USING WAVELENGTHS OUTSIDE THE TELECOM SPECTRUM

What applications can the unused wavelengths outside of the Telecom spectrum be used for?

Remy de Boer
Stefan Plug
CONTENTS

- The project
- The additional wavelength
- Proof of concept
- Tests
- Conclusion
THE PROJECT

- CWDM
- passive device
- from 1270nm to 1610nm
- 20nm wide channels

Basic CWDM setup
THE PROJECT (2)

- BeetleFiberOptics
- Low-cost
- Use of extra wavelength

*CWDM setup with extra out-of-band wavelength*
THE ADDITIONAL WAVELENGTH

<table>
<thead>
<tr>
<th>Band</th>
<th>Descriptor</th>
<th>Range [nm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-band</td>
<td>Original</td>
<td>1260-1360</td>
</tr>
<tr>
<td>E-band</td>
<td>Extended</td>
<td>1360-1460</td>
</tr>
<tr>
<td>S-band</td>
<td>Short wavelength</td>
<td>1460-1530</td>
</tr>
<tr>
<td>C-band</td>
<td>Conventional</td>
<td>1530-1565</td>
</tr>
<tr>
<td>L-band</td>
<td>Long wavelength</td>
<td>1565-1625</td>
</tr>
<tr>
<td>U-band</td>
<td>Ultra-long wavelength</td>
<td>1625-1675</td>
</tr>
</tbody>
</table>

“The U-band has been defined exclusively for possible maintenance purposes.”

Ref: ITU-T manual 2009 P. 134
THE U-BAND
(1625 TO 1675)

**Attenuation per \( \lambda \) per km**
Ref: Computer networks, fourth edition. 2002

**Attenuation per \( \lambda \) with bends**

1625nm seems the logical choice
PROOF OF CONCEPT

- Inteno XG6746
- Raspberry Pi
- 1625nm optics

"plug and play"
VLAN 10

- RP-Switch units
- IPv4 default addresses
- RP# SNMP polls only its own switch
VLAN 11

- RP-groups
- IPv6 Link-Local addresses
- Automatic neighbor discovery script
VLAN 12

Out-of-band management
PROOF OF CONCEPT: ISSUES

- Inteno's closed-source
- Wrong DDM values

<table>
<thead>
<tr>
<th>Switch</th>
<th>Tx</th>
<th>Rx</th>
<th>OPM measured Rx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sw1</td>
<td>-4.61 dBm</td>
<td>-0.44 dBm</td>
<td>-9.8 dBm</td>
</tr>
<tr>
<td>Sw2</td>
<td>-4.86 dBm</td>
<td>-0.83 dBm</td>
<td>-12.4 dBm</td>
</tr>
</tbody>
</table>
PROOF OF CONCEPT: SECOND SET-UP

Attenuation network
• Zyxel properly reads DDM values
• $\text{AttF}_1 - \text{F}_3 = \text{Tx}_1 - \text{Rx}_3$
• Doesn't support 100mbit SPF
TESTS

- Attenuation
- Stability
ATTENUATION TEST

OTDR base test, 1550nm, 25 Km, 7.009 dB

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>1M</th>
<th>25KM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1550nm</td>
<td>-0.05 dB</td>
<td>8.3625 dB</td>
</tr>
<tr>
<td>1610nm</td>
<td>0.0875 dB</td>
<td>7.975 dB</td>
</tr>
<tr>
<td>1625nm</td>
<td>2.275 dB</td>
<td>14.325 dB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>1M</th>
<th>25KM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1550nm</td>
<td>0.4425 dB</td>
<td>9.2325 dB</td>
</tr>
<tr>
<td>1610nm</td>
<td>0.62375 dB</td>
<td>9.2825 dB</td>
</tr>
<tr>
<td>1625nm</td>
<td>2.25125 dB</td>
<td>14.95625 dB</td>
</tr>
</tbody>
</table>
STABILITY TEST

10-mbit, 15 hours
Total of 62.9GB transferred
45918348 packets
RP1: iperf -suV
RP2: iperf -c fe80::ba27:eb27:ebff:fe58:69e2%eth0.11 -V -b 10000000 -t 54000
CONCLUSION

Altough 1625nm is more sensitive to:

- distance
- bending
- temperature changes
Still stable over long distances
FIN

https://github.com/remydb/rp1