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DOCSIS 3.1 Configurations for HFC and RFoG

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Thesis

Using DOCSIS 3.1 upstream (OFDMA) over RFoG increases the probability of OBI

On operator planning to implement DOCSIS 3.1 upstream over RFoG should consider looking into OBI mitigation

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What Causes OBI

OBI occurs when two things happen at the same time:

1. Two (or more) RFoG ONUs are transmitting at the same time.
2. Those two RFoG ONU upstream lasers are at substantially the same wavelength.

While OBI is happening, the upstream is can be impaired

OBI happens in the optical domain. Has nothing to do with DOCSIS per se, just that two CMs (and hence RFoG ONUs) are transmitting at the same time.

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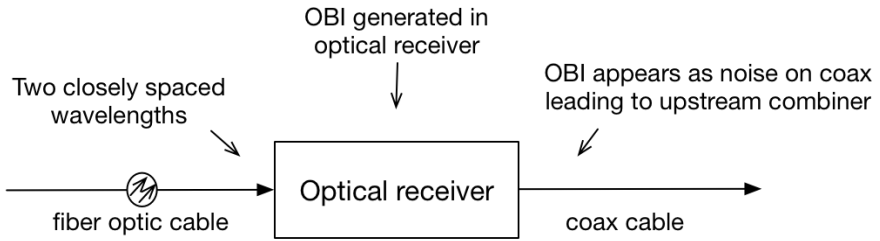
How OBI impacts upstream



OBI is generated in the optical receiver and appears as noise going into the upstream combiner

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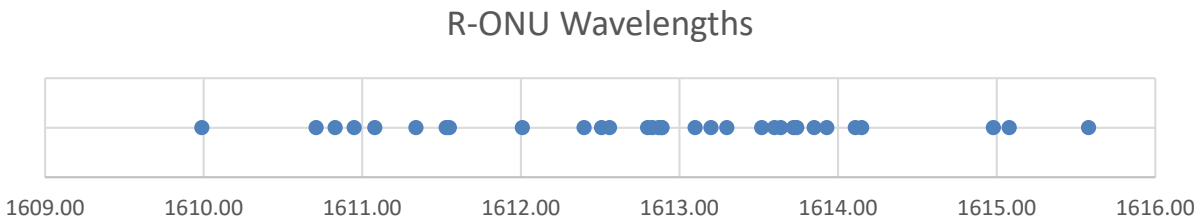
R-ONUs at substantially the same wavelength



Above are the wavelengths of a group of 32 R-ONUs used in the lab

Normal manufacturing variations will show a spread of wavelengths

No two RFoG installations will be the same

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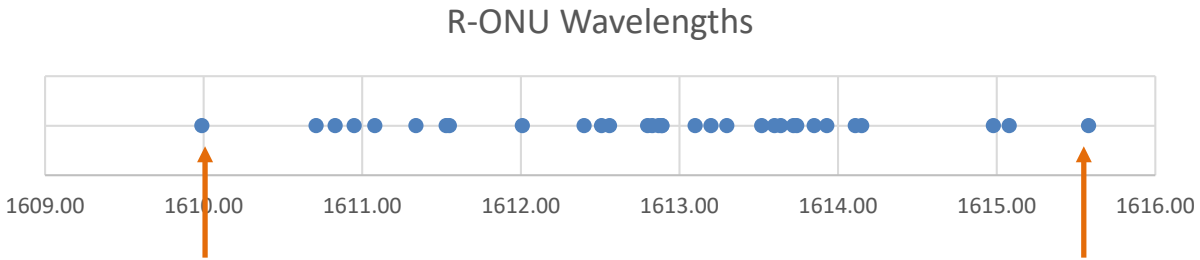
R-ONUs at substantially the same wavelength



These two R-ONUs could transmit simultaneously and not cause OBI; the wavelengths are very far apart.

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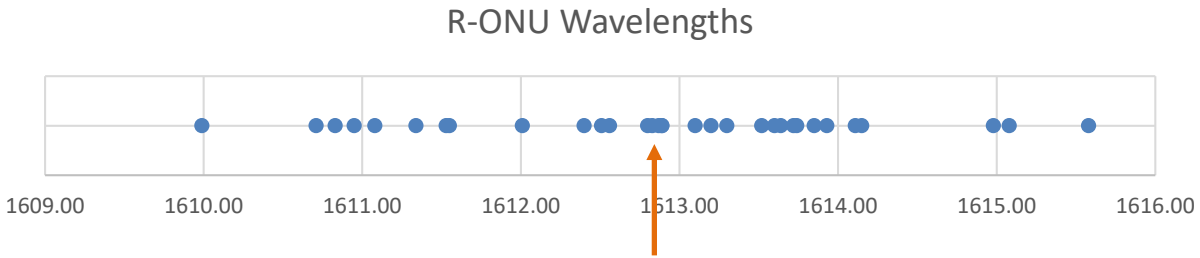
R-ONUs at substantially the same wavelength



