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Design and Implementation of LeNSE2

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Topics

- Background to procurement
- Limitations of LeNSE1
- LeNSE2 procurement objectives
- Technical design issues & options
- LeNSE2 implementation
- Key attributes of the LeNSE2 solution
- Summary
- (If time: example of other potential solutions)

Background to Procurement

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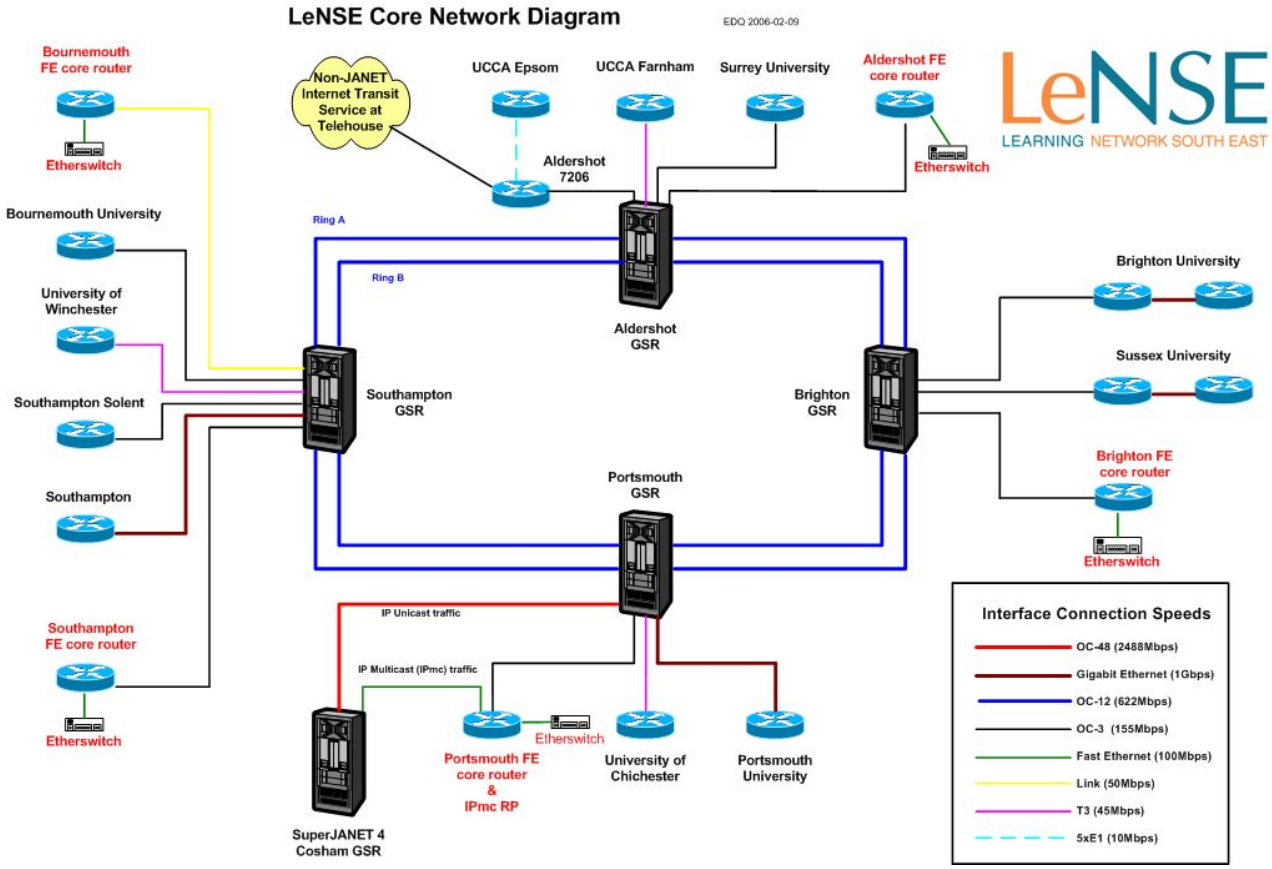
LeNSE1:

- Was a 6 year ‘fully managed’ 24x7 IP service contract with SSE Telecom (SSET) which expired in September 2007.
- LeNSE did not own the core ‘P’ routers or the edge ‘PE’ routers.
- LeNSE had no access to SSET’s underlying transmission circuits.
- Core network was based on a Ring topology with 4 C-PoPs.
- LeNSE member HEIs wanted no part in LeNSE2 service delivery, hence we had to continue using supplier C-PoP locations.

Therefore, for LeNSE2 we needed:

- A major reprocurement, rather than incremental upgrade.
- A budget of circa £5M+ over 5 years to fund the procurement.

LeNSE1 Network (2001-2007)



Limitations of LeNSE1

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- Cisco GSR12000 ‘P’ core routers were becoming old and software upgrades problematical.
- Cisco 7200 ‘PE’ edge routers did not exhibit carrier class performance with the original NSE-1 processors (NPE-G1s were better!).
- The design had too many edge IP routers (2 per HEI).
- Bandwidth limitations on inter-core links (2x622Mbps SDH) were becoming restrictive.
- MPLS was enabled by SSET but presented problems deploying IPv4 multicast and IPv6.
- IP Resilience limited by Ring topology.

LeNSE2 Procurement Objectives

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- OJEU Competitive Dialogue procurement process for
  - A solution technically compliant with SJ5.
  - A new contract service model compliant with the JPA.
- Increased core infrastructure reliability & resilience
  - Five 9s reliability for transmission network and IP routers.
  - Better C-PoP environments.
- Simplified IP routing architecture
  - Reduction of number of core and edge IP routers.
  - 'Dual homed star' rather than IP ring topology?
- Reduction of Single Points of Failure
  - Resilience links for all core FE aggregation routers.
  - Optional secondary links for member HEIs.

