PONderings of a Network Engineer

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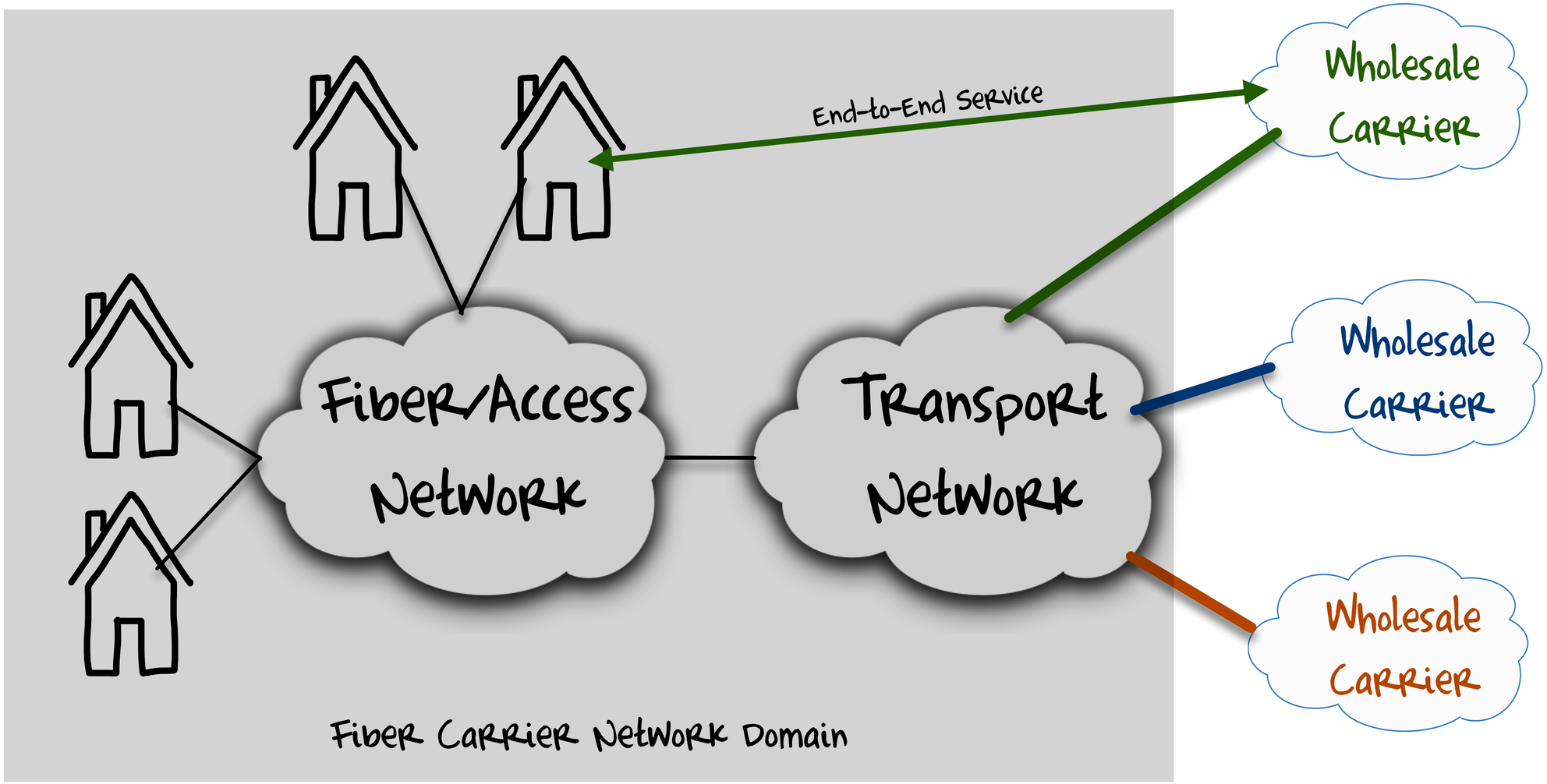
Introduction

- Affiliation: Vattenfall Eurofiber, we are building FTTH in Berlin
- All views and opinions expressed here are mine
- This presentation also exists as a series of articles, if you rather read: www.lys.is/pon/
- Motivation: networking community discusses access networks, fiber build-outs, has opinions about technology based on their field of work
- But, access networks are different from service provider or datacenter networks
- I went through the learning process, and want to give some insights and explain access networks details in the language of Service Provider Engineers

Assumption

Fiber carrier wants to resell access to subscribers



AON? PON? P2P?

