# FTTP Networks: Topology and Competition

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# Conclusions Up Front

- FTTP networks have significant economies of scale
  - ➔ facilities-based competition is unlikely to be sustainable
- Service-level competition can exist over shared network infrastructure
  - Sharing possible at different levels
  - Sharing of dark fiber requires attention to fiber layout
- There is great variety in the models of sharing which can be found today

# Outline

- Models of Competition in FTTP
- Alternative FTTP architectures: impact on competition
- Economics of FTTP

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- **Models of Competition in FTTP**
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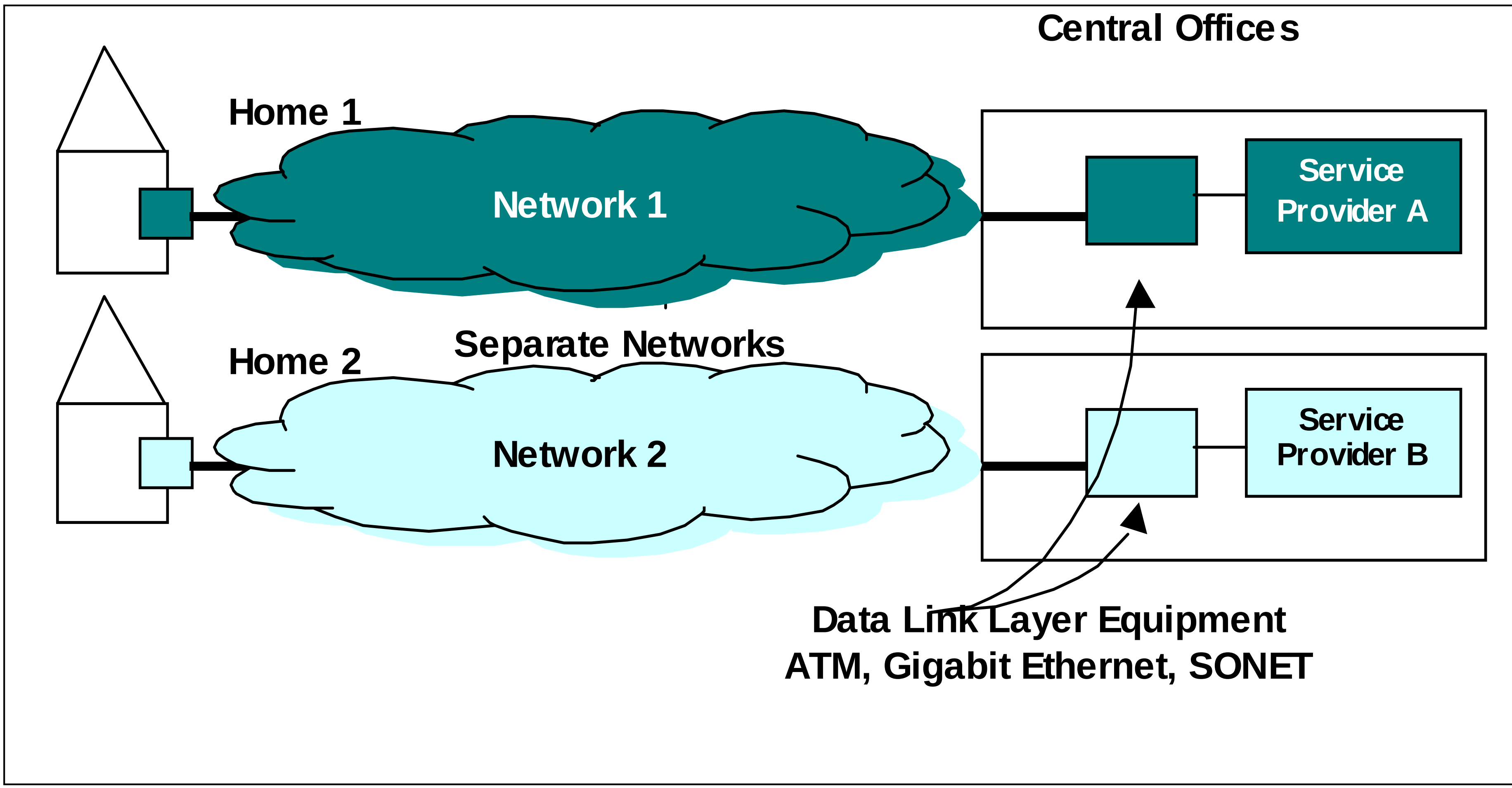
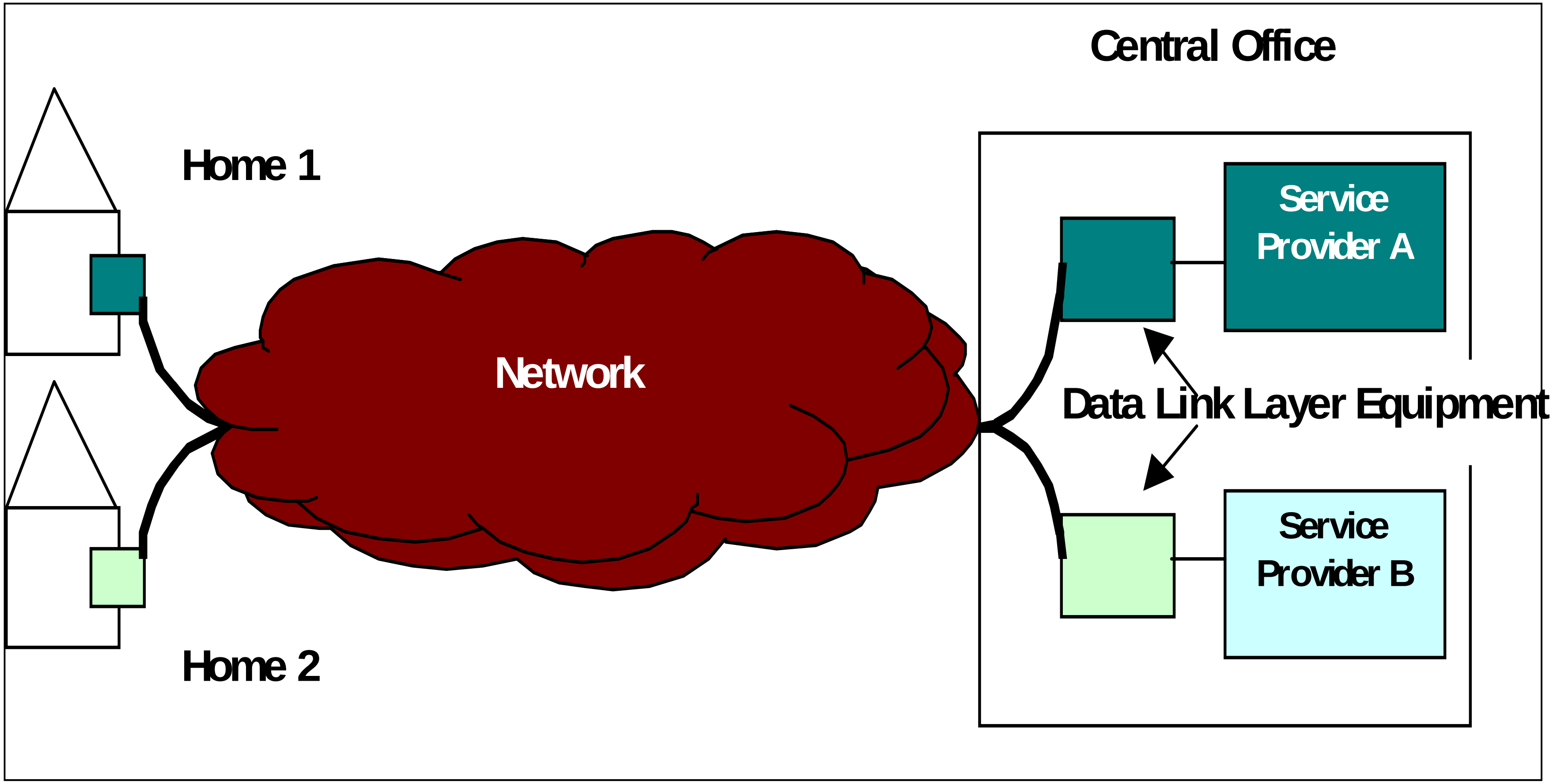
# Facilities based competition – each competitor builds FTTP network

