

West-Highland Internet Exchange

Collaborative Network Infrastructure in Scotland

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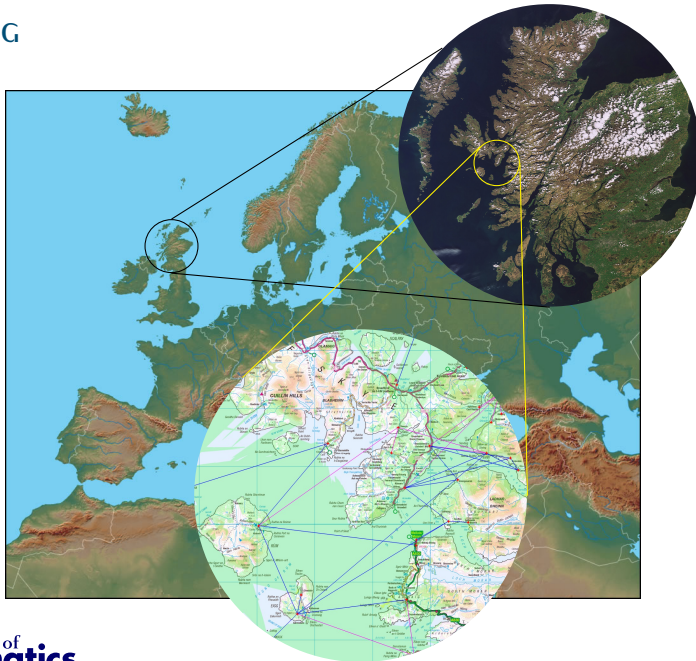
SETTING



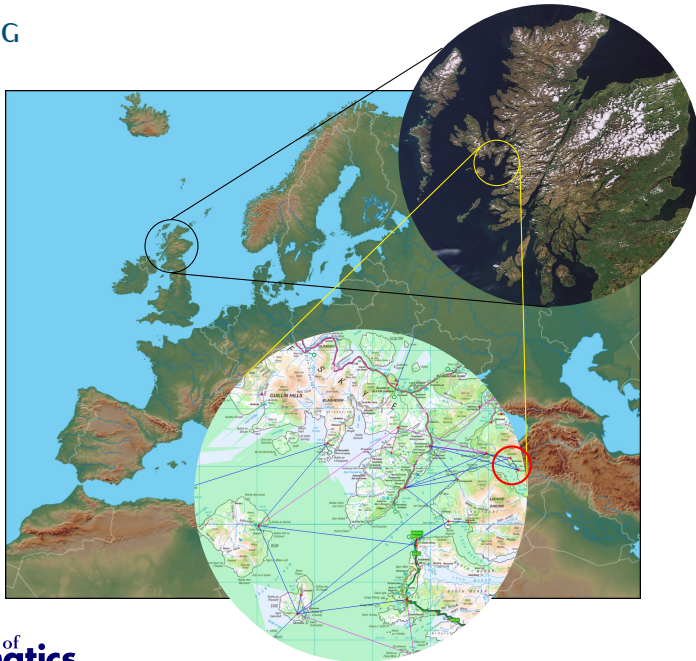
SETTING



SETTING



SETTING





Corran

Arnisdale

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!



TEGOLA¹

- ▶ 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



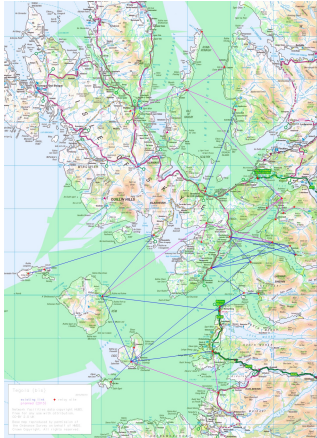
¹An Italian word meaning *tile*, this name is in honour of the effect of wet roof tiles on 2.4GHz RF propagation which beset some early experiments.

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** ...

