West-Highland Internet Exchange
Collaborative Network Infrastructure in Scotland

William Waites
ww@hubs.net.uk

HUBS c.i.c.
&
School of Informatics
University of Edinburgh

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Setting
Setting
Arnisdale

- 9 miles from BT remote exchange
- Barely good enough for 2400 baud
- Ladhar Bheinn blocks satellites
  ... slow & expensive anyway

What to do?

- Write letters?
- Build it yourself!
Tegola

- Tegola — Loch Hourn from 2008
- 15km trial link → 512kbps ADSL
- Expanded to a ring of six masts
- Gateworkx, OpenWRT, Quagga, OSPF, 802.11a
- Giacomo Bernardi, Peter Buneman, Mahesh Marina (UoE)
- Upstream bandwidth from UHI Sabhal Mòr Ostaig

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1 An Italian word meaning *tile*, this name is in honour of the effect of wet roof tiles on 2.4GHz RF propagation which beset some early experiments.
The Neighbours

- Nearby islands Eigg, and Rum build networks on a similar model with advice from Tegola.
- Knoydart in the next Loch builds theirs with help from Eigg.
- Later, Applecross to the north joins in...
  ... and Locheil
  ... and northern Mull
  ... and Sleat
- Farther afield Laggan, Lothian, Heriot, Stobo ...
The Internet in Microcosm

- Heterogeneous networks → encapsulate in AS
- Physically adjacent networks → connect them
- Good radios are poor routers → transparent ethernet bridges
- Local skillsets differ → advise, but *do not* dictate intra-AS methods, topology, policy
- *Much* smaller scale than usual
West Coast Network circa 2012
Southern Developments: HUBS

- Borders: West Coast pattern repeated
- Several adjacent networks
- Good bandwidth available in Edinburgh
- Confederation within AS60241

Works well except:
- Networks don’t just want transit
- Unmediated (L3) bilateral connections
- Facilitates mutual support
  → Need Layer 2
Meanwhile...

▶ BT gets £500m from SG
▶ Good news? Bad news?
▶ Ethernet services!
Layer 2 services only:

- VPLS pseudo-wire
- PtP or PtMP
- 802.1q handoff (MEF-style)
West Highland Internet Exchange

- Made with WHAN VPLS
- Typical IXP rules
- Route-server
- Anycast DNS, etc
- Except:
  - sub-/24 announcements
  - transit is typical
Great! We’re done, right?

- Networks fully-connected by default
- Uniform border router configuration
- Arbitrary L2 virtual circuits are easy
much more interesting!

history repeating

1 year + 1 week after order

(★)
**Tidal Fading**

![Graph showing tide height and RX power over time](image)
\[ \frac{\lambda}{2} = s - (r_1 + r_2) \]

\[ = \sqrt{\delta^2 + d^2} + \frac{d}{\cos(\theta)} \]

\[ \tan(\theta) = \frac{2h + \delta}{d} \]

\[ \frac{\lambda}{2d} = \frac{1}{\cos(\theta)} - \frac{1}{\cos(\theta')} \]
Further Reading

Thank you

https://hubs.net.uk/