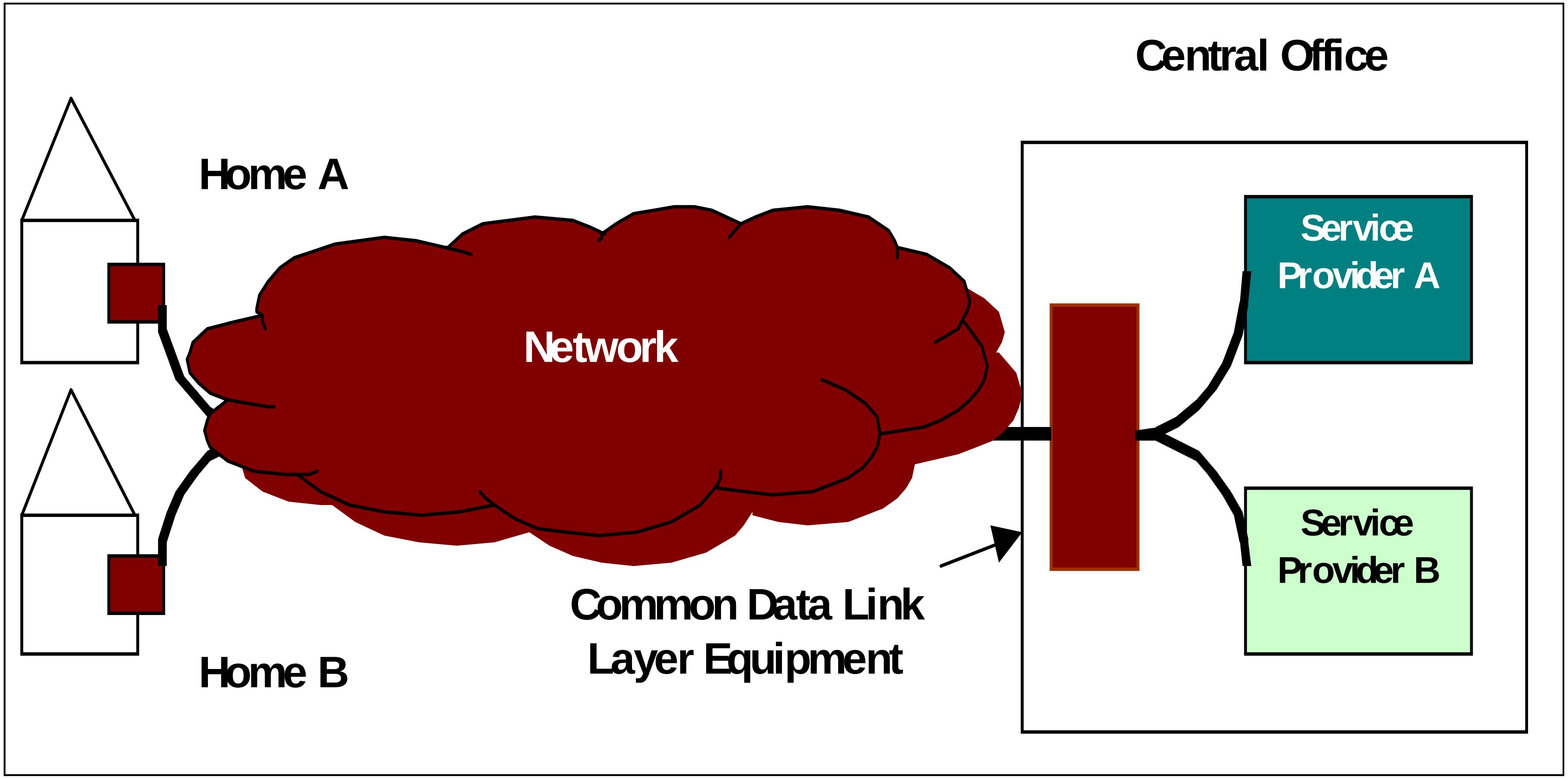


# UNE based Competition in FTTP

- Dark fiber based – network owner wholesales dark fiber
- Wavelength based – network owner wholesales wavelengths



# Open Access based competition – network owner wholesales transport capacity



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# Sharing Network Infrastructure: Summary

| Layer: | Shared Infrastructure… |
|---|---|
| 0 | **Conduit and collocation facilities.** |
| 1 **(Physical Layer Unbundling)** | **Dark fiber leasing, or perhaps, Optical Layer unbundling (CWDM or DWDM in PONs)** |
| 2 **(Data Link Layer Unbundling)** | **Dark fiber and link-layer electronics at each end. For example, Ethernet-based VLAN, or ATM-based PVCs.** |
| 3 **(Network Layer Unbundling)** | **Basic network service provided. For example, IP Layer 3 service over cable using policy-based routing to multiple ISPs** |

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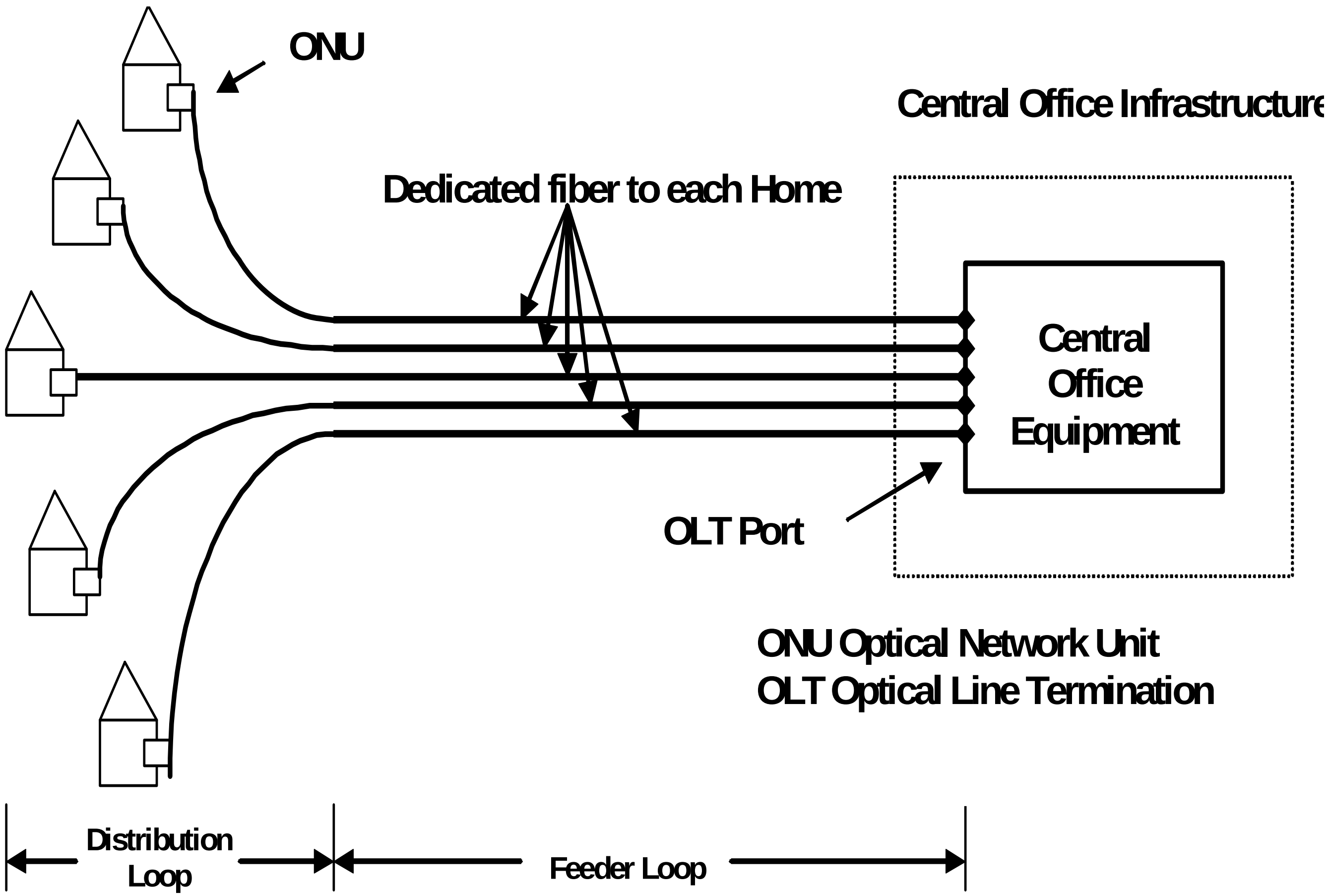
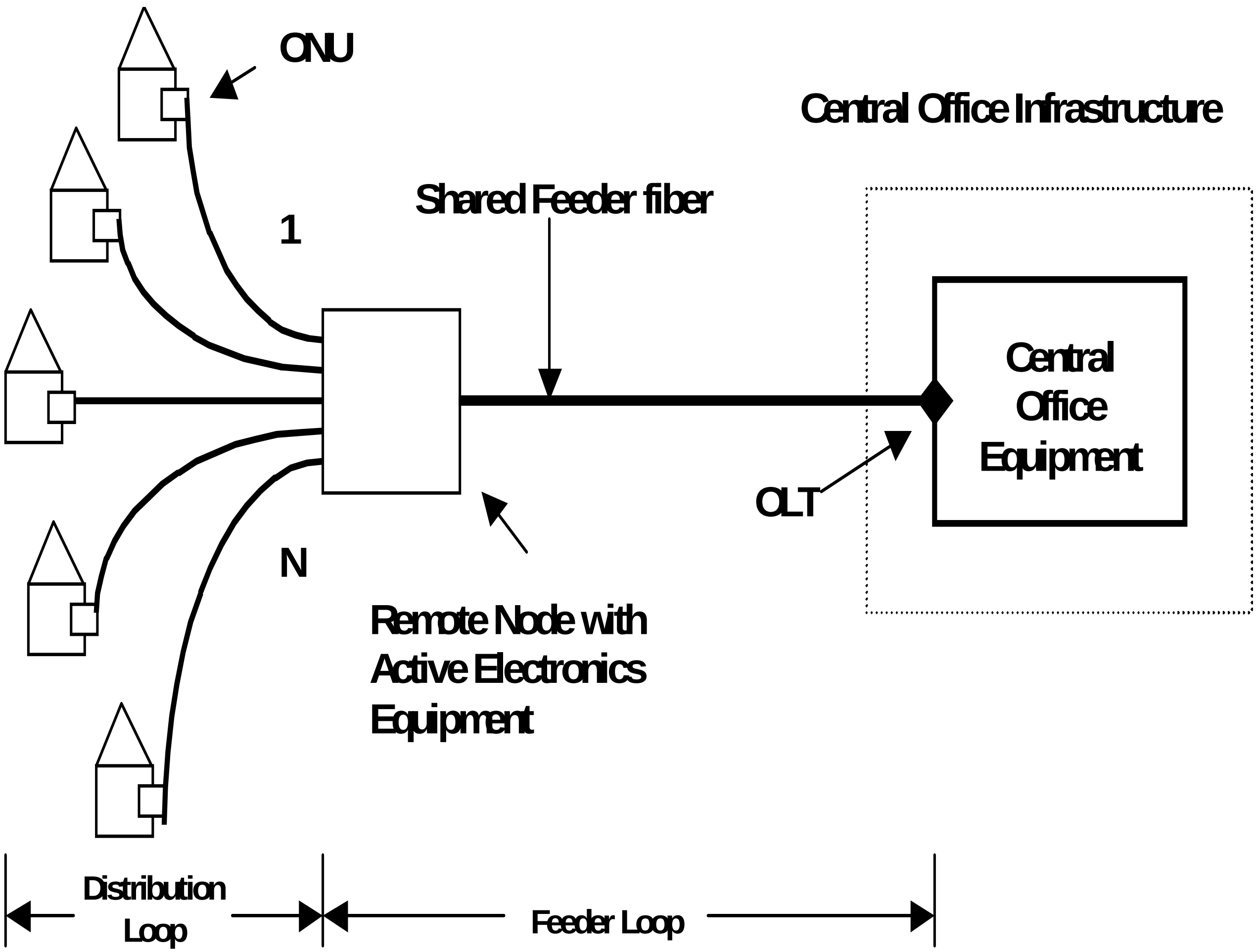
# Home Run Architecture