Here is a group of 5 R-ONUs with very similar wavelength

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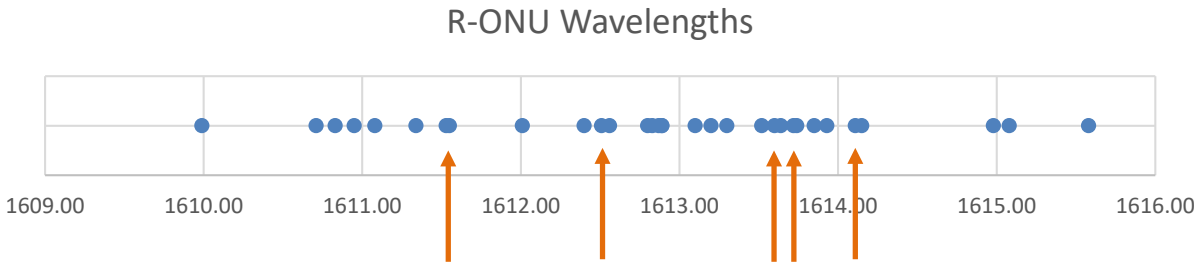
R-ONUs at substantially the same wavelength



And five groups of two R-ONUs with very similar wavelength

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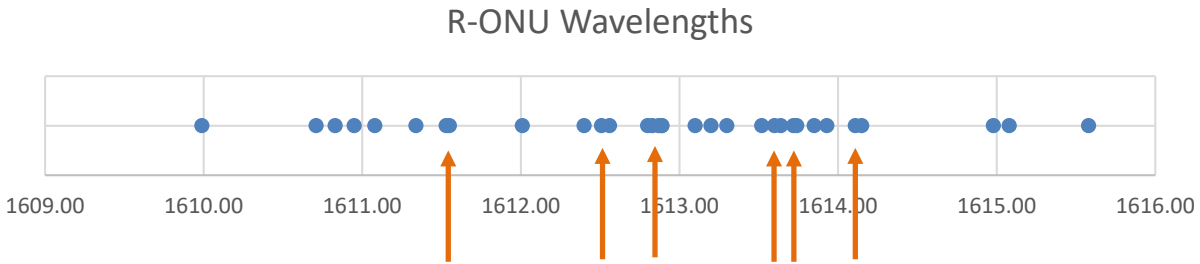
R-ONUs at substantially the same wavelength



This sample of 32 R-ONUs shows multiple groups that could cause OBI if certain pairs of them transmit simultaneously

Another sample of 32 R-ONUs may have enough spread that OBI does not occur

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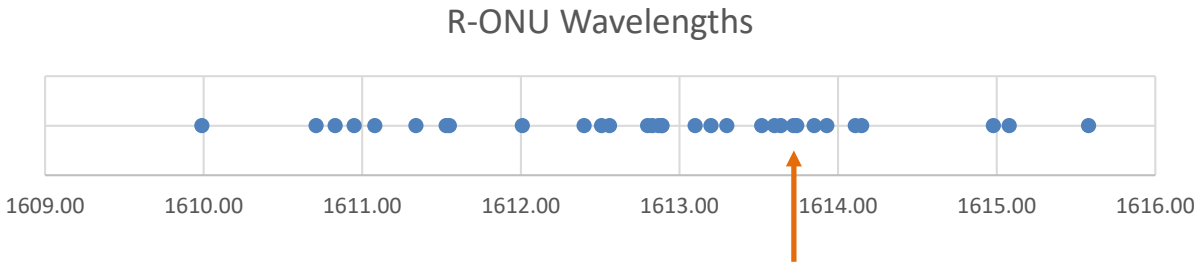
R-ONUs at substantially the same wavelength



The video (up next) used this pair of R-ONUs to induce OBI. One R-ONU was heated so the laser changed wavelength to overlap the other R-ONU.

Which shows how temperature variations can also play a roll in OBI.