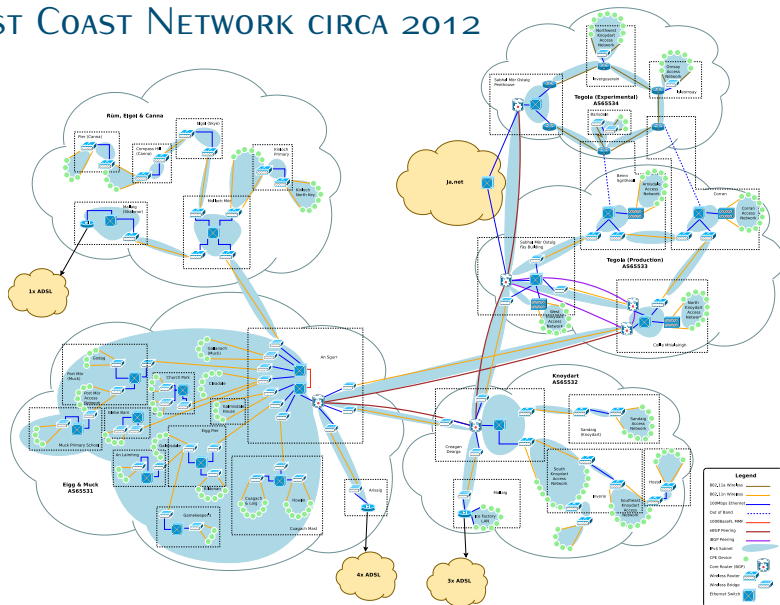
THE INTERNET IN MICROCOSM



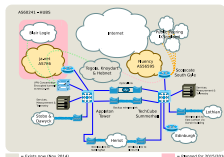
- ▶ Heterogeneous networks
→ encapsulate in AS
- ▶ Physically adjacent networks
→ connect them
- ▶ Good radios are poor routers
→ transparent ethernet bridges
- ▶ Local skillsets differ
→ advise, but *do not* dictate intra-AS methods, topology, policy
- ▶ *Much* smaller scale than usual



WEST COAST NETWORK CIRCA 2012



SOUTHERN DEVELOPMENTS: HUBS

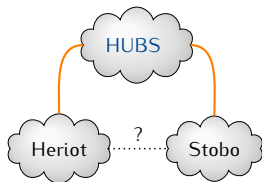


- ▶ Borders: West Coast pattern repeated
- ▶ Several adjacent networks
- ▶ Good bandwidth available in Edinburgh
- ▶ Confederation within AS60241

Works well except:

- ▶ Networks don't just want transit
- ▶ Unmediated bilateral connections
- ▶ Facilitates mutual support
- ▶ Help with internal links (★)

→ Need Layer 2



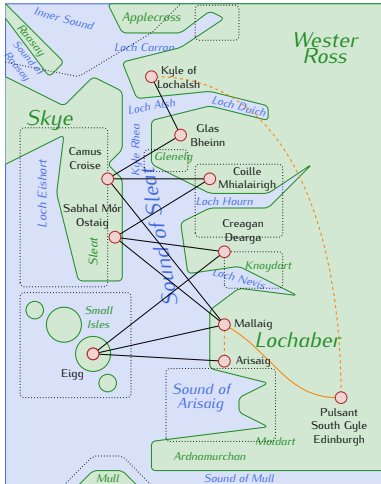
MEANWHILE...



- ▶ BT gets £500m from SG
- ▶ Good news? Bad news?
- ▶ Ethernet services!



WEST HIGHLAND ACCESS NETWORK

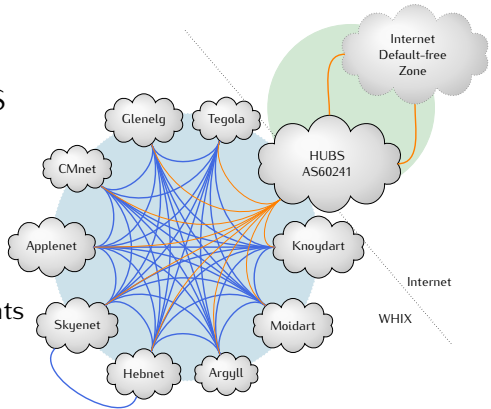


Layer 2 services *only*:

- ▶ VPLS pseudo-wire
- ▶ PtP or PtMP
- ▶ 802.1q handoff (MEF-style)

WEST HIGHLAND INTERNET EXCHANGE

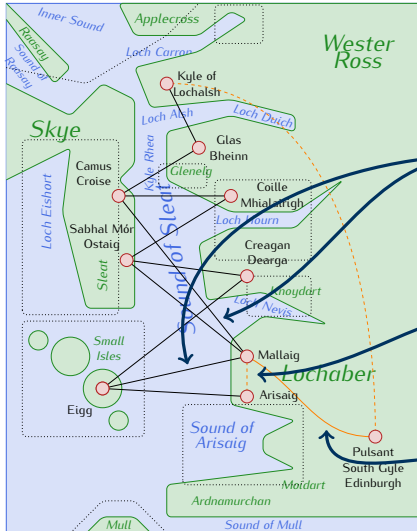
- ▶ Made with WHAN VPLS
- ▶ Typical IXP rules
- ▶ Route-server
- ▶ Anycast DNS, etc
- ▶ Except:
 - ▶ sub-/24 announcements
 - ▶ transit is typical



GREAT! WE'RE DONE, RIGHT?

- ▶ Networks fully-connected by default
- ▶ Uniform border router configuration
- ▶ Arbitrary L2 virtual circuits are easy





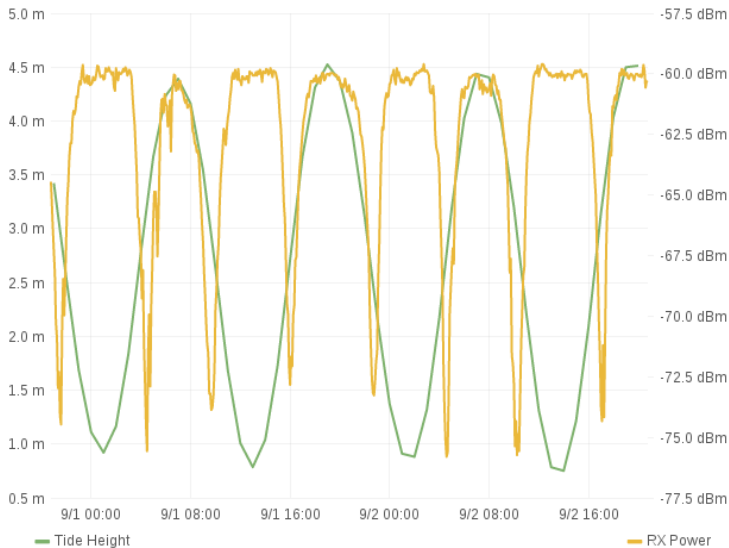
much more interesting!

history repeating

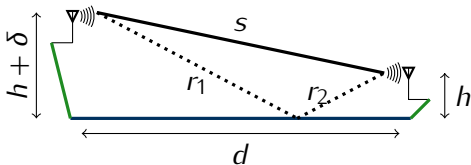
1 year + 1 week after order



TIDAL FADING



TIDAL FADING



$$\begin{aligned}
 (2n - 1) \frac{\lambda}{2} &= s - (r_1 + r_2) \\
 &= \sqrt{\delta^2 + d^2} + \sqrt{(2h + \delta)^2 + d^2} \\
 &\approx \frac{2h(h + \delta)}{d}
 \end{aligned}$$

$$h = \frac{1}{2} \left(-\delta + \sqrt{\delta^2 + (2n - 1) \lambda d} \right)$$

FURTHER READING

William Waites, James Sweet, Roger Baig, Peter Buneman, Marwan Fayed, Gordon Hughes, Michael Fourman, and Richard Simmons. Remix: A distributed internet exchange for remote and rural networks. In *Proceedings of the 2016 Workshop on Global Access to the Internet for All, GAIA '16*, pages 25–30, New York, NY, USA, 2016. ACM. ISBN 978-1-4503-4423-4. doi: 2940157.2940162. URL <http://doi.acm.org/2940157.2940162>.



Thank you

<https://hubs.net.uk/>