Design issues (1)

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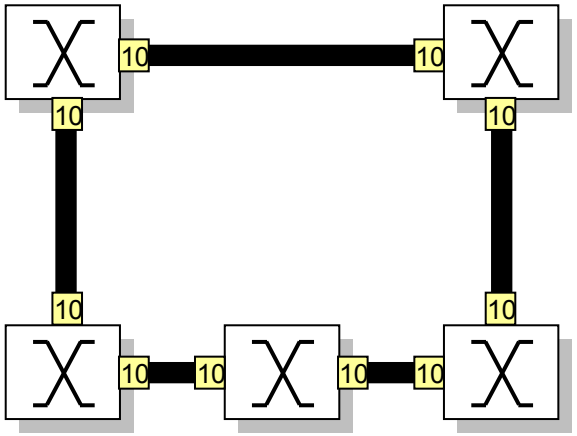
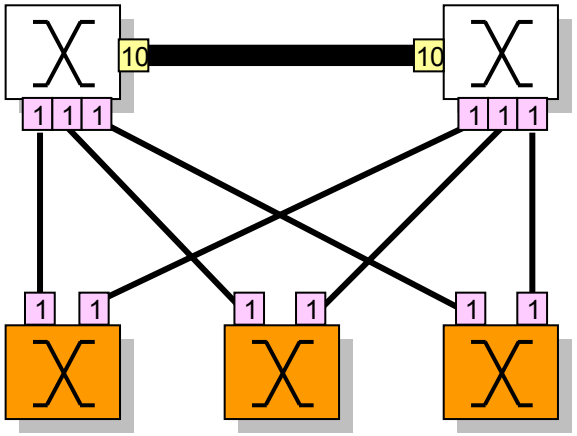
- IP Design – Ring versus Dual Homed Star?
  - Suppliers fell equally into both camps.
  - We concluded that the dual homed star architecture was technically superior as it offered greater resilience to circuit/interface failures, but is dependent on affordable transmission circuits/channels, especially for an RN the size of LeNSE.
  - Implementation needs High Availability (HA) router platforms and we concluded that protected DC power was highly desirable for all core routers.

Ring



Dual Homed Star



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Key

- Core 'P' Router
- Site 'PE' Router
- 10 Gbit/s circuit
- 1 Gbit/s circuit
- 10 — 10Gbit/s interface
- 1 — 1Gbit/s interface

ADVANTAGES of Dual Homed Star Network:

- Cheaper 1GbE Interfaces on most routers.
- Improved resilience – A circuit or interface failure only takes down one connection to one customer's router. SJ5 RNEP failures do not cause loss of service. Very fast convergence (sub 500msec).
- Routers only need to route their own 1GbE of traffic, and not the entire RN traffic (as in Ring case).
- More gradual incremental upgrade path – Additional GbE circuits can be added to serve specific individual sites – the entire Ring doesn't need upgrading.

MAIN DISADVANTAGE of Dual Homed Star Network:

- Requires more transmission channels, but these can be cost effectively provided if access to DWDM wavelengths (dark fibre or leased).

Design issues (2)

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- Optical Plant Requirements?
  - Physical rings across our region add resilience.
  - LeNSE did not mandate use of G.655 (40Gbps) fibre; G.652 (10Gbps) was sufficient by using multiple 2.5Gbps or 10Gbps circuits on different wavelengths.
  - The key was access to multiple DWDM wavelengths.
  - Also, it was advantageous if the supplier C-PoPs and fibre infrastructure already existed (lower risk to delivery timescale and reduced cost to the supplier).
  - Greatest challenge: Cost effective & timely access to extra wavelengths/circuits for future JANET Lightpath channels (pre-configured dynamic capacity adds £millions to cost).

Design issues (3)

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- Transmission Equipment Options?
  - We investigated a range of popular transmission products from the Ciena 4200 (SJ5) to the LuxN Gigabit (Neos).
  - All our potential suppliers used different products – so hard to find preference but…

    a) Who is going to monitor, manage, maintain & develop the equipment?

    Not us, hence product choice was best left to the suppliers.

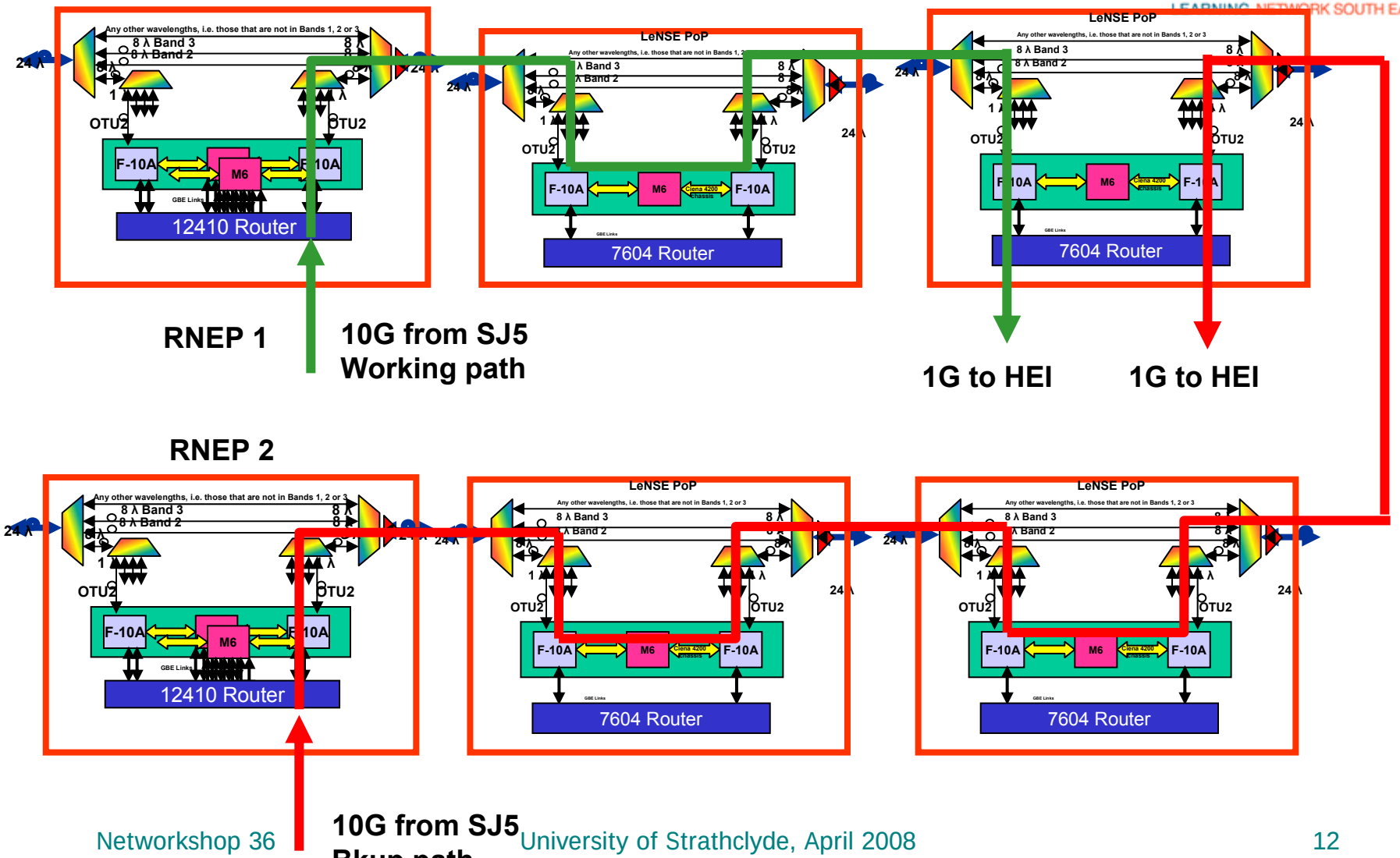
    b) What level of product feature set and configuration flexibility is actually needed?