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DOCSIS 3.1 OFDMA upstream operation

D3.1 OFDMA upstream uses very narrow channels (e.g., 50 kHz spacing @ 2K FFT)

Earlier versions of DOCSIS technology use much wider channels (e.g., 3.2 & 6.4 MHz)

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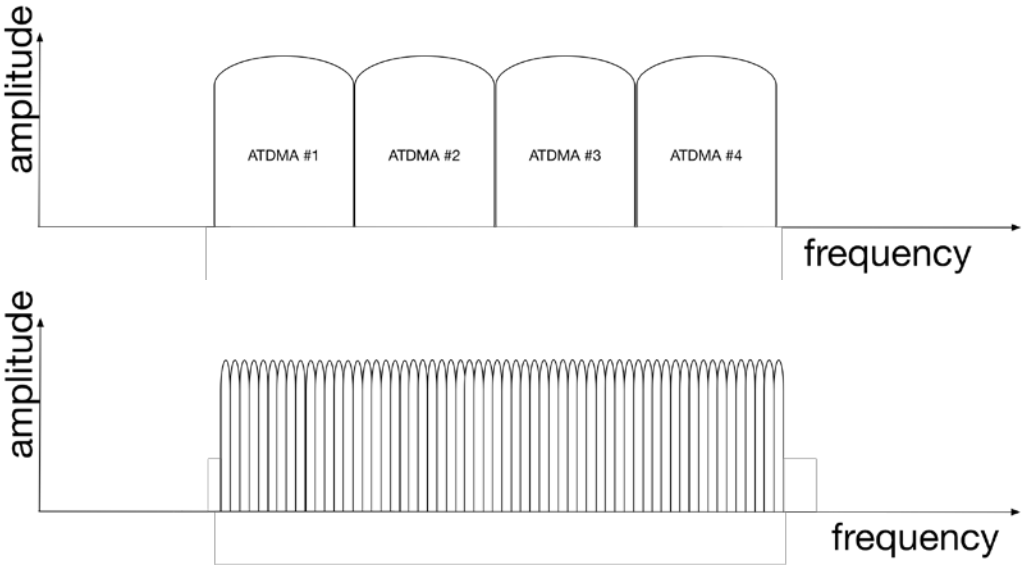
ATDMA vs OFDMA operation



One modem can transmit per carrier

A typical ATDMA return path with 4 carriers could have up to 4 CMs transmitting at once.

OFDMA breaks the spectrum into much smaller carriers, and in this case there are 60 opportunities to transmit at once

(24 MHz spectrum, 2K FFT, 8 subcarriers per minislot)

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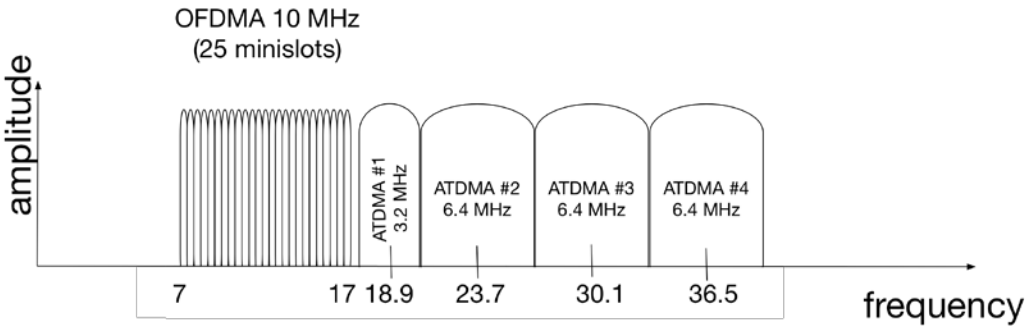
ATDMA and OFDMA on the return



With both OFDMA and ATDMA on the upstream, this example offers 29 opportunities to simultaneously transmit

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OFDMA Increases Simultaneous Transmission Opportunities

Set-up	Simultaneous upstream transmit opportunities	Notes
D3.0 (4 ATDMA)	4	
D3.1 (10 MHz + 4 ATDMA)	29 (25+4)	4 ATMDA + narrowest OFDMA channel (2K FFT)
D3.1 (24 MHz)	60	Spectrum use compares to 4 ATDMA
D3.1 (70 MHz)	175	Example 5-85 MHz return

(from examples on previous two slides)

(OFDMA using 2K FFT @ 50 kHz spaced subcarriers)

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Summary

OBI only happens when CMs at same wavelength simultaneously transmit

The distribution of R-ONU wavelengths is a factor

DOCSIS 3.1 OFDMA upstream increases the number of simultaneous transmit opportunities

The conclusion is that OBI could be more of an issue with an OFDMA upstream, depending on the spread of R-ONU wavelengths

OBI mitigation products and techniques are available

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THANK YOU!

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