Confusing definitions

- ***AON***: Active Optical Network, but really means: point-to-point structure of fibers
- ***P2P***: Point-to-Point, synonym for AON

➡Each subscriber has their own fiber to the first active network element

- ***PON***: Passive Optical Network, describes a passive network design which introduces a passive aggregation layer with the use of optical splitters

➡Multiple subscribers share one fiber

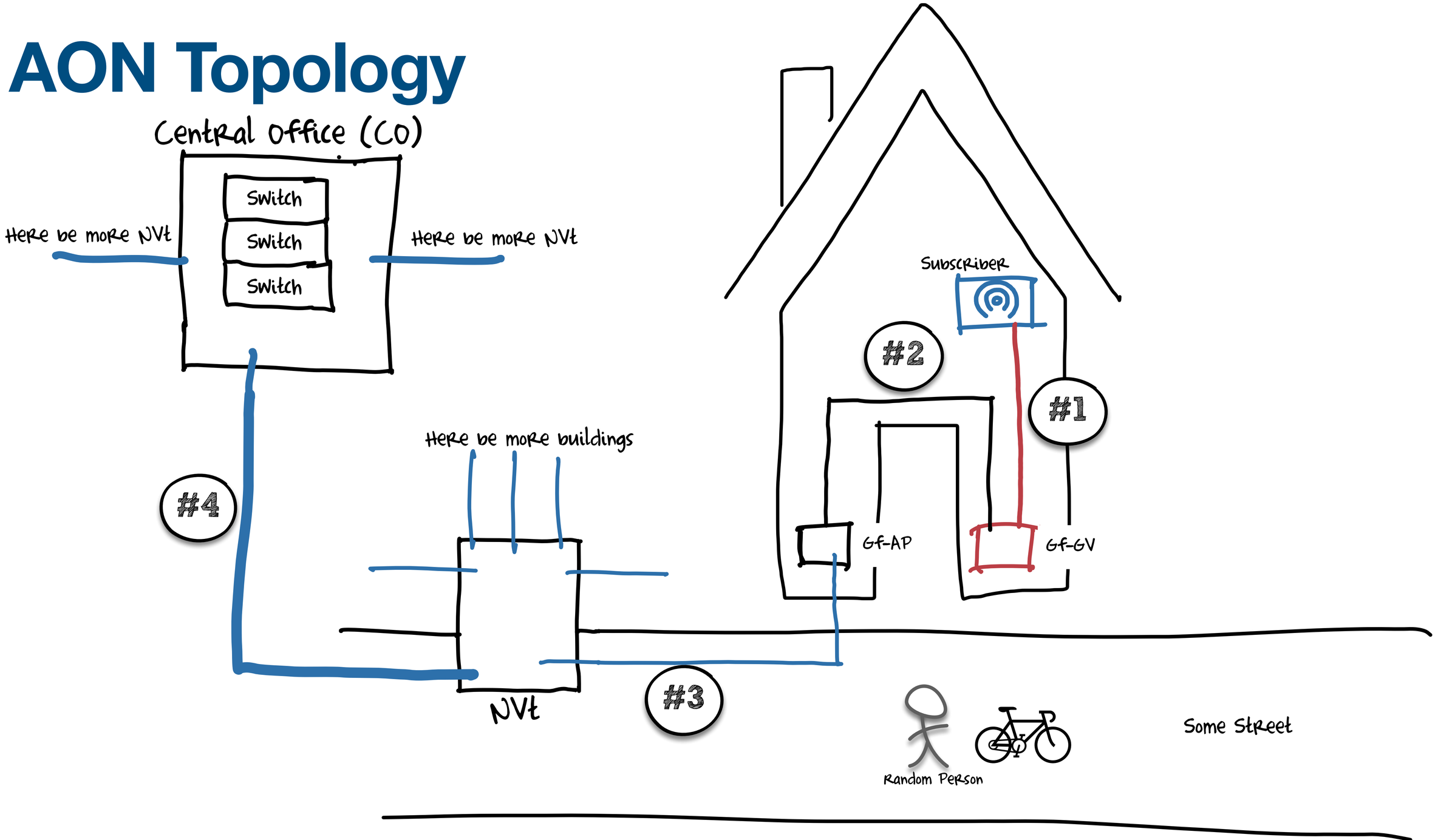
Contents

- AON design & topology
- PON passive design, distinction to AON
- PON active network devices and protocols
- Adjustments to overall PON network design for reselling
- Discussion/Summary

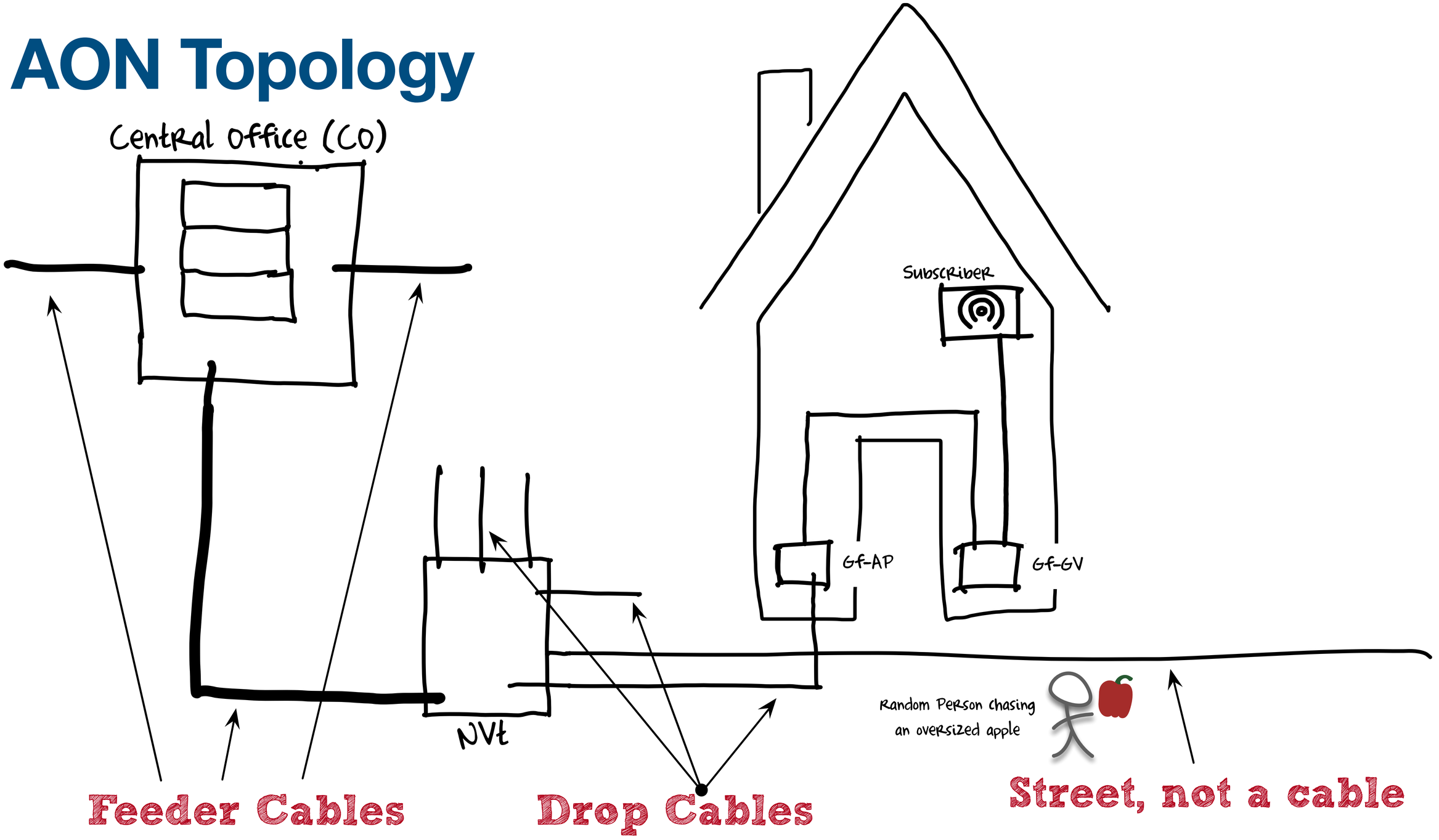
Acronyms Y0!