    We concluded a design based entirely on point-to-point GbE circuits would not require many changes and did not require sophisticated transmission products. Product and transmission path reliability were more important to us.

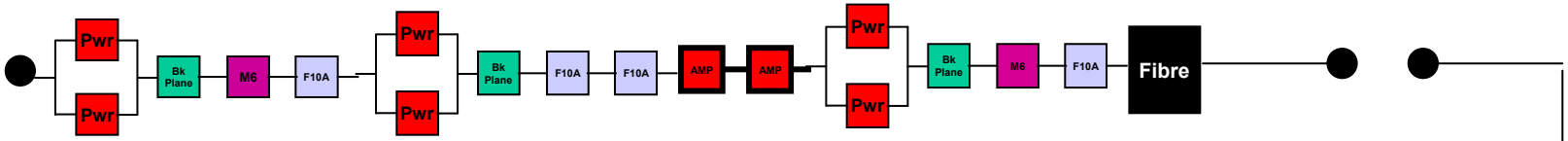
Design issues (4)

- PoP design
  - Separate East and West facing transmission circuits in difference transmission chassis for added resilience.
  - Where possible, East and West facing chassis should be housed in separate PoP racks on separate power feeds.
  - Use DC power.
- Signal path versus Physical path
  - Most suppliers have physical fibre rings, so dual homed star designs have to carry multiple circuits along ring segments.
  - Ring designs carry signal path through intermediate transmission nodes, hence more components in signal path.

Signal Paths in Rings (Geo/Synetrix example)



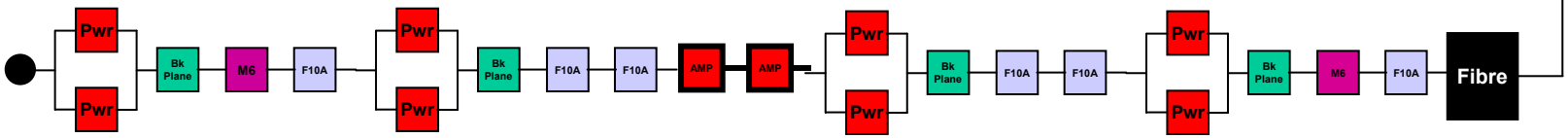
Transmission reliability block diagram for production IP traffic



HEI

RNEP 1

Geo/Synetrix model for calculating path reliability: Aggregate individual component MTBFs to estimate overall MTBF for each circuit



RNEP 2

LeNSE2 Contract Awards

Contract awards placed in December 2006:

Neos Networks for:

- Lot 1 – transmission network/services
- Lot 5 – additional bandwidth or circuits

Alcatel-Lucent for:

- Lot 2 – supply of new IP routers
- Lot 3 – systems integration/migration services
- Lot 4 – 24x7 network monitoring service, 24x7 HEI/FEI Help Desk service, spares management service and 24x7x4 equipment maintenance services

LeNSE2 Implementation

LeNSE procured a managed transmission service from Neos:

- Dedicated managed wavelengths across the Neos regional DWDM core (actually 30 Gbps worth).
- Dedicated LuxN Gigamux DWDM transmission equipment in serving PoPs, configured in pairs of East and West facing chassis for added resilience.
- All connected via fibre pairs dedicated to LeNSE.
- JANET Lightpath solution: Initial capacity for up to 8 wavelengths via SJ5 RNEP1 (Southampton).