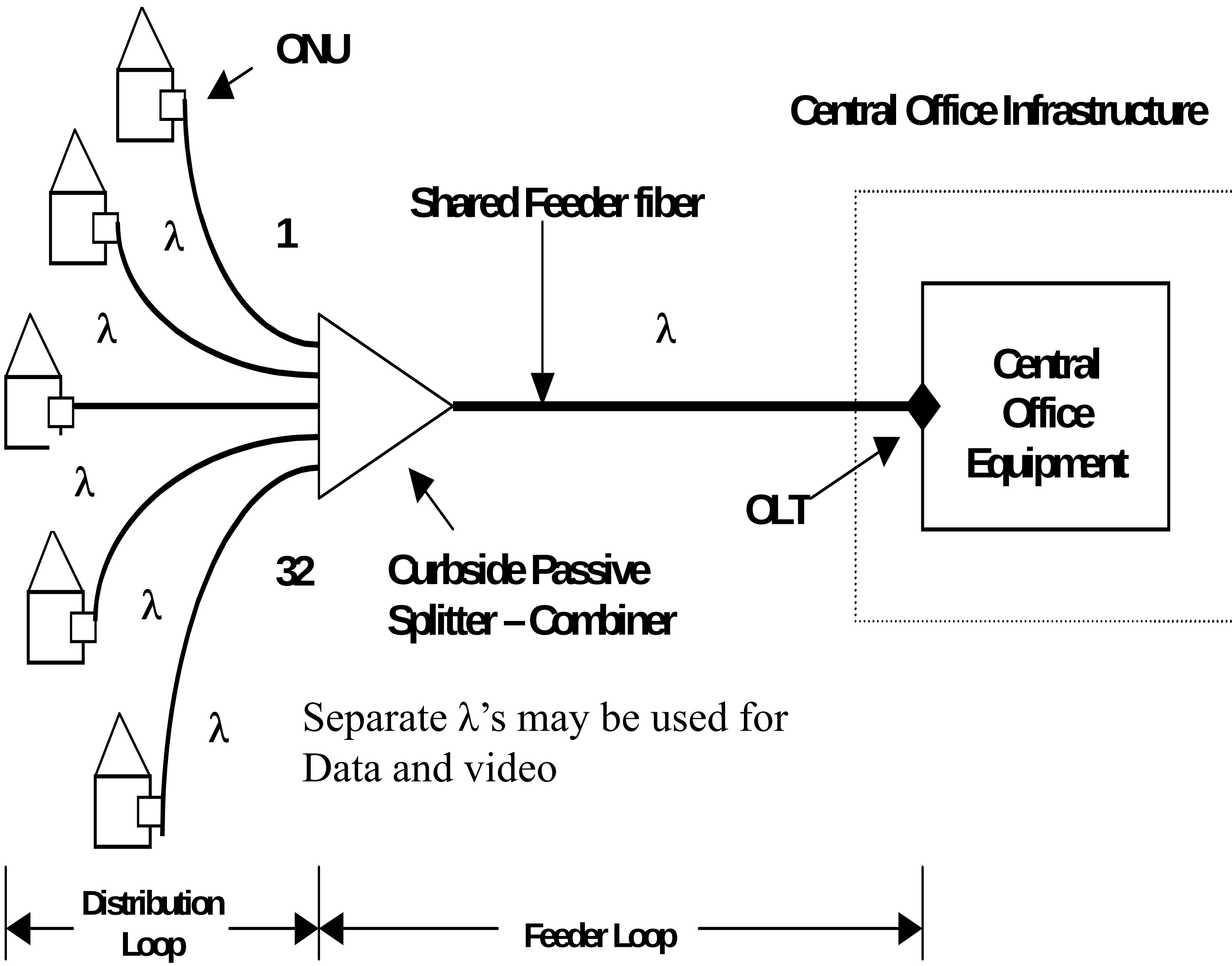

- Implications for Competition
- **Physical layer unbundling possible**
  **– wholesaler can sell individual fiber**
- **Also supports open access**

