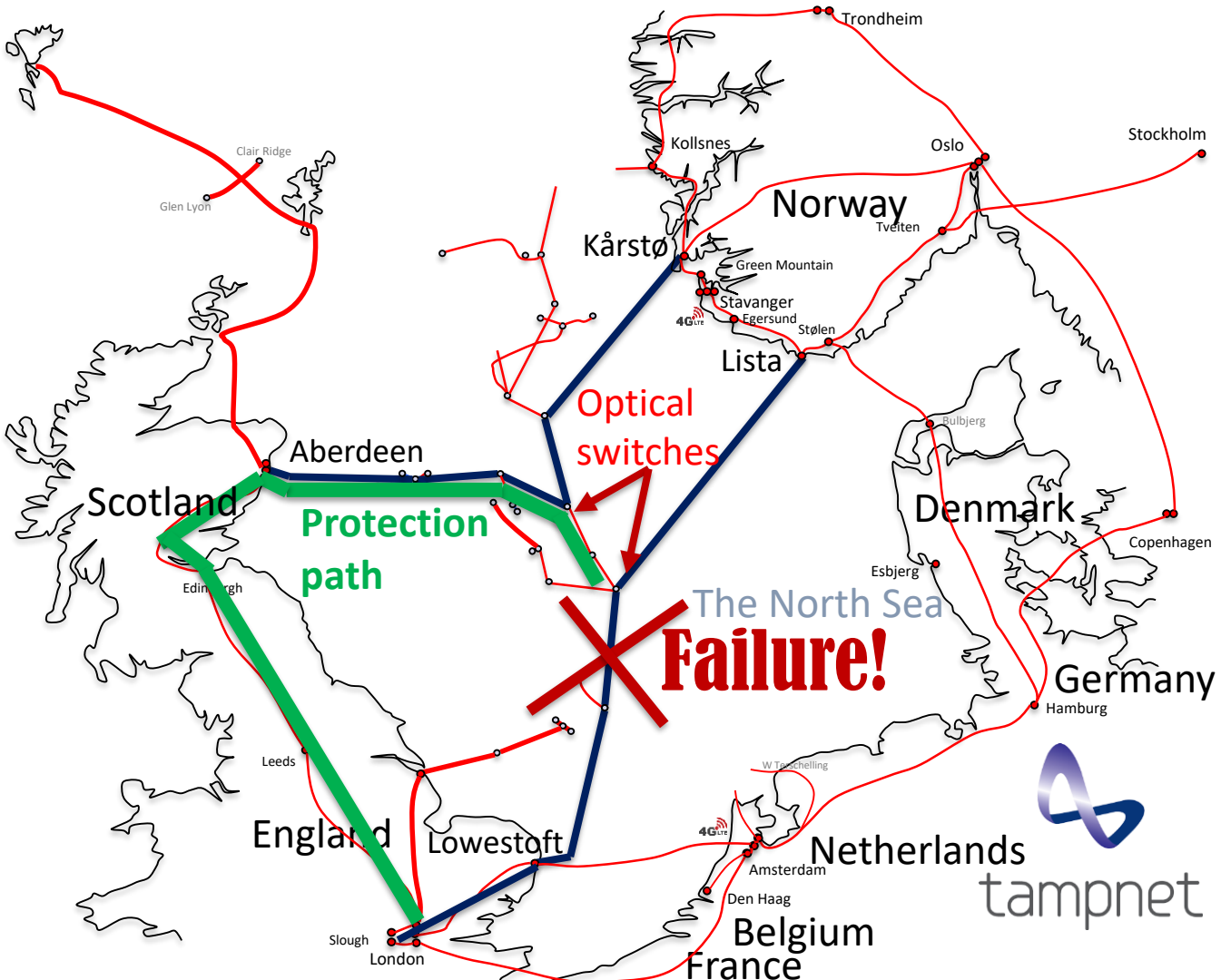

Functionality increasing availability

- Off-shore optical protection switching
- Continuous OTDR monitoring on vacant fibre pairs
  - Attenuation
  - Potential damage/cut of cable
- Any new beneficial technology may be installed when becoming available
- Dark fibre offering still possible with optical protection switching

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Additional functionality increasing availability

- Active monitoring and machine learning for predicting network element failures
  - Useful when equipment can easily be replaced like e.g. on an oil-platform
- AES monitoring and warning system for preventing damage from fishing gear.
- DAS monitoring for preventing damage from fishing gear
  - Applicable for passive cables
- OTDR monitoring for rapid fibre break location