Neos fibre network

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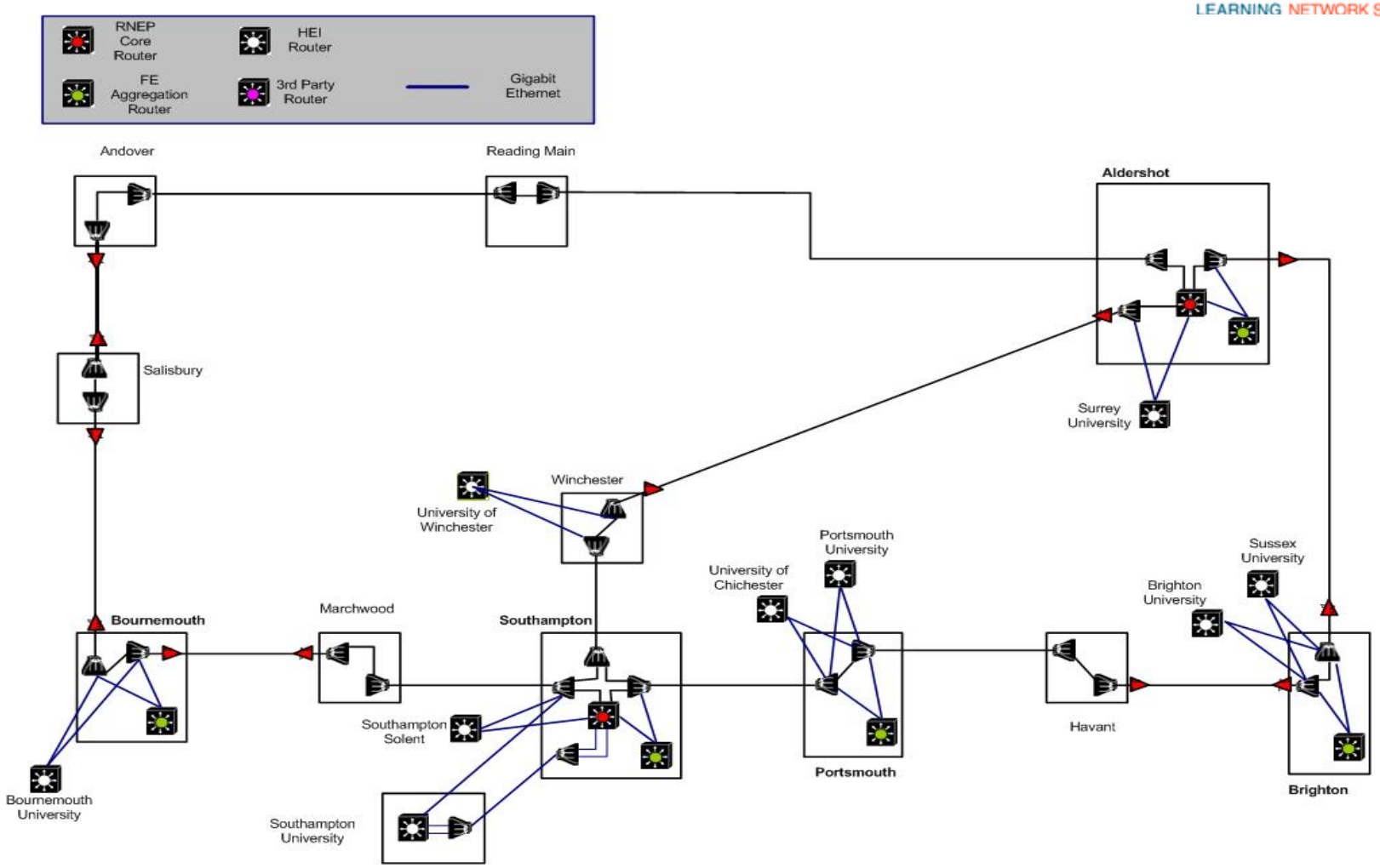
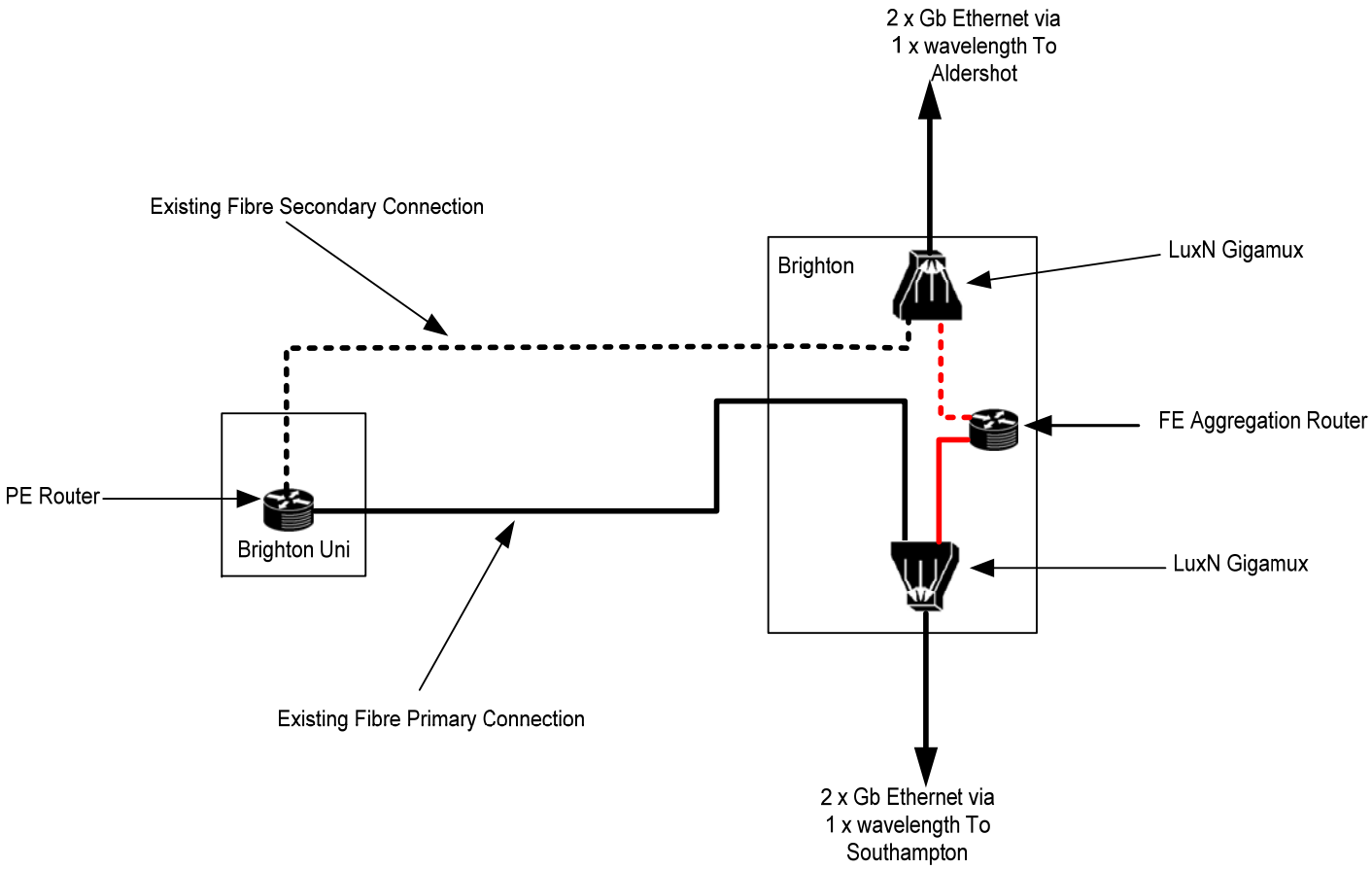
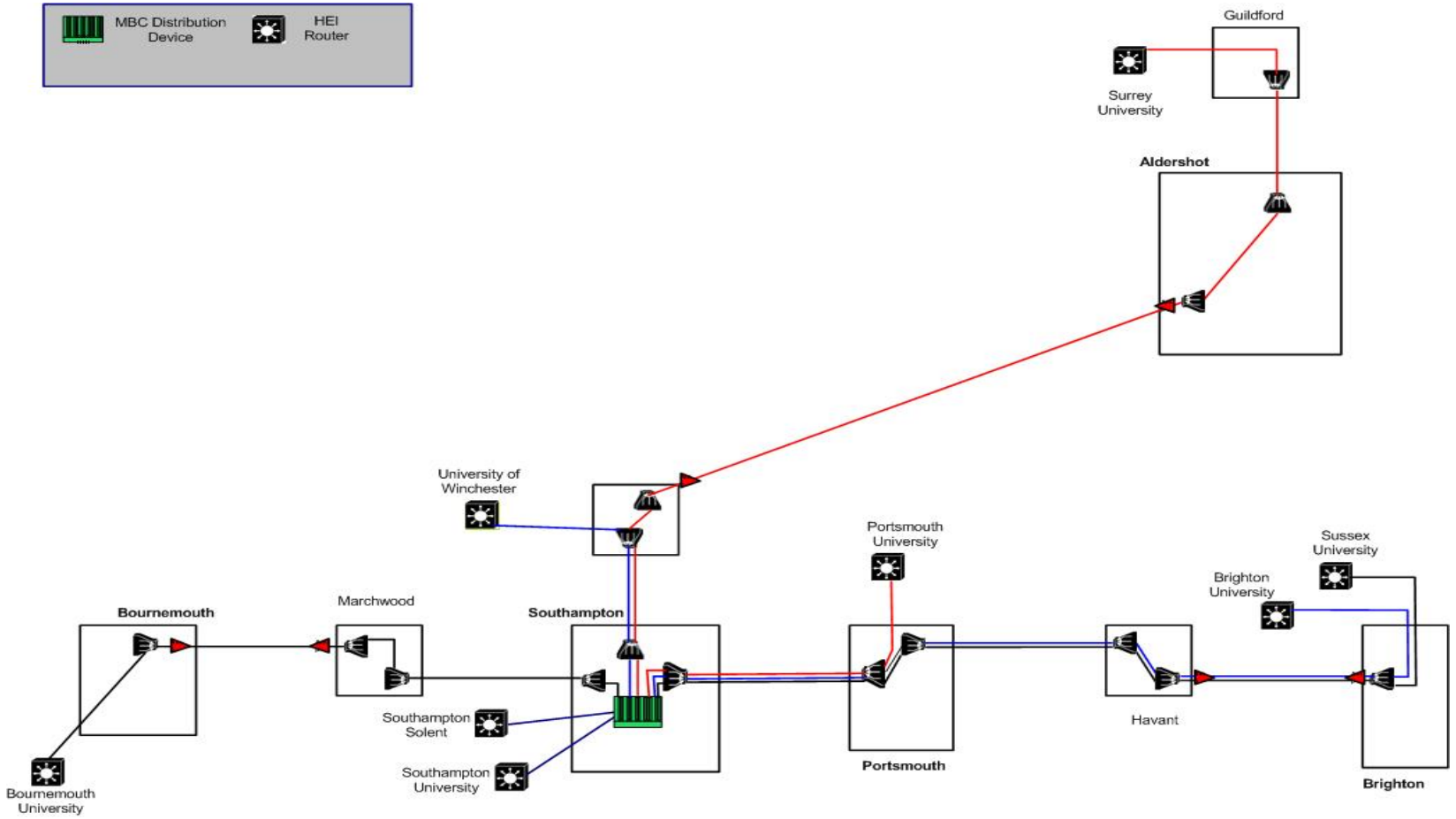
LeNSE2 Transmission network



