Evaluation of a Statewide Fibre Network

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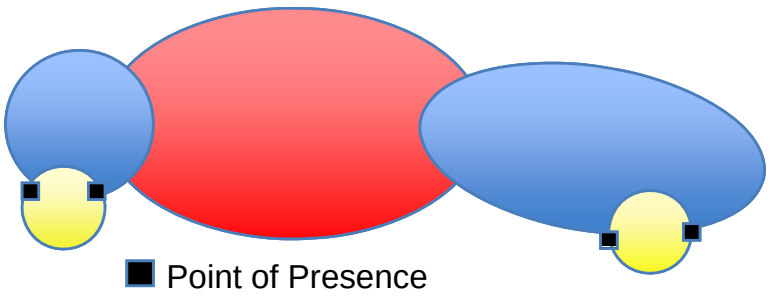
What is VERN? - The Vision

- Abundant bandwidth
- Long life infrastructure – 15 to 30 years
- Reliability through built-in resilience
- Many parallel channels (“thick” fibre)
- Passive optics (“dark” fibre)
- Support multiple networks of arbitrary topology through patching or splicing

Achieving the Vision – 1
Indefeasible Right to Use (IRU)

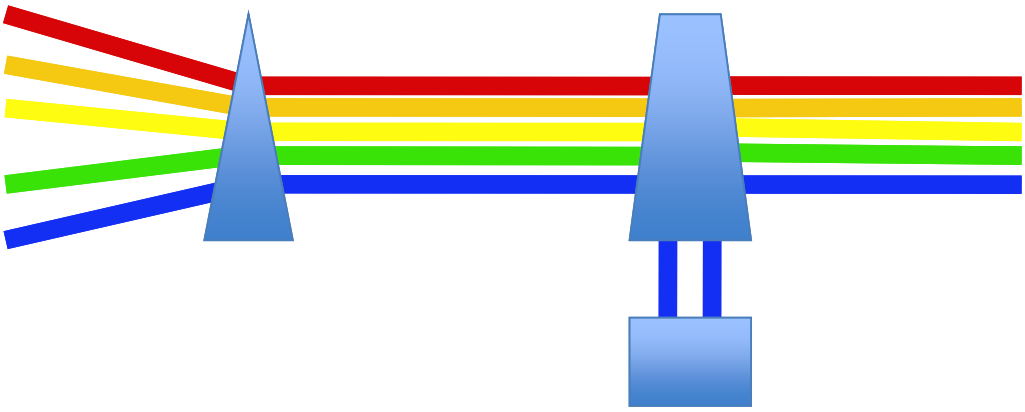
- An IRU is a legal contract which secures the long term use of a part of the capacity of a communications element such as a fibre cable
- Limited or no ability of the grantor to terminate
- IRU's provide a way of acquiring one or two pairs of fibre over a long-haul route
- Typical duration of IRU is 20 years
- Usually minimal constraints on use
- Often a significant upfront fee, plus annual maintenance charge

Achieving the Vision – 2
Hierarchy of dual-attached rings (Clarke)



- Hierarchy for economy, dual-attached for resilience
- Lowest layer is a "precinct" (D=10km, "thick" fibre)
- Next layer is region (D=50-100km, WDM)
- Third layer is "state" (D=500-1000km, WDM)