# Active Star Architecture



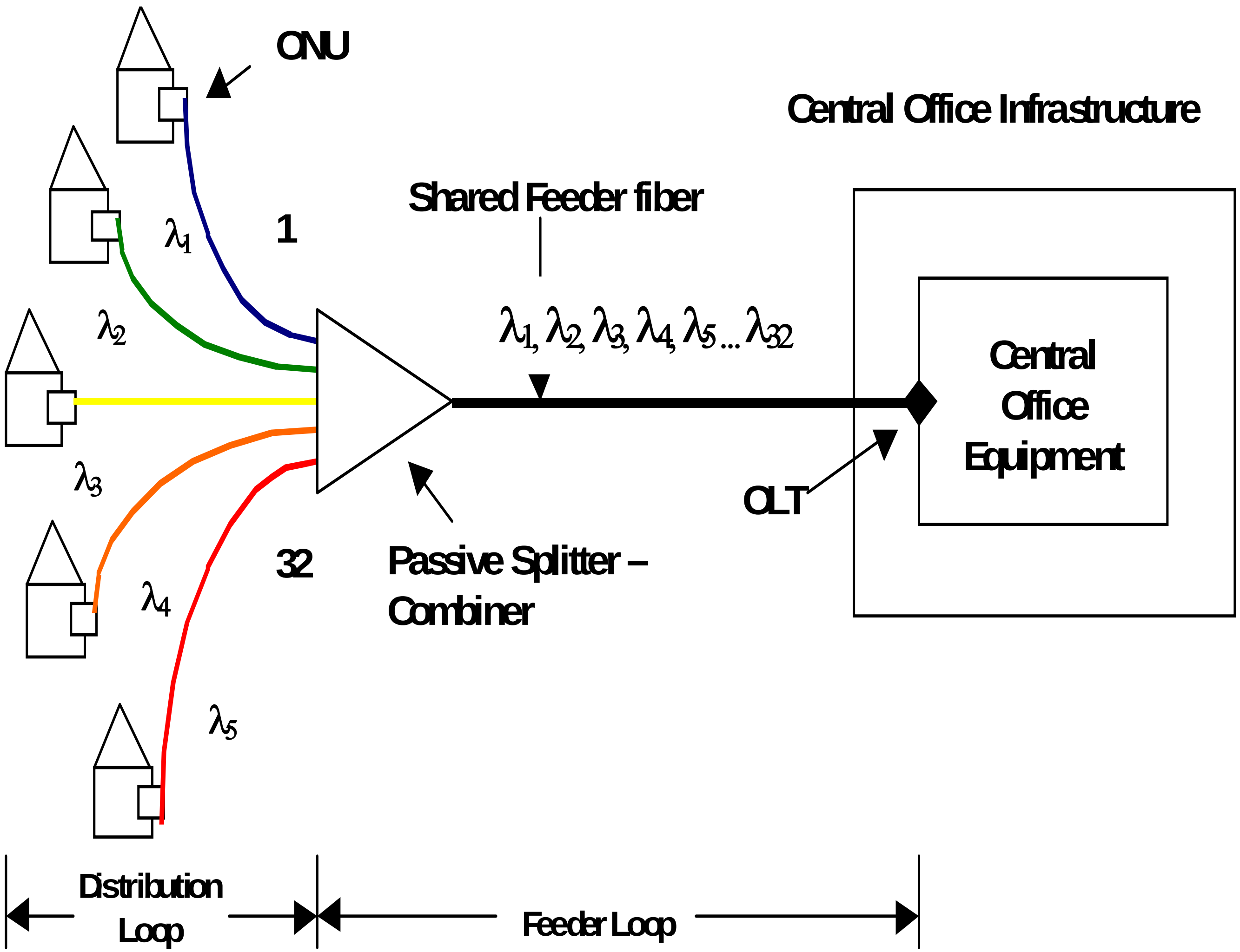

- Implications for Competition
- Physical layer unbundling is difficult
  - requires competitors to collocate electronics at remote node
  - Must provide feeder fibers for each competitor
- Logical layer unbundling possible - supports open access

# Curb side Passive Star Architecture (PON)




- **Implications for Competition**
- **Physical layer unbundling not possible**
- **Logical layer unbundling possible - supports open access**

# WDM PON




- Implications for Competition
- **Physical layer unbundling not possible**
- **Optical layer unbundling possible – wholesaler can sell wavelengths**
- **Also supports open access**

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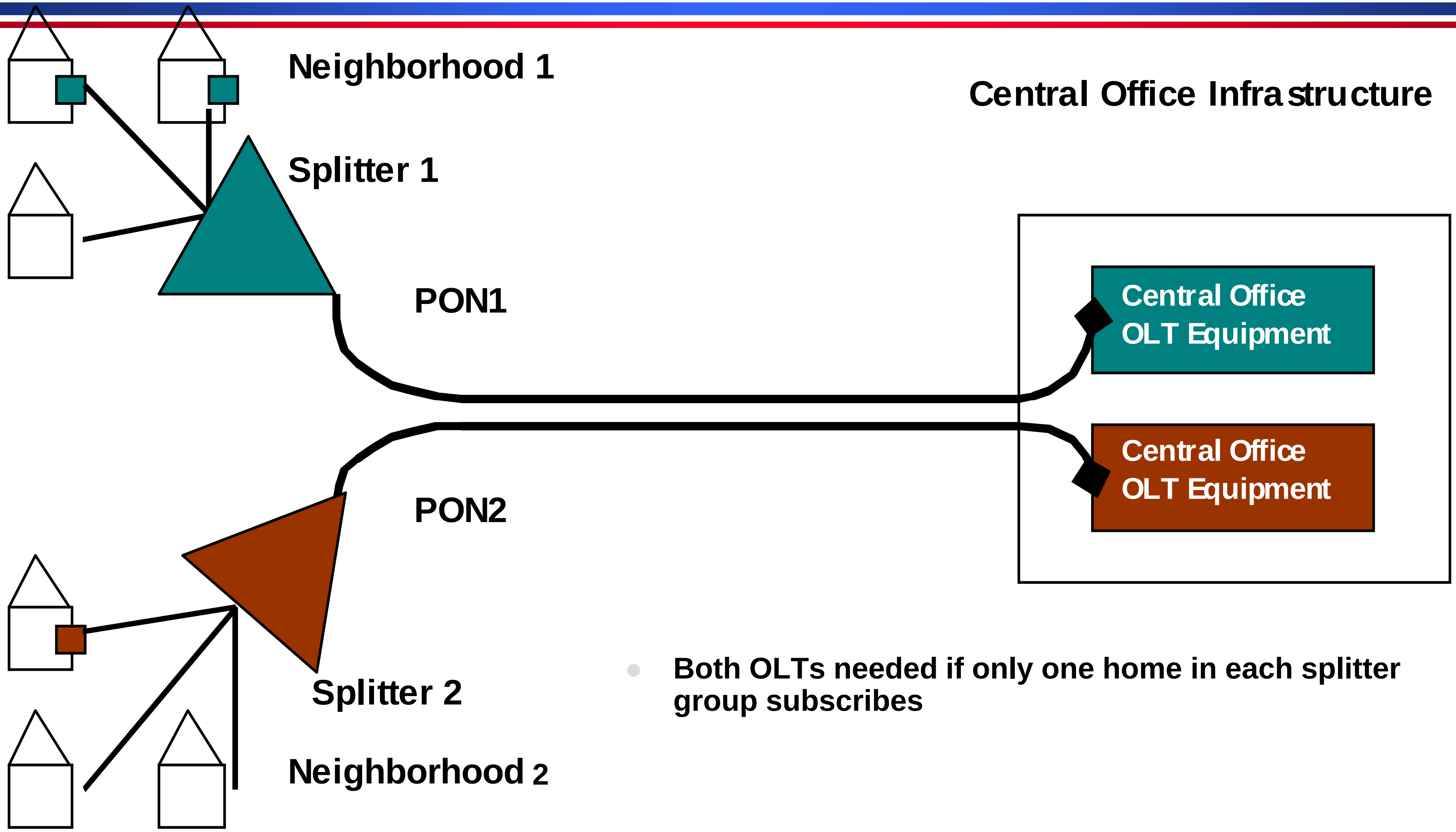
# Design Considerations in a PON: A Curb-side PON




- Both OLTs needed if only one home in each splitter group subscribes

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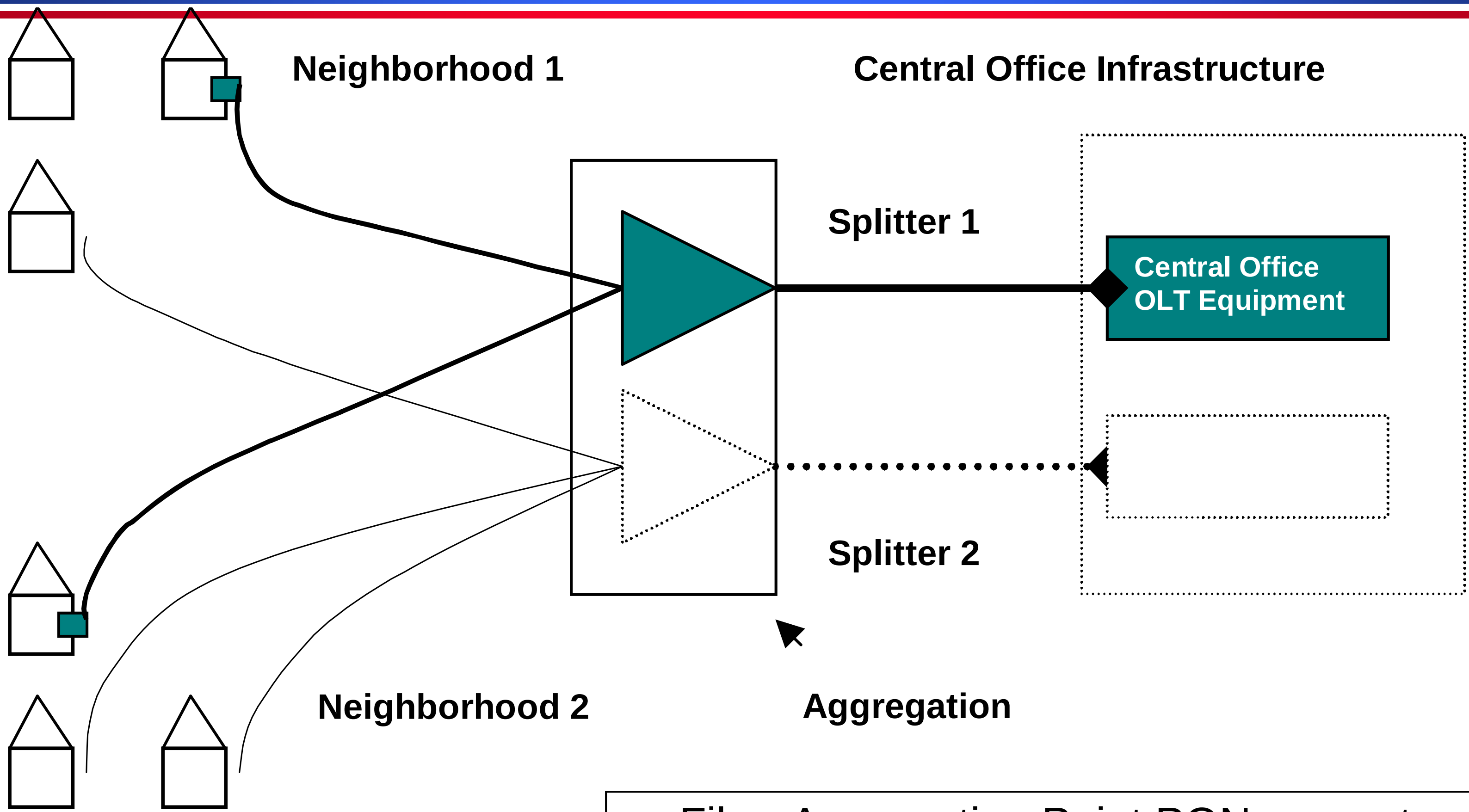
# Design Considerations in a PON: A Fiber Aggregation Point (FAP) PON




- Fiber Aggregation Point PON supports all models of competition

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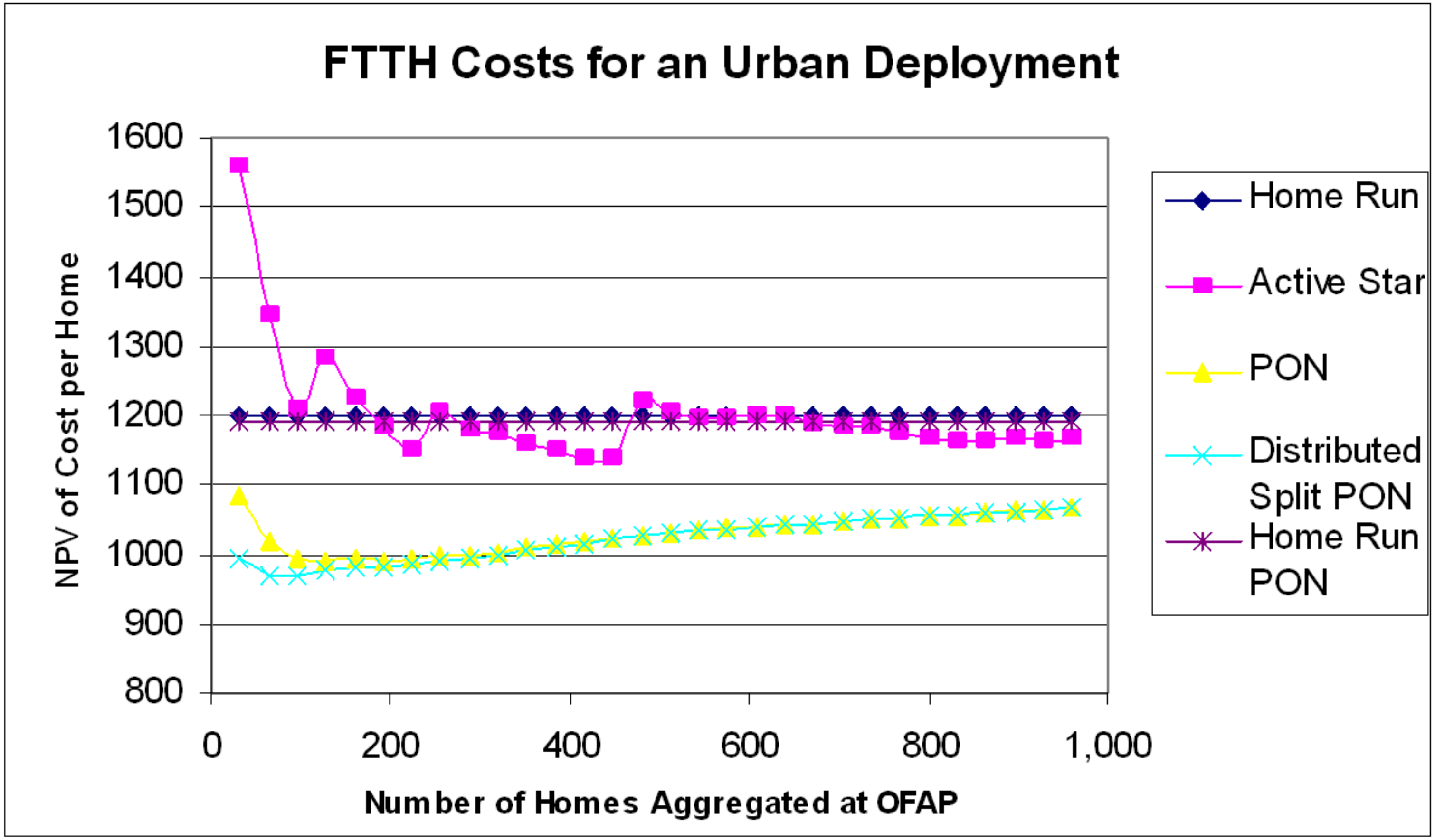
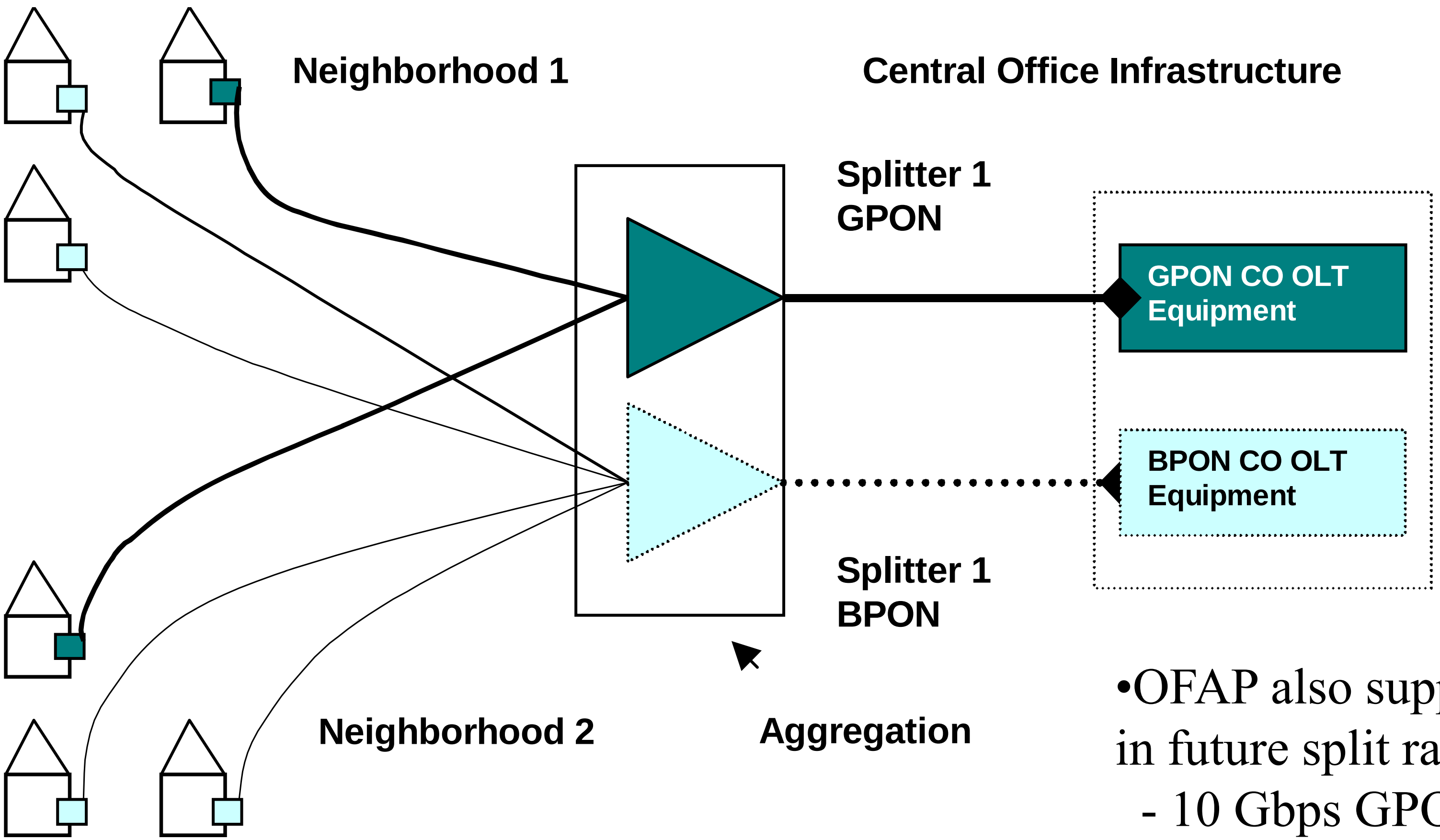
# How many homes should be aggregated at an Optimal FAP?