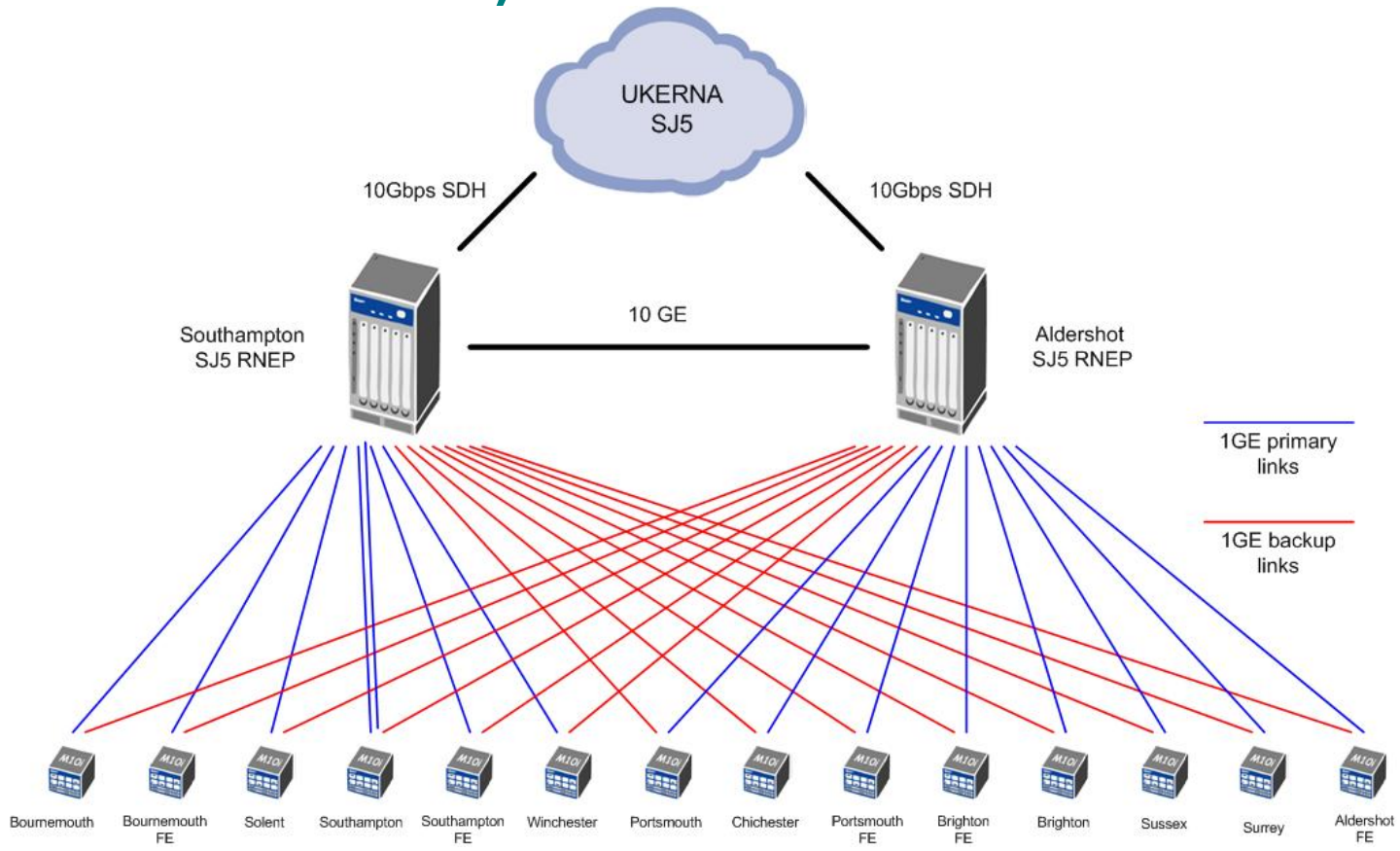
Connection details



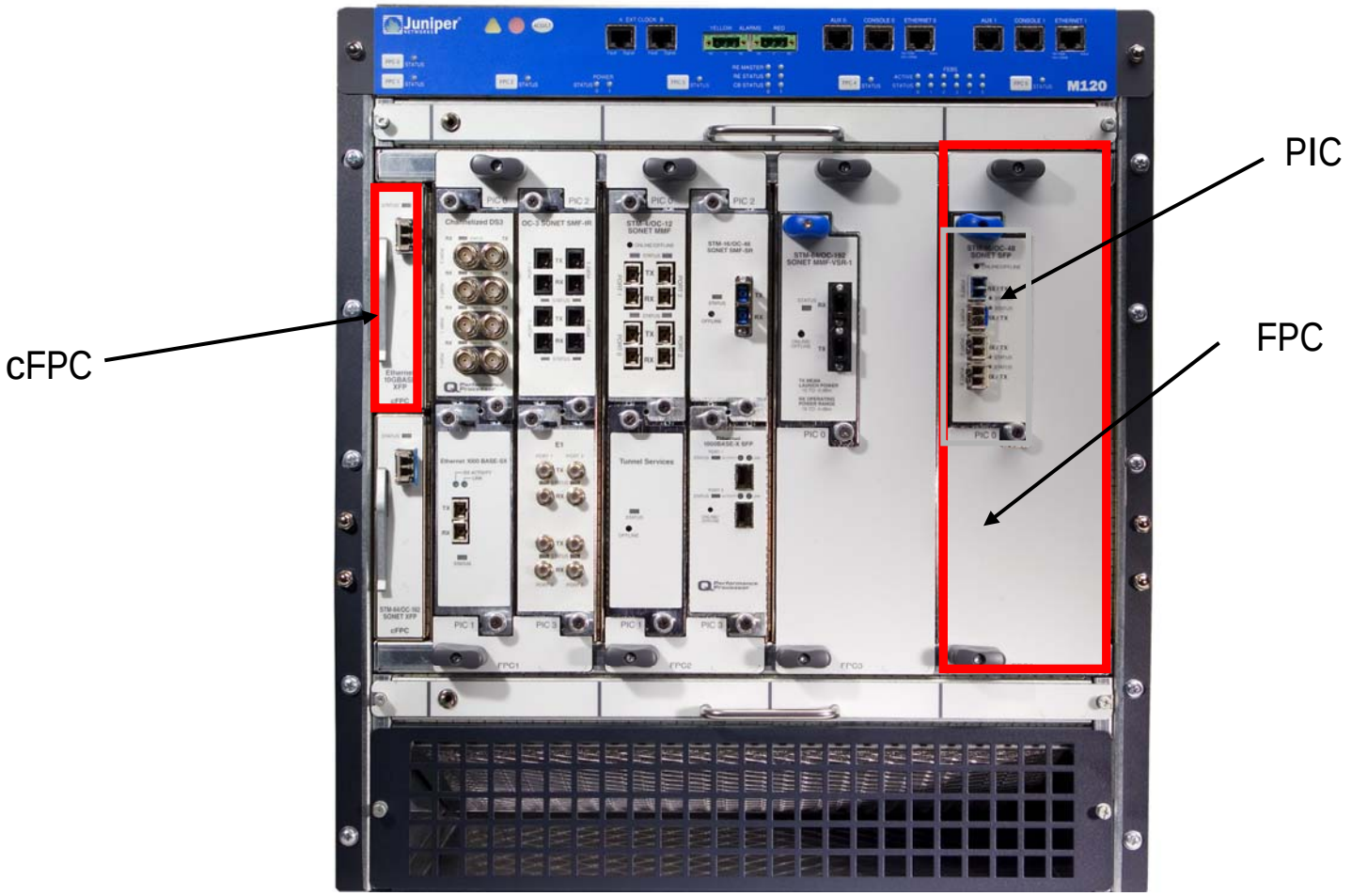