Achieving the Vision – 3
Wave Division Multiplexing

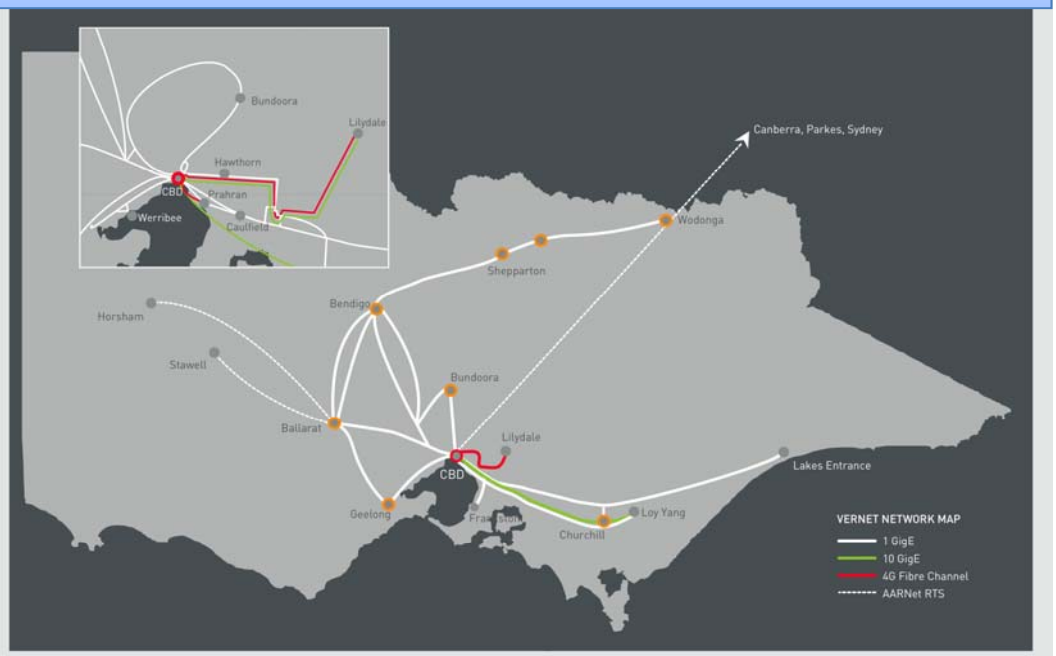


- DWDM permits at least 70 wavelengths per fibre
- Wavelengths can be dropped or added individually (ROADM), or in groups
- All wavelengths can be amplified together by one EDFA

Achieving the Vision – 4
Sub-multiplexing

- VERNet's **initial** service offering was based on 1 Gbit/s services
- In some cases nine 1 Gbit/s Ethernet channels are electrically multiplexed into a single 10 Gbit/s wavelength

The Reality – Map of VERN Dec 2008



Network Assurance
1 - High-level questions

An audit of VERN as built to answer such questions as:

- Is the network fit for purpose?
- What are the current capabilities of the network, and what are the limitations, risks and opportunities it represents for the future?
- Does the network represent good value for funds invested?

Network Assurance
2 - Consultants and Process

- Consultant chosen competitively
- Refine scope, method and deliverables (2 weeks)
- Gather information (8 weeks) through
  - interviews,
  - documents,
  - Retrieval from Asset Management System
- Build model for cost comparison (in parallel)
- Write and present report (3 weeks)

GQ·AAS
GIBSON QUAI·AAS
CONSULTING

Network Assurance
3- Key Findings

Is the network fit for purpose?

".. our findings that the VERN is fit for purpose"

".. some deviations from the conceptual requirements driven by funding constraints have not, in our opinion, prevented the network from substantially meeting the member requirements"

Network Assurance
4 - Key Findings (cont)

Current capabilities, and limitations, risks and opportunities it represents for the future?

"The existing fibre network provides a good platform for meeting future member requirements.."

Network Assurance
5- Key Findings (cont)

Does the network represent good value for funds invested?

"..members obtained good value for money for the investment that they have made.."

Network Assurance
6- Key Findings (cont)

Some gaps to be addressed include

- Development of a funding model
- Development of a well defined planning process that VERNet and members participate in..
- Renewal of leases as they mature
- Resolve known technical limitations

Network Assurance
7 – Other limitations…

- Fewer fibres than intended in some precinct loops
- Wavelengths rather than fibre pairs, on a couple of routes
- 5 year leases for wavelengths rather than 15-30 years (due to equipment lifespan)
- In a few cases there is no ring, but a spur network
- Some sites have single attachments (single lead-ins)

Network Assurance
8 - Extensions

- Network Assurance of individual networks? Present project looks at whole network, doesn't consider value etc for individual institutions, or quality of individual networks
- Possibility for individual universities?

Where to from here?

Some Possibilities:

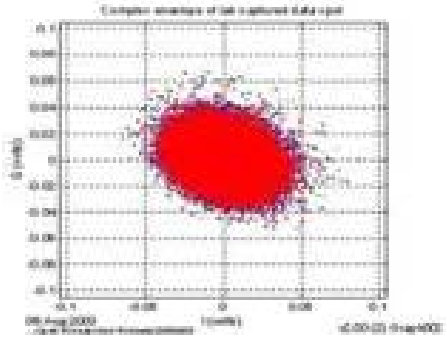
- Close loops (improve resilience)
- Remove bottlenecks
- Extend reach
- Enhance performance (bandwidth)

Looking ahead to 40 Gbit/s - and beyond

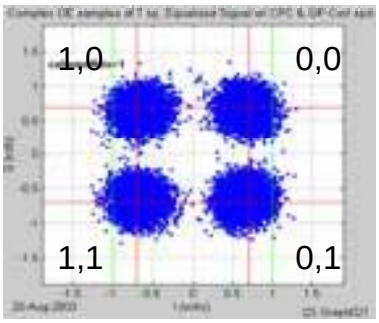
Increasing bandwidth has a disastrous effect on dispersion tolerance, hence reach.
eg CD tolerance varies as $1/B^2$