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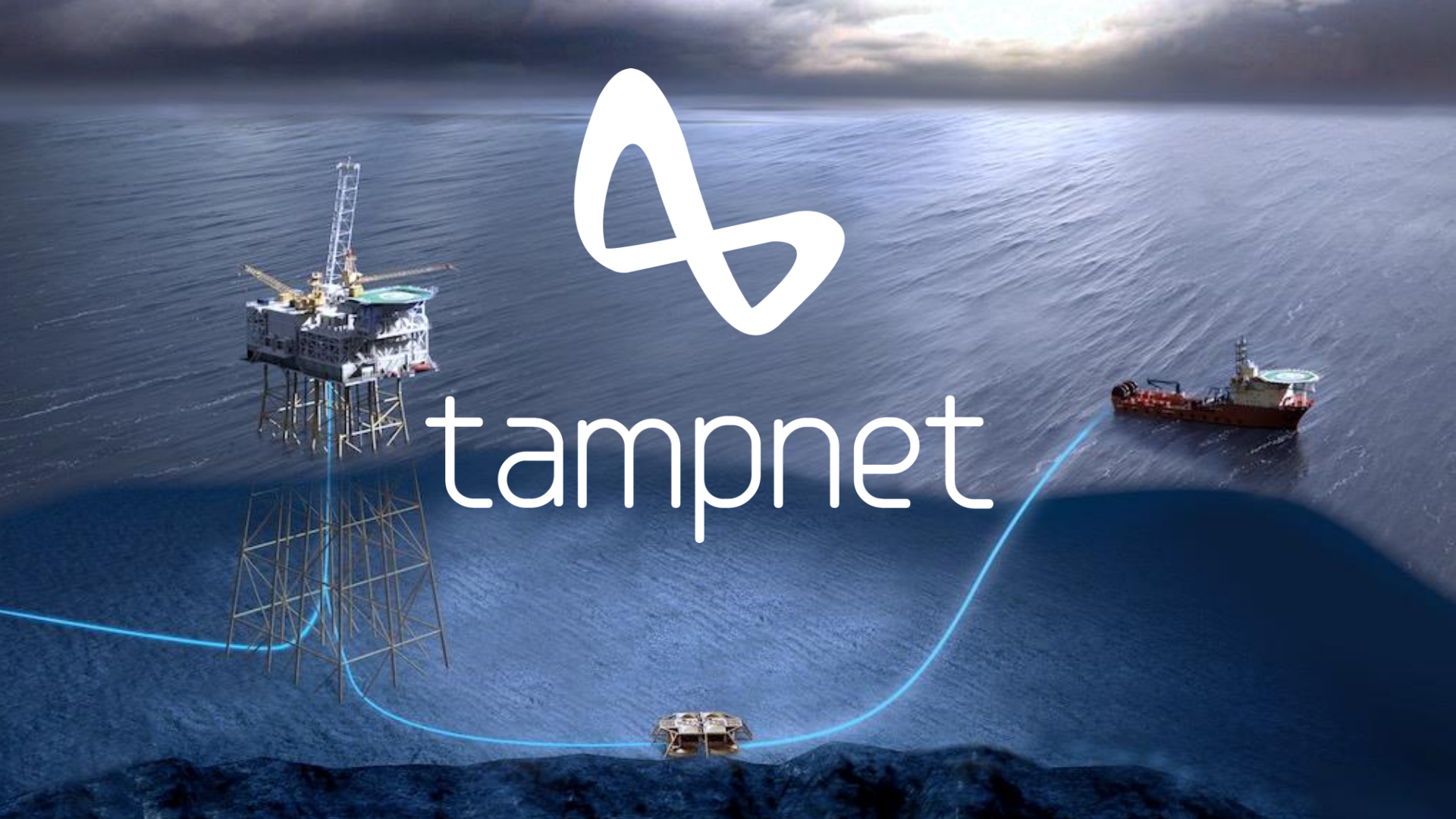
Summary

- High availability achievable in sub-sea network
  - Redundancy through multiple connections
  - Optical protection switching
  - Variety of monitoring techniques
  - Proactive initiatives: Bury the cable well
- Tampnet has a highly available network ensured by optical protection switching and active monitoring

Highly available networks is key for the datacenter and 5G age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