SJ5 JANET Lightpaths



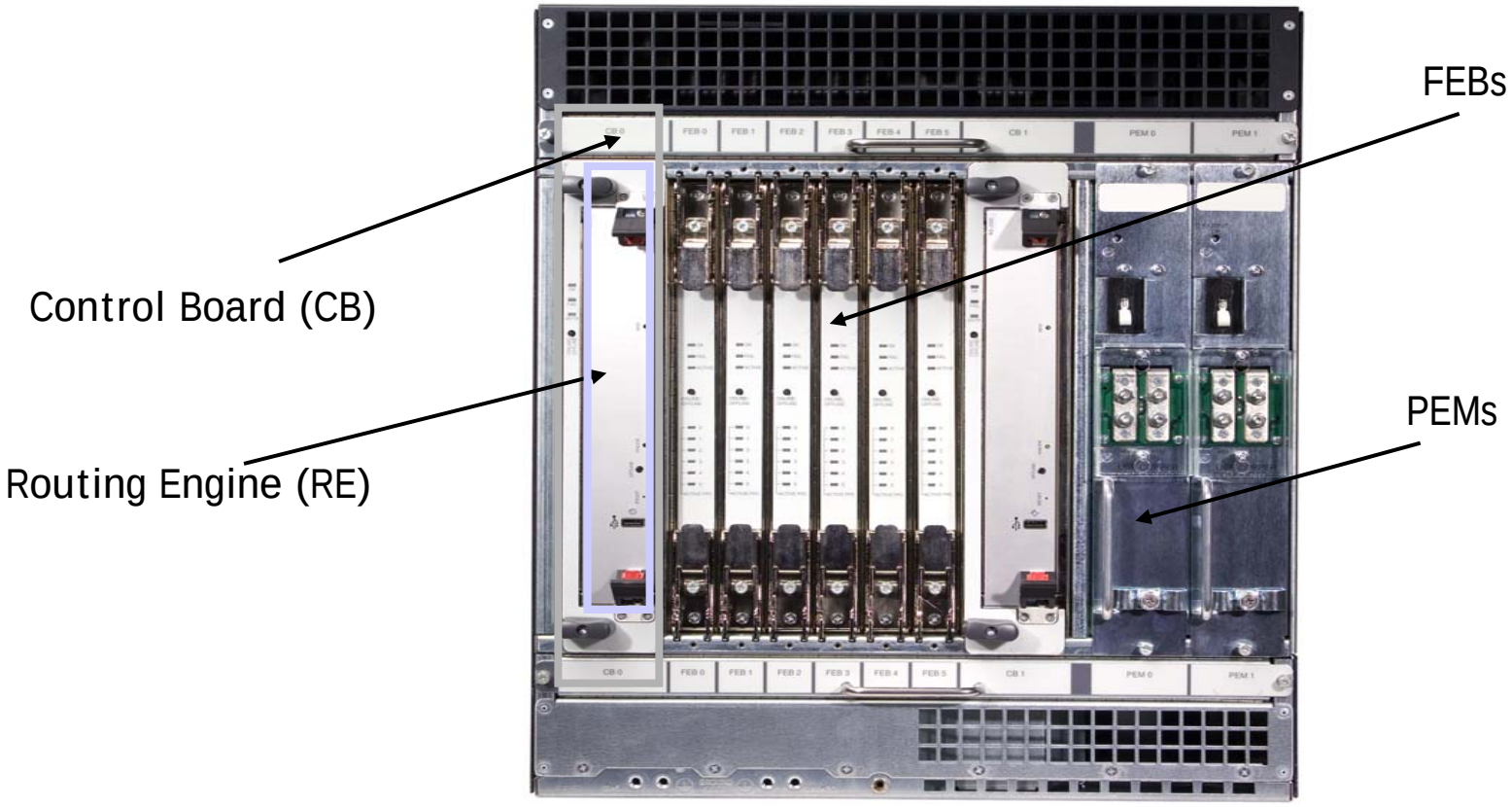
LeNSE2 IP network design
("dual homed star")