- ***Gf-GV***: Glasfaser-Gebäudeverteiler / Building Fiber Termination Point
  - Box inside a building, terminates inner building fibers
- ***Gf-AP***: Glasfaser-Anschlusspunkt / Fiber Termination Point
  - Box inside a building, terminates fibers coming from the outside
- ***NVt***: Netzwerk-Verteiler / Network Distribution Point
  - Street Cabinet, terminates fibers coming from buildings and fibers going to the next distribution point
- ***CO***: Central Office / Central Office
  - Larger aggregation point, first point in the network where active network elements live

AON Topology



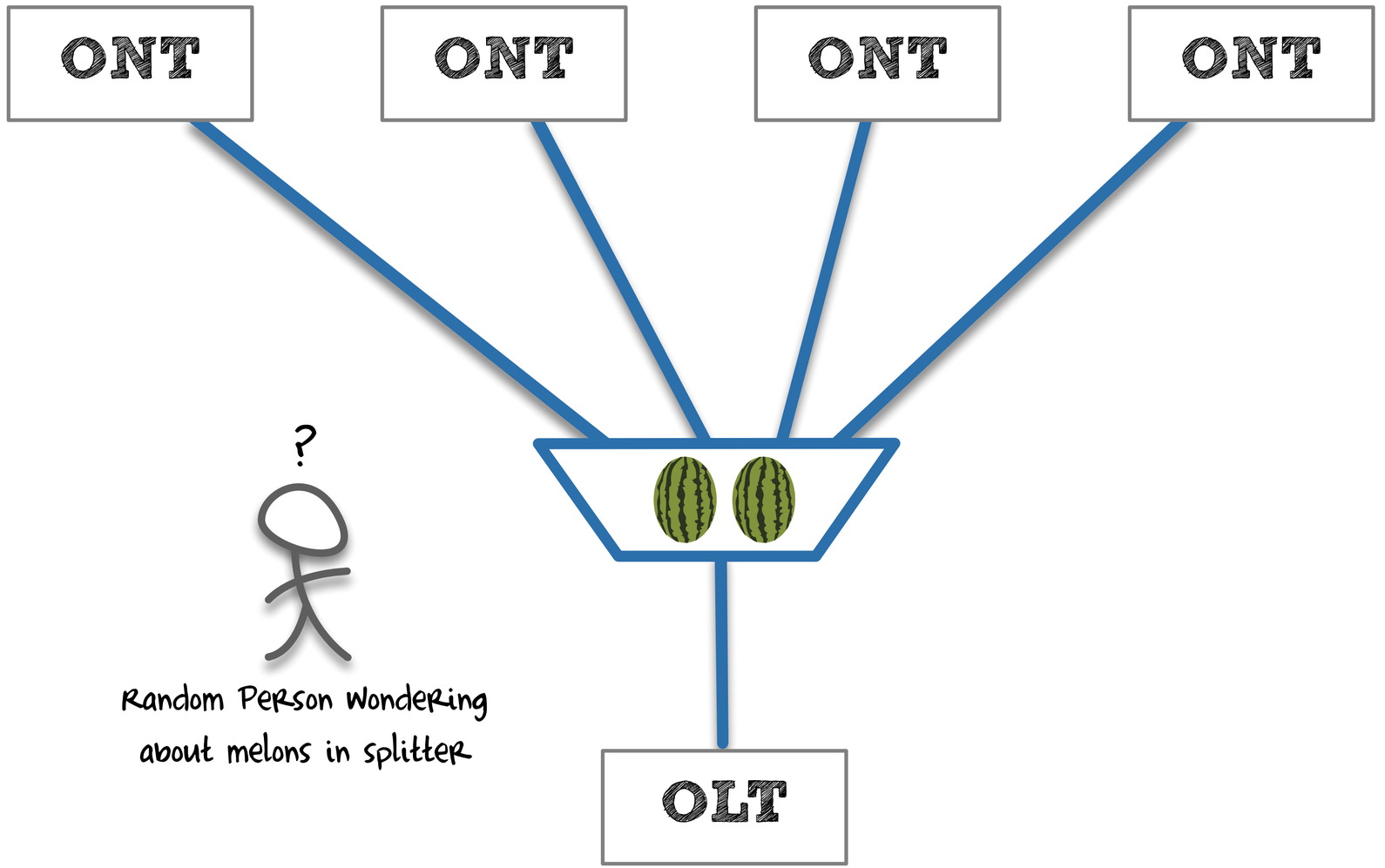
AON Topology



PON Passive Network Design

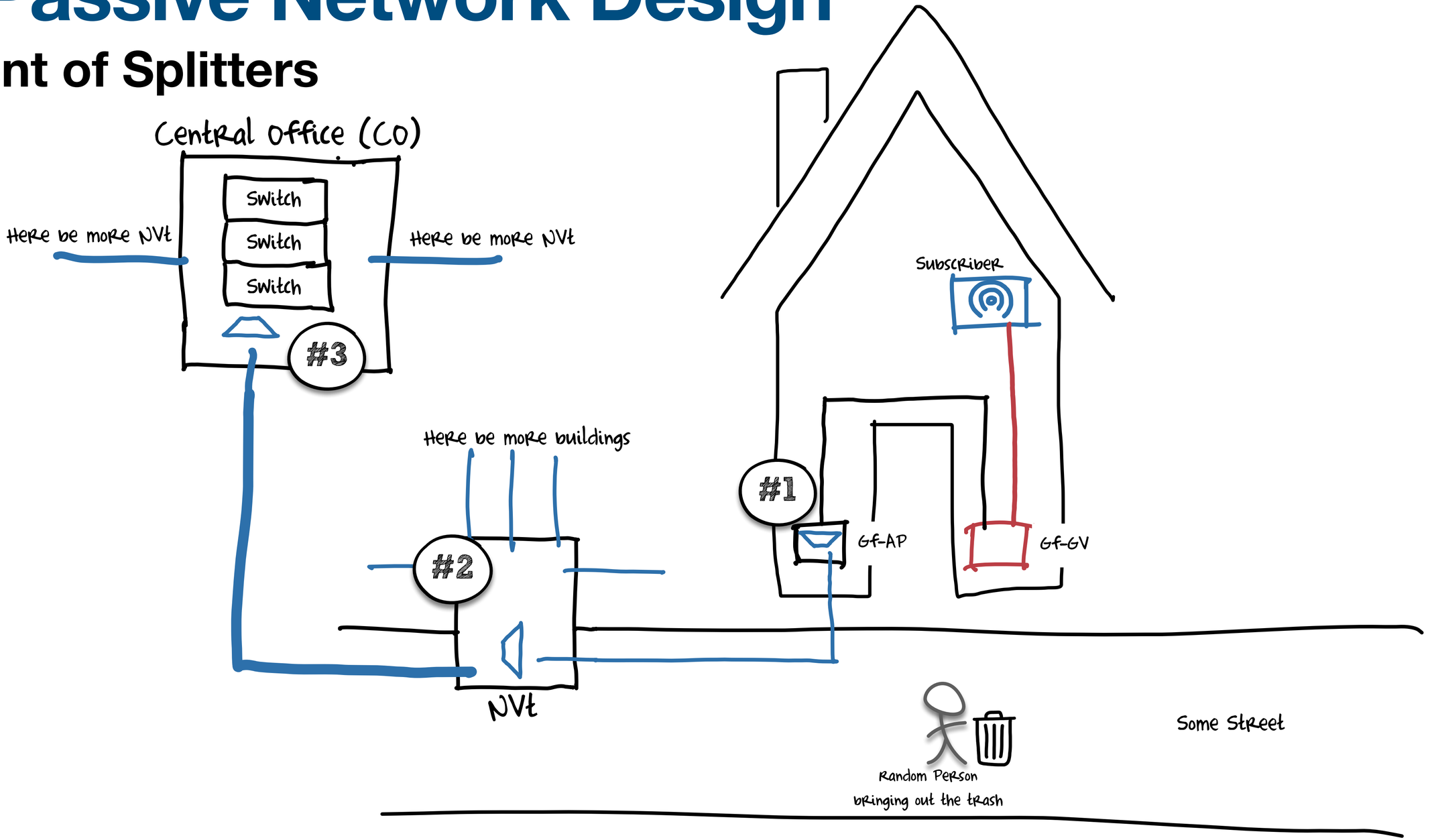
- ***PON***: “Passive Optical Network”
- Term is misleading, since AON design we've seen before is also completely passive
- PON brings a passive distribution layer with power splitters (1:2^n)
- Sharing one fiber between multiple subscribers
- Splitter adds approx. 3 dB loss