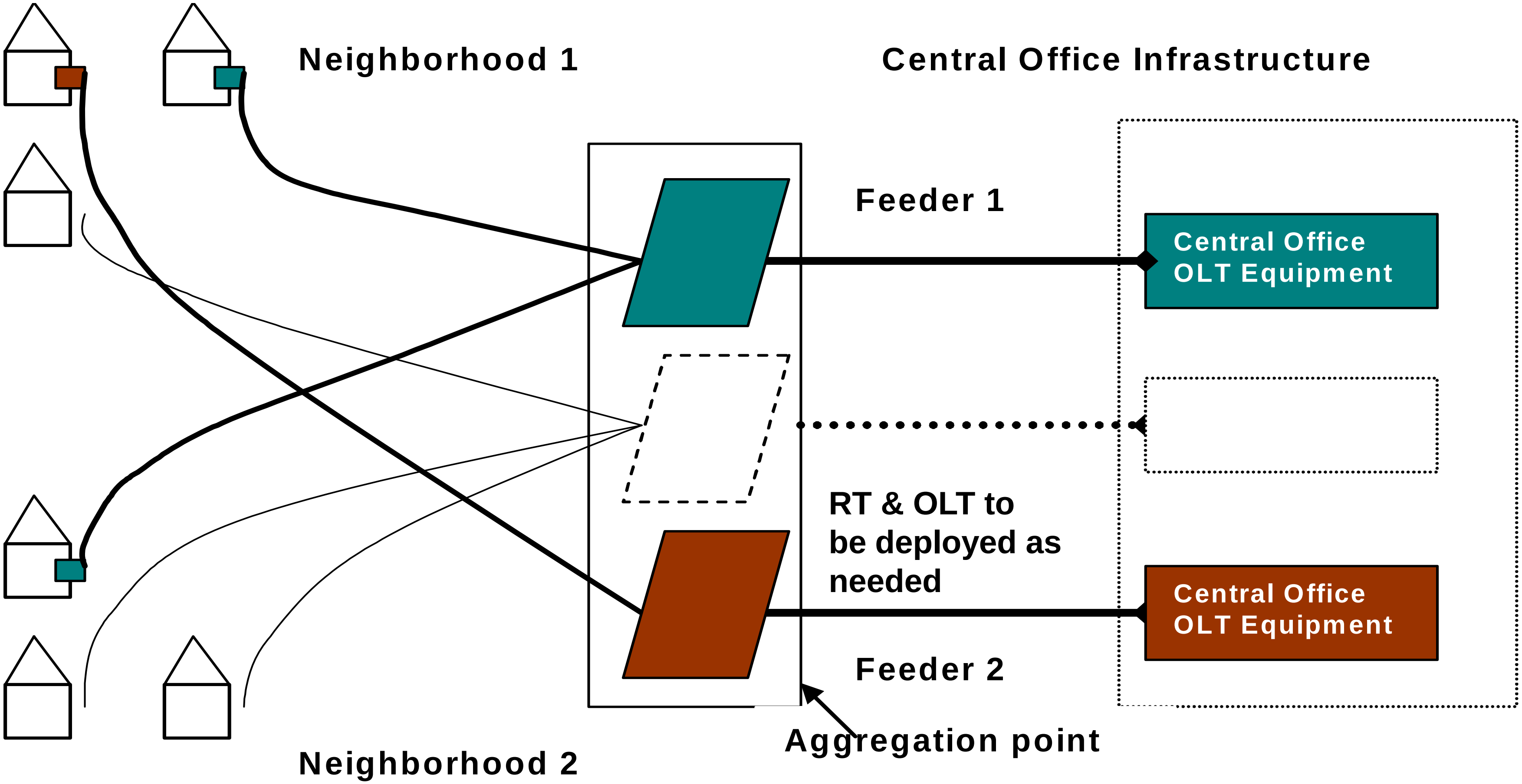

- **OFAP allows deferring investment in OLTs until penetration requires it**

# OFAP as a *Real Option* to Phase-in New Technologies




- OFAP also supports flexibility in future split ratios
  - 10 Gbps GPON, GEPON
  - WDM PONs

# OFAP Benefits with an Active Star Architecture




- Higher utilization of RT and OLT ports
- Neighboring homes can be served by different technology generations

- Larger serving area

# Sharing in the "Second Mile"

- As video becomes dominated by unicast Video on Demand (VOD) metro aggregation network costs soar
- In smaller communities, access to regional transport to a Tier 1 ISP is a major barrier to entry
- Retail service providers sharing an FTTH access network may also need to share at the metro/regional level in order to be economically viable.
- There is a tradeoff with distributed video servers
  - Sharing a content delivery network (*e.g.* Akamai) may be an alternative.
    - This requires distributed colo space and interconnection


- See Han, S. *et al* "IPTV Transport Architecture Alternatives and Economic Considerations," *IEEE Comm Mag*, Feb 2008
- Lamb L., *forthcoming.*
- NSP, "A Business Case Comparison of Carrier Ethernet Designs for Triple Play Networks,"

# Regulatory Implications

- If regulators want to be able to require dark fiber unbundling, they need to require compatible fiber layout
  - OFAP PON vs curb-side PON
  - Even larger OFAP for competitive active star
    - Need for additional feeder fibers
- All architectures support logical layer (“bitstream”) unbundling
  - IPTV unbundling possible at bitstream layer
  - If video distributed over a separate wavelength, issues of access to RF multiplex.

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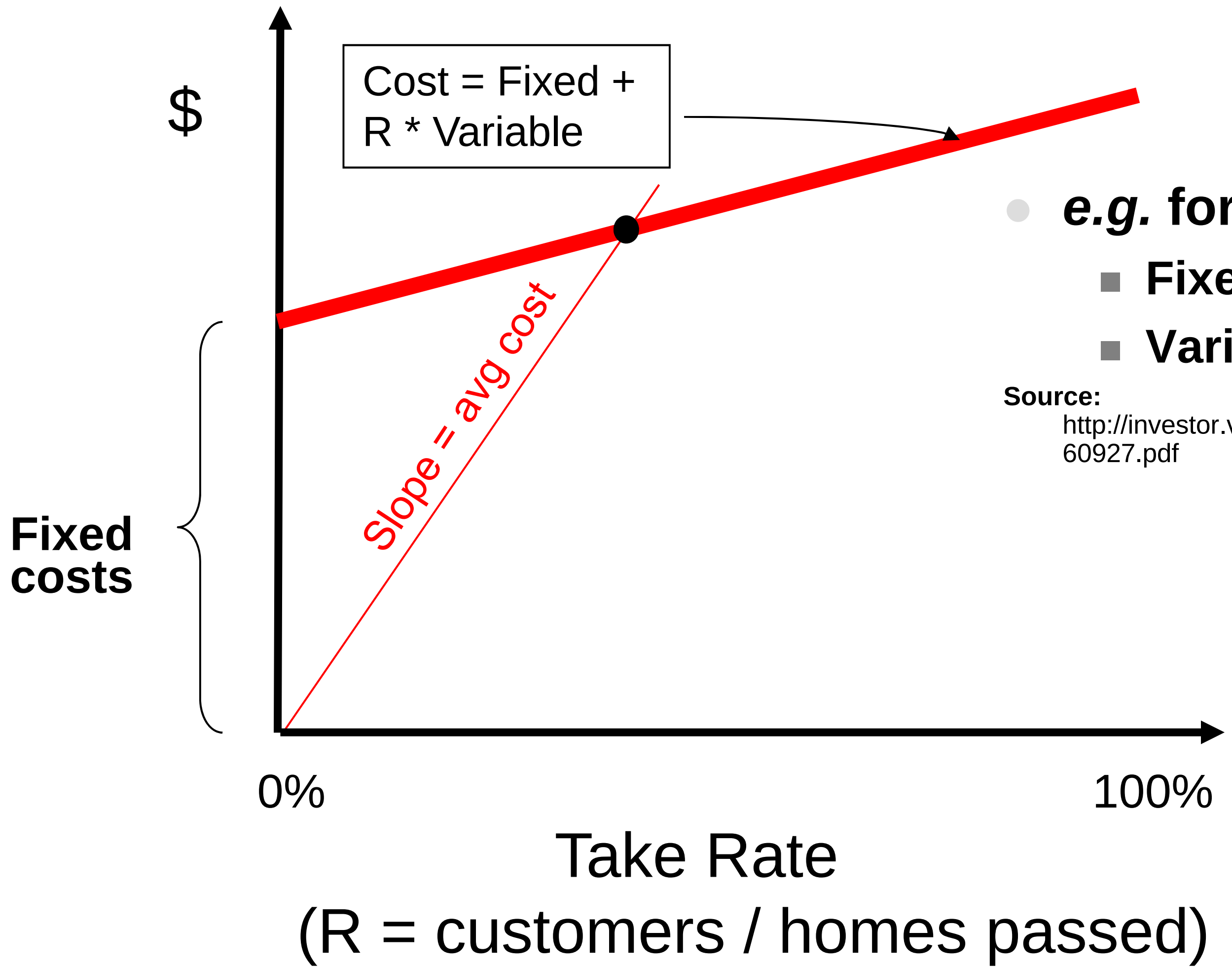
- **Economics of FTTP**