Juniper M120 Core ‘P’ HA Router



M120 – Rear View

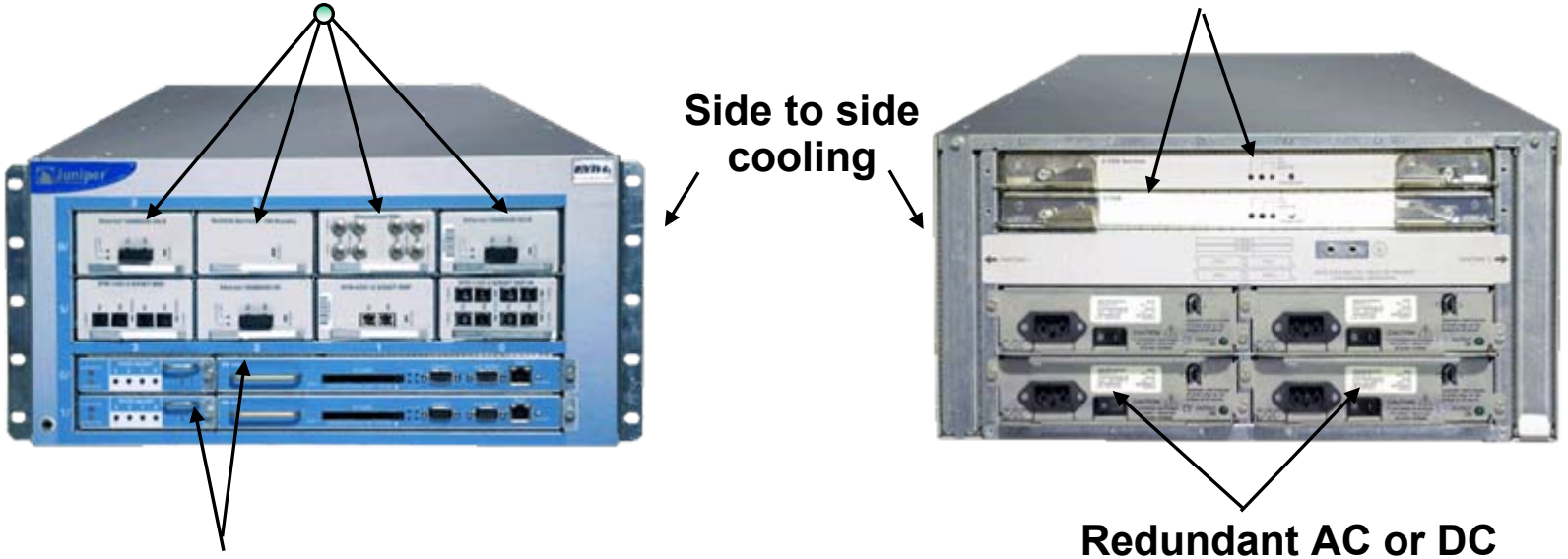


Juniper M10i edge 'PE' HA router

- Production proven high performance technology
  - Leverages Internet Processor II
  - Ethernet modules have IQ2 PICs
  - Runs JUNOS software (same as T640 etc)
- IPv6 – Juniper provides hardware IPv6 support on all platforms
- Multicast – Juniper's multicast performance is unparalleled and available on all platforms, including multicast over L3 VPNs
- Fully redundant configuration available
  - Redundant forwarding engine board
  - Redundant cooling
  - Redundant power
  - Redundant routing engine
  - Graceful RE Switchover supports RE failover with zero packet loss
  - In Service Software upgrades

Ideal for:
Fully redundant edge services solution for lower density PoPs

M10i Components



Key Attributes of Solution (1)

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1) Best technical design & implementation

- Dual fibre rings around region (diverse fibre routing).
- Effectively 30Gbps+ core network.
- Primary & secondary uncontended GbE access circuits.
- Only design to treat all LeNSE HEIs equitably, but can also easily satisfy individual HEI bandwidth upgrades (e.g. 2x1GbE or 10GbE).

2) High reliability and resilience to all HEIs

- Five 9s reliability for transmission system and router components.
- Minimum number of core and edge routers, now owned by LeNSE.
- “Dual homed star” IP network design which maintains the IP service despite a core fibre break, intermediate node or RNEP failure (better than ring).
- Sub-500msec convergence after link/interface failure.
- In service software upgrades.

Key Attributes of Solution (2)

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3) Control and flexibility in line with JPA requirements

- Managed wavelengths, very scaleable on individual link basis.
- PoP transmission equipment and fibre pairs dedicated to LeNSE.
- Ability to add JANET Lightpaths between C-PoPs and HEIs.
- Fully compatible with SJ5 at the IP level (same Juniper router family).

4) Reduced risk of project implementation failure

- C-PoPs, fibre and transmission systems were largely in place.
- Existing fibre into all HEIs (hence minimal disruption for sites).

5) High SLA targets in contract

- 99.98% (protected links).
- 99.96% (unprotected links).

LeNSE2 Project Summary

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- Did we meet our procurement objectives?
  - Yes – and within budget!
- Are we satisfied with the technical solution?
  - Very.
- Actual network performance?
  - Excellent! No core/HEI link failures (in 6 months), sub-500msec IP resilience tests to SJ5 (all protocols – no noticeable packet loss).