Power Splitter



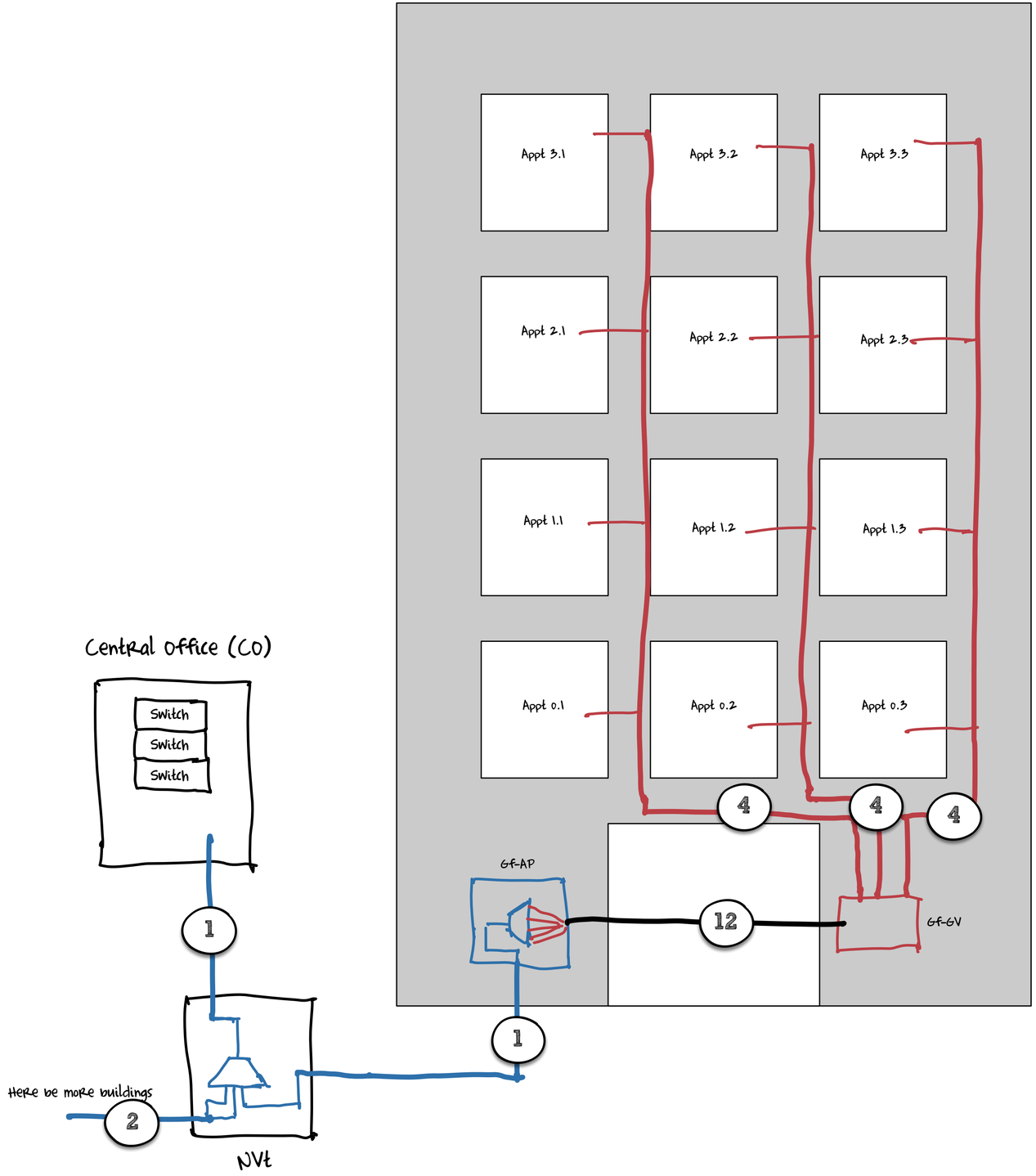
PON Passive Network Design

Placement of Splitters



Impact of Splitting

- Apartment building with 12 units, 4 fibers per staircase going to Gf-GV
- 12 fibers used on cable between Gf-GV and Gf-AP
- Splitter in Gf-AP, 12 fibers combined into 1 going to NVt
- Splitter in NVt, combining multiple buildings into one fiber, going to CO
- 1 fiber arriving at CO



Impact of Splitters

Summary

- Fiber becomes shared medium
- Passive networks become cheaper to build, easier to scale
- Downside: more complex and error-prone, adds oversubscription to last mile between customer and active network
- Balancing the number of subscribers per fiber/port, i.e. the split ratio, is the hard part

Random Person Wondering Why they Weren't in the previous diagram

PON Active Network Basics

Main active components

- ***OLT***: Optical Line Terminal
  - switch-like aggregation device located in Central Office
  - PON ports and uplinks to transport network
- ***ONT***: Optical Network Terminal
  - Small CPE-like device located in subscribers apartment
  - media converter from PON to Ethernet

PON Active Network Basics

Technologies

- Main technologies: GPON (ITU G.984) and XGSPON (ITU G.987)
- S in XGSPON means symmetric
- BiDi Optics, i.e. one fiber per ONT and one fiber per PON port on OLTs

Random Person missing their street

	GPON	XGSPON
Wavelength Downstream	1480-1500nm	1575-1580nm
Wavelength Upstream	1290-1330nm	1260-1280nm
Max. Line Rate Downstream	2.488 Gbit/s	9.953 Gbit/s
Max. Line Rate Upstream	1.244 Gbit/s	9.953 Gbit/s

Key facts: Protocols

- OLTs and ONTs communicate with a control protocol (OMCI) and a dedicated control channel for each ONT
- Usually encryption between OLT and ONTs since fiber is shared medium, so other stations can’t sniff easily
- Shared medium, so needs media access control
  - Downstream (OLT to ONT) easy: OLT broadcasts to ONT encrypted for this specific ONT
  - Upstream (ONT to OLT): ONTs only allowed to send at pre-assigned time slots (TDMA - Time Division Multiple Access)