	10G NRZ Reference	Duo-Binary	DPSK	DQPSK
Normalized Reach	1	.4	.8	.65
CD Tolerance	1000	150	70	250
PMD Tolerance	15	3.5	3	7
No of 50-GHz OADM	10	3	N/A	3
No of 100-GHz OADM	20	8	8	8

Looking Ahead - 2



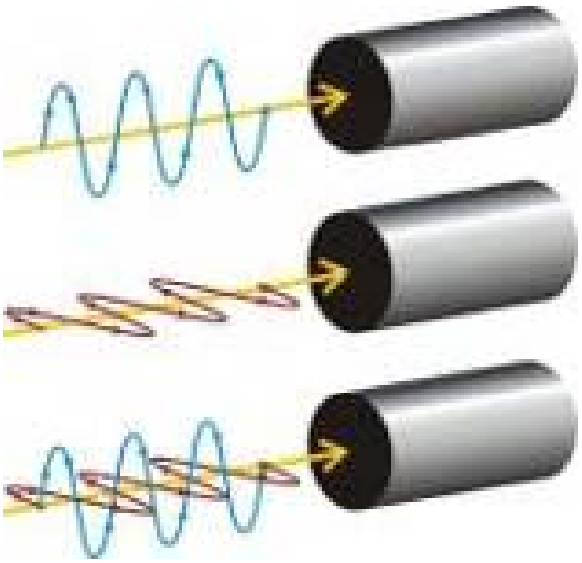
Received signal before DSP



Received signal after DSP

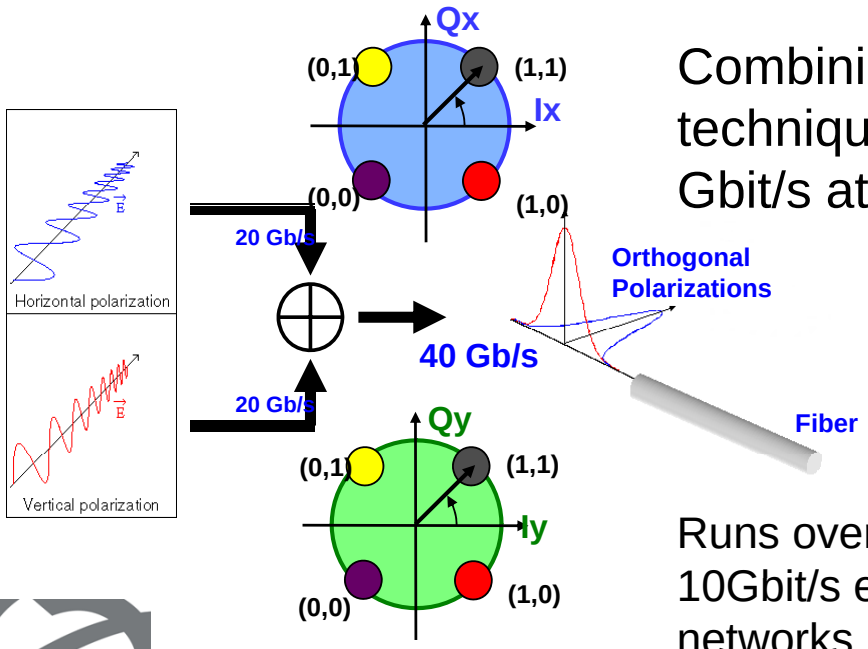
Using Quadrature Phase-shift keying (QPSK) gets 2 bits per symbol

Looking ahead - 3



Modulation in 2 orthogonal directions achieves a doubling in throughput with no increase in optical bandwidth

Looking Ahead - 4



Combining 2 techniques gives 40 Gbit/s at 10 Gbaud

Runs over standard 10Gbit/s engineered networks

Embodied in Nortel's Dual polarization QPSK products.

Looking ahead - 5

	10G NRZ Reference	2-Pol QPSK	DuoBinary	DPSK	DQPSK
Normalized Reach	1	1	.4	.8	.65
CD Tolerance	1000	50,000	150	70	250
PMD Tolerance	15	25	3.5	3	7
No of 50-GHz OADM	10	>16	3	N/A	3
No of 100-GHz OADM	20	>16	8	8	8

Thank you…
Questions and discussion