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Passive Design for RFoG Networks

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SCTE Piedmont Chapter Meeting

Agenda

- Why all-fiber access?
- RFoG overview
  - What and why RFoG?
  - Network elements
  - A look at the R-ONU
  - Compare to GPON and EPON
- All-fiber access
  - Architectures
  - Current deployment methods
  - Migration

REMEMBER:

RFoG is a work in progress

It has come a long way

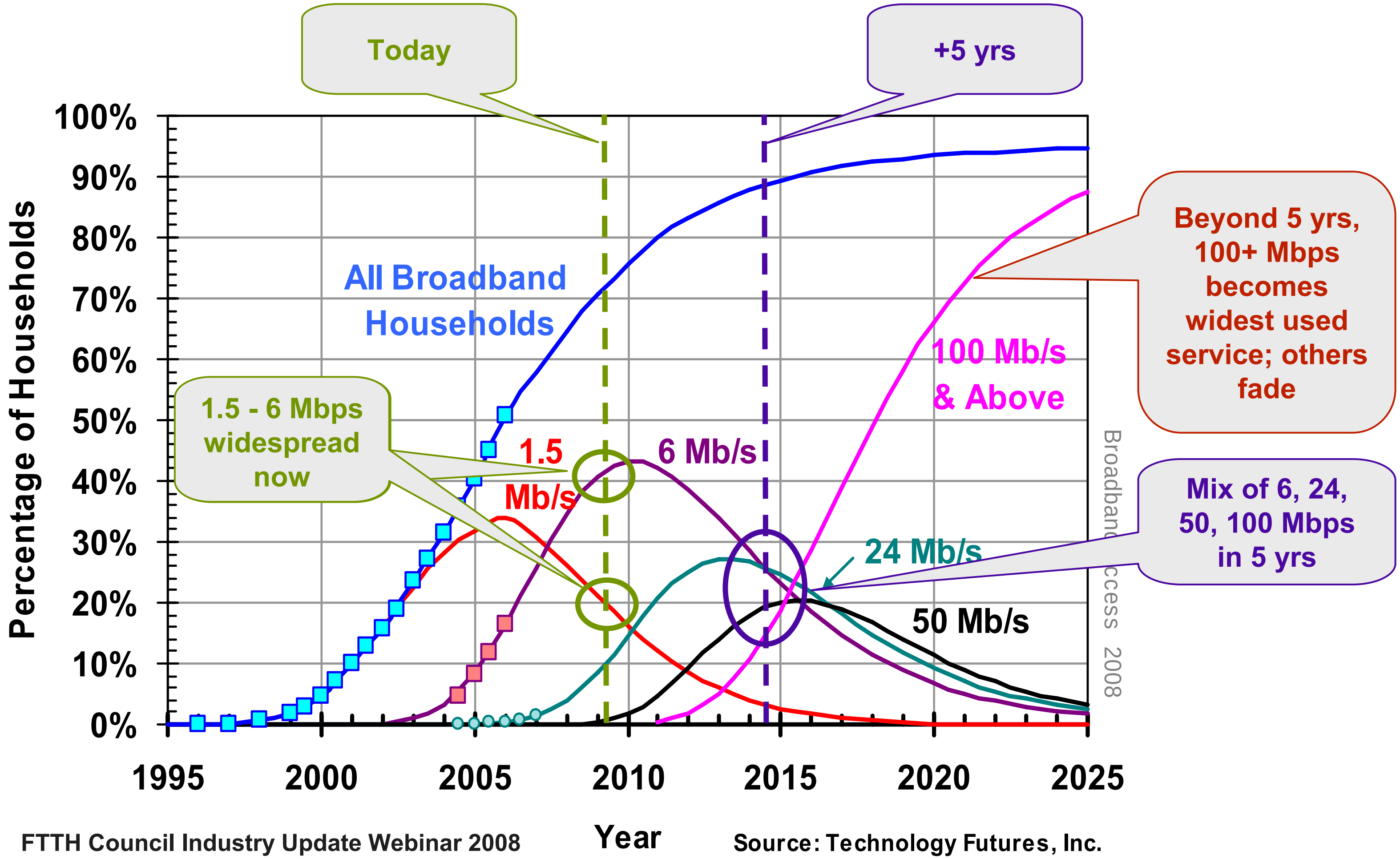
But it has not been through balloting

Many parameters are still being worked through

What All-Fiber?

- Bandwidth supply/demand
- Competition
- Reduce operating costs
- In greenfield deployments, reduce long term total cost
  - Avoids major rebuild by deploying fiber first
- All-fiber access can be a universal strategy
  - Commercial
  - Residential

Bandwidth – Movin' On Up!



FTTH Council Industry Update Webinar 2008