PON Active Network Basics

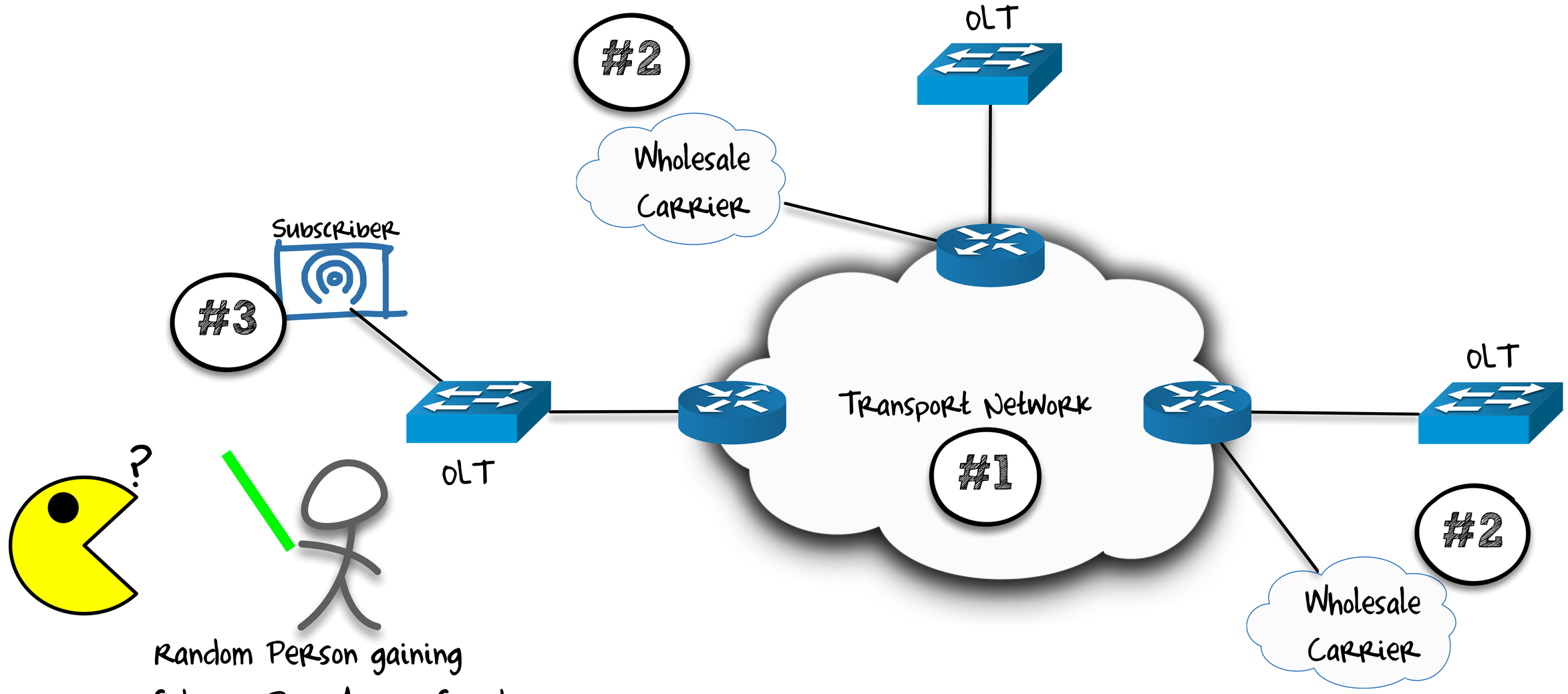
Bandwidth per user

	GPON	XGSPON
Max. Line Rate Downstream	2.488 Gbit/s	9.953 Gbit/s
Max. Line Rate Upstream	1.244 Gbit/s	9.953 Gbit/s
Split Ratio	1:32	1:64
Min. Downstream Bandwidth / Subscriber	77 Mbit/s	155 Mbit/s
Min. Upstream Bandwidth / Subscriber	38 Mbit/s	155 Mbit/s

Reselling single subscriber connections

- Problem for PON: can’t break out one subscriber on a fiber for a specific wholesale carrier
- Solution: L2BSA, Layer 2 Bitstream Access.
  - Layer 2 transport of data between subscriber and wholesale carrier

Layer 2 Bitstream Access



Comparison

AON

+ maximum flexibility for carrier
+ can light access medium themselves
- more aggregation points needed
- higher economic threshold
- With Resale model no G.fast for transition possible

➡ possible benefit for larger/ established wholesale carriers

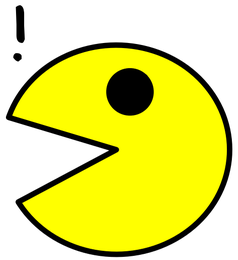
PON

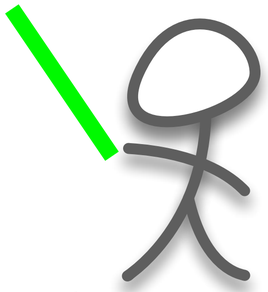
+ handover to wholesale carriers at fewer sites, fewer aggregation points
+ more potential customers reachable via those aggregation points
+ better economic threshold for deployment
- stricter model, less flexibility for wholesale carrier
- dependency on fiber carrier for active network as well, layer 2 transport

➡ better possibility for smaller providers to start

Summary

- No "one size fits all" solution
- Technology also depends on economic parameters
- Technical and environmental requirements as well
- All factors dictate speed of deployment





Questions