Other Potential Solutions

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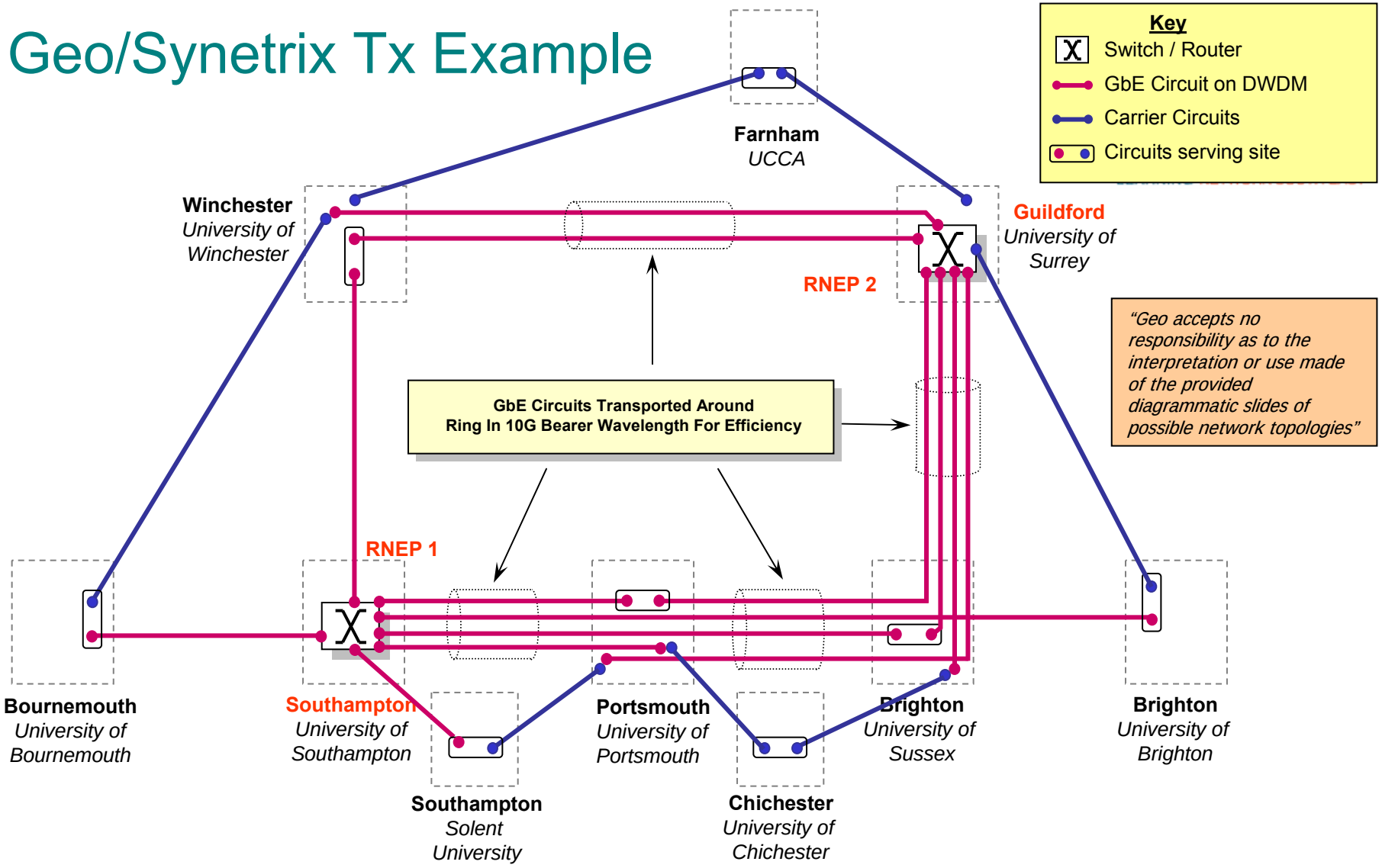
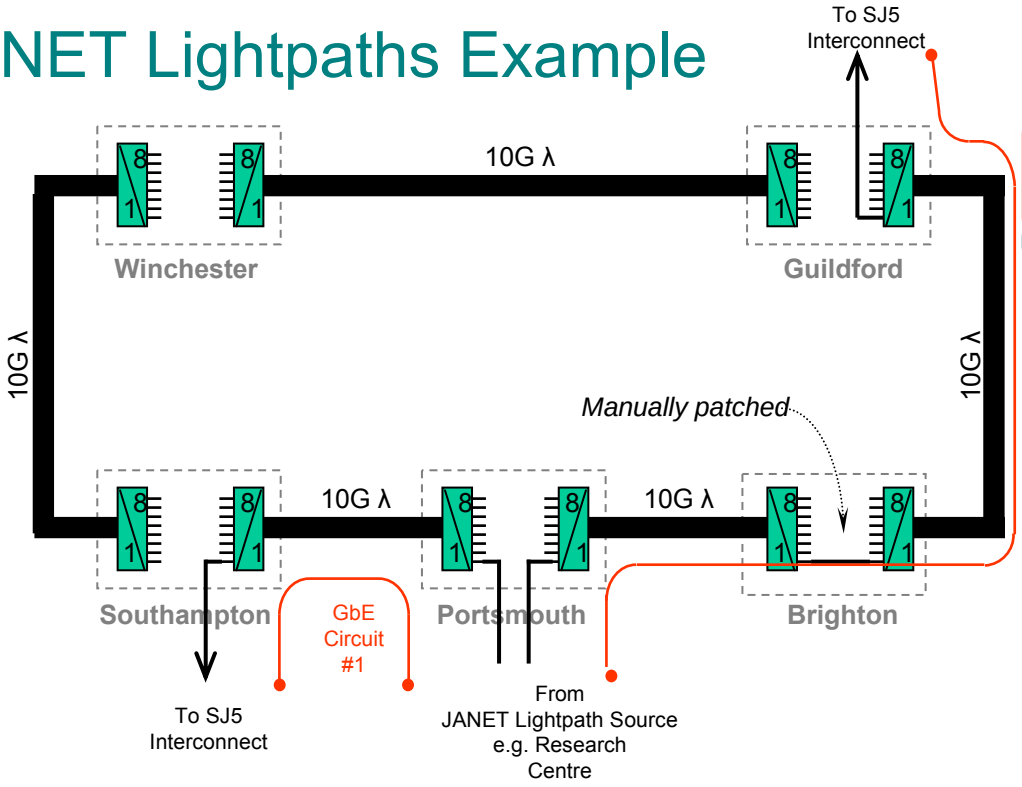
- Optical transmission: a range of potential solutions were tendered:
  - Generally either shared with other customers
  - Some bespoke solutions
  - An example of a bespoke solution follows……

Geo/Synetrix Tx Example



Geo/Synetrix JANET Lightpaths Example

Manually Patched



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A sub-multiplexed 10Gbps wavelength (8 x GbE circuits) forming a ring linking the sites would give significant immediately available bandwidth to support JANET Lightpath requirements.

- Circuits can be simply and easily manually patched to provide uncontended / unswitched point-to-point GbE channels.

- Depending on the flexibility of the DWDM multiplexing card, some of these circuits could be used to transport other service types (e.g. SDH).

Questions?

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