# Simple FTTH Economics: FTTH Includes Fixed Plus Variable Costs

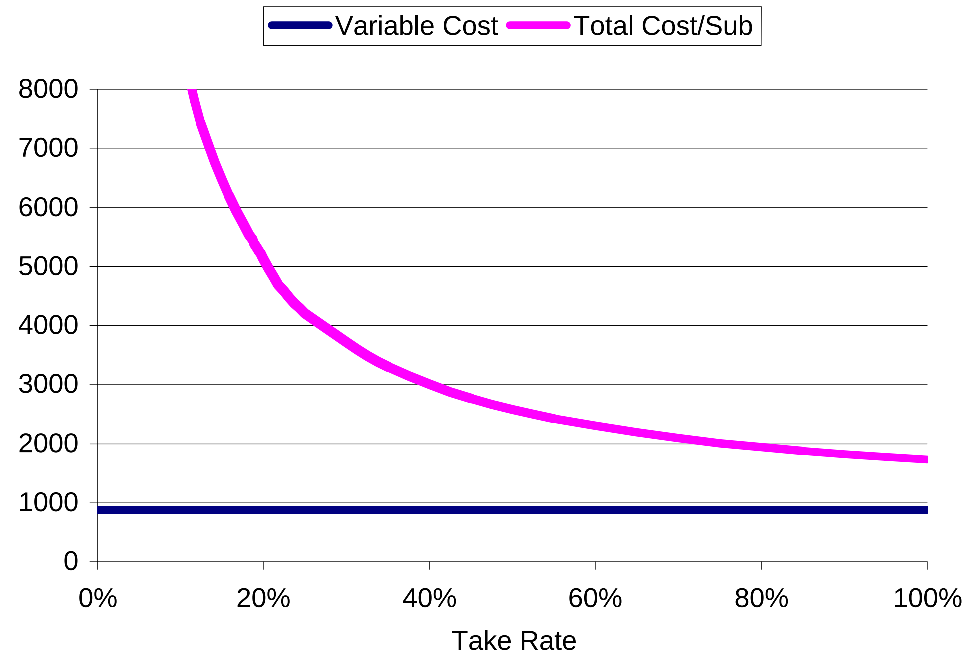



- ***e.g.* for Verizon YE06**
  - **Fixed=$850**
  - **Variable=$880**

**Source:**
http://investor.verizon.com/news/20060927/20060927.pdf

Adapted from Friogo, *et.al.*
http://ieeexplore.ieee.org/iel5/35/29269/01321382.pdf

# Cost Per Subscriber vs Take Rate

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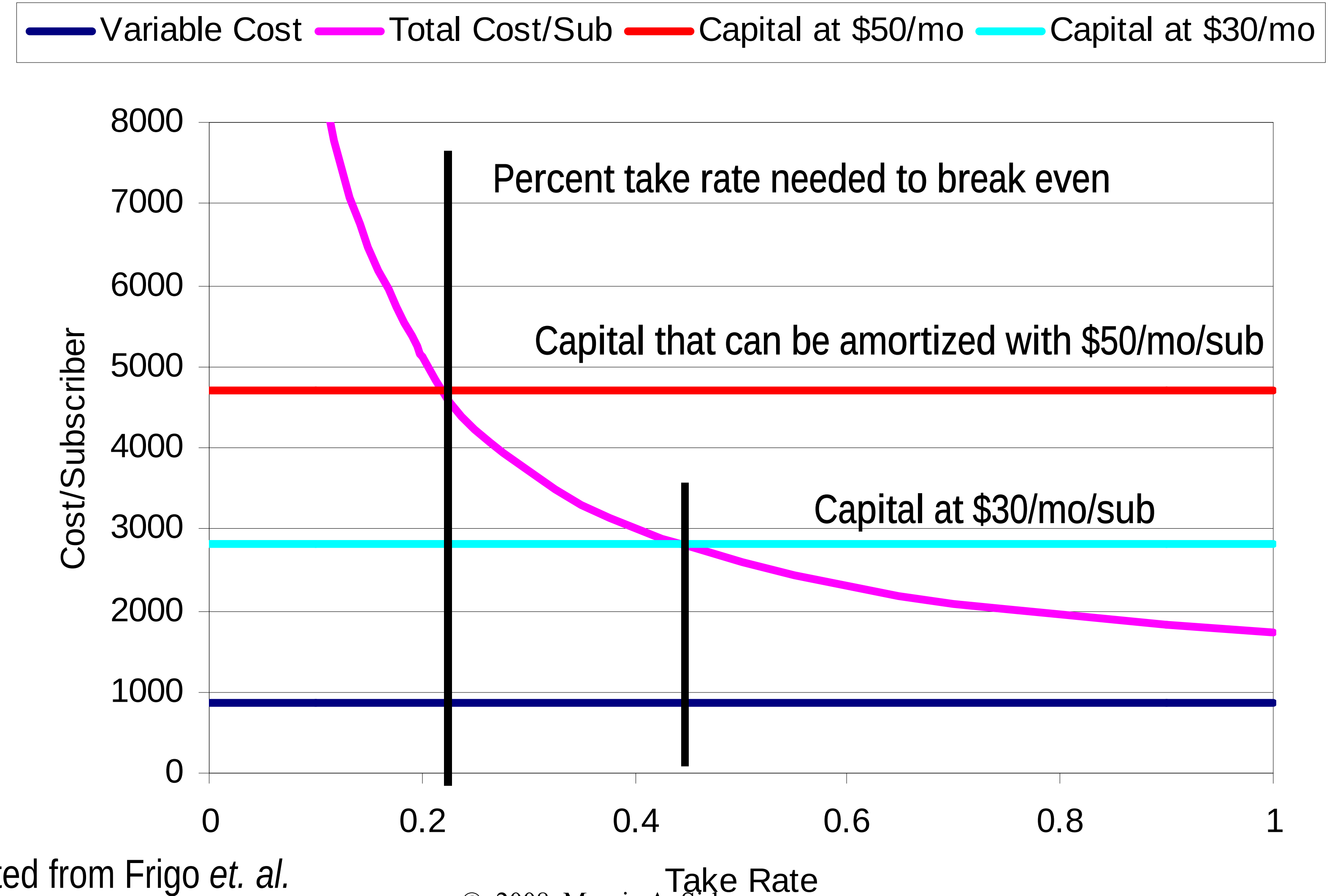
# How Much Revenue to Support FTTH?

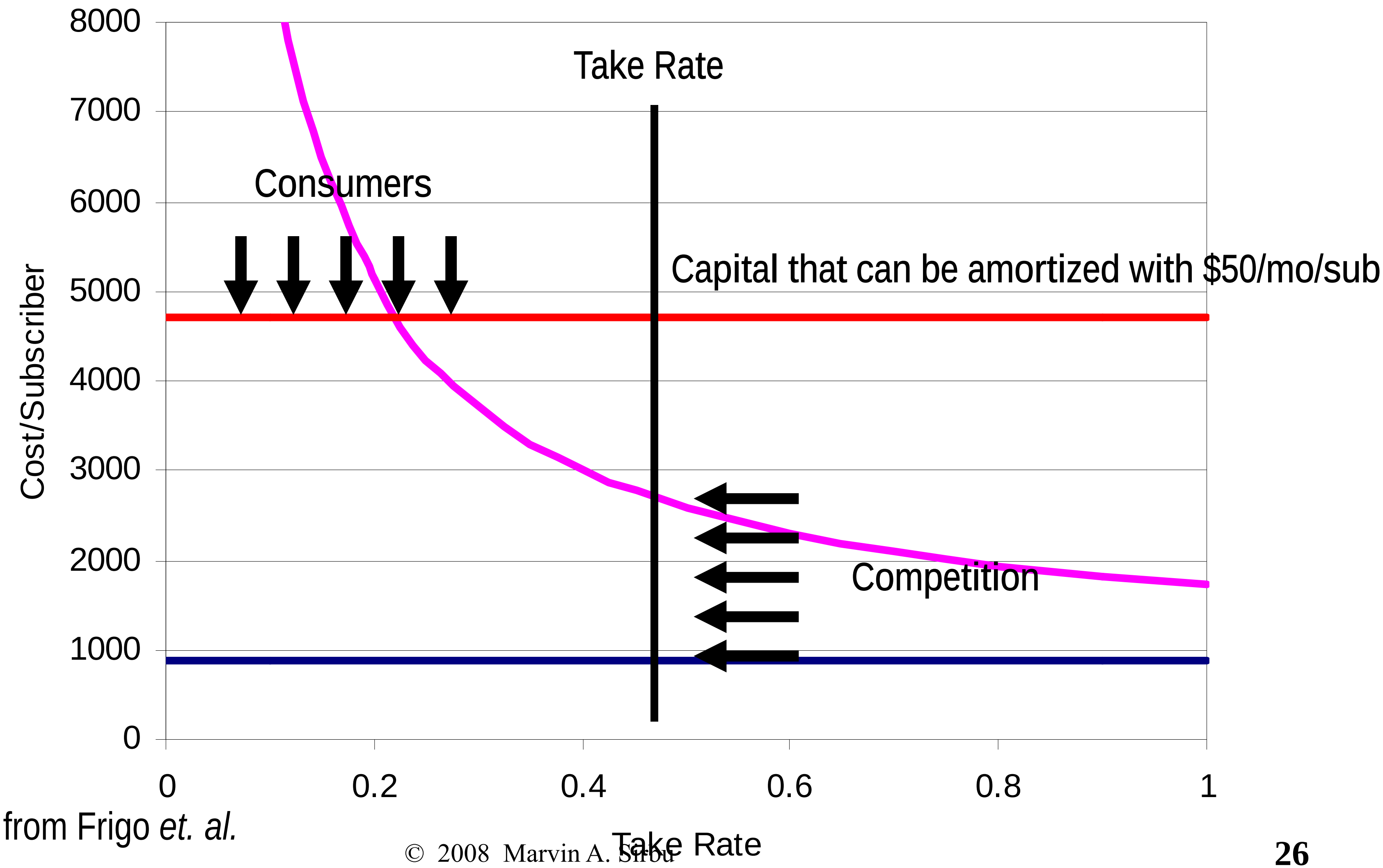
- One operator estimates $90/month per subscriber
  - $40 for ongoing services cost
  - ➔ $50/month to cover capital costs
- Assume an average of 10 year lifetime, 5% cost of capital
  - Fiber lasts 40 years
  - Electronics lasts five years
- $50/month can amortize $4700
- What if Average Revenue Per User (ARPU) is less?
- $30/month can amortize $2800

# Cost Per Subscriber vs Take Rate




Adapted from Frigo *et. al.*

# Cost Per Subscriber vs Take Rate




Adapted from Frigo *et. al.*

# Economic Implications:

- If revenue available to amortize plant is only $30/month, must reach penetration of > 45%
- ➔ room for *at most* 2 facilities-based providers
- This analysis understates the problem
  - No customer acquisition (marketing/sales) cost included
    - Customer acquisition drives up Fixed costs pushing breakeven penetration higher
  - Unlikely to see >90% total penetration

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# Regulatory Implications

- Facilities-based competition among fiber network providers is unlikely
  - Economies of scale
- Regulators should be cautious of waiving open access requirements in return for investment in fiber
  - Could lead to remonopolization
- At best duopoly competition
  - If service competition limited to ISPs which own facilities ➔greatly reduced service level competition
  - Operators will have Significant Market Power (SMP)
  - Reduced service-level competition raises Network Neutrality issue

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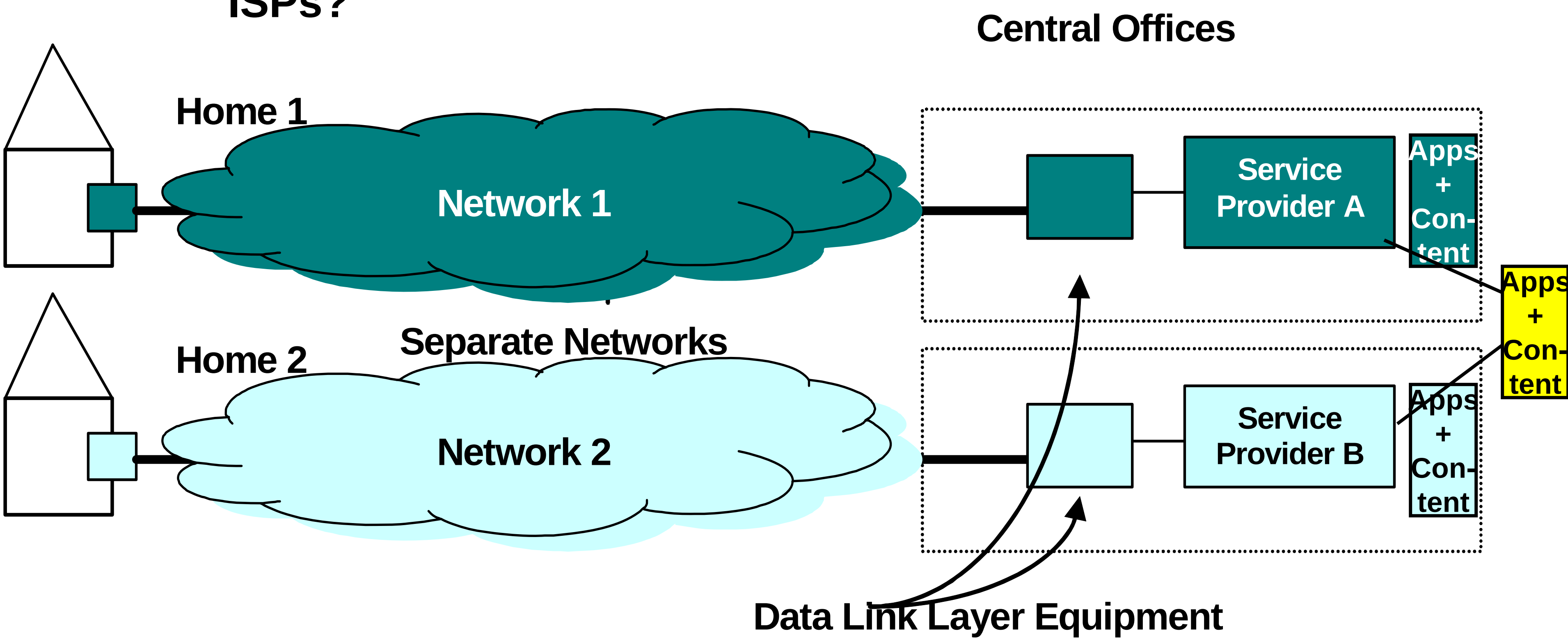
# Net Neutrality

- Can third parties compete with vertically Integrated ISPs?



# Conclusion

- What are the different models of competition in FTTP?
  - Facilities based
  - Service level (over shared network infrastructure)
- Fiber layout affects options for competition
  - OFAP supports fiber unbundling even for PONs
  - More feeder fibers required for competition
- FTTP networks have significant economies of scale
  - Unlikely to support multiple facilities-based providers
  - “Second Mile” sharing also important

# For Further Information

- http://www.andrew.cmu.edu/user/sirbu/pubs/Banerjee_Sirbu.pdf
- http://web.si.umich.edu/tprc/papers/2006/648/Banerjee_Sirbu%20TPRC_2006.pdf
- http://cfp.mit.edu/groups/broadband/muni_bb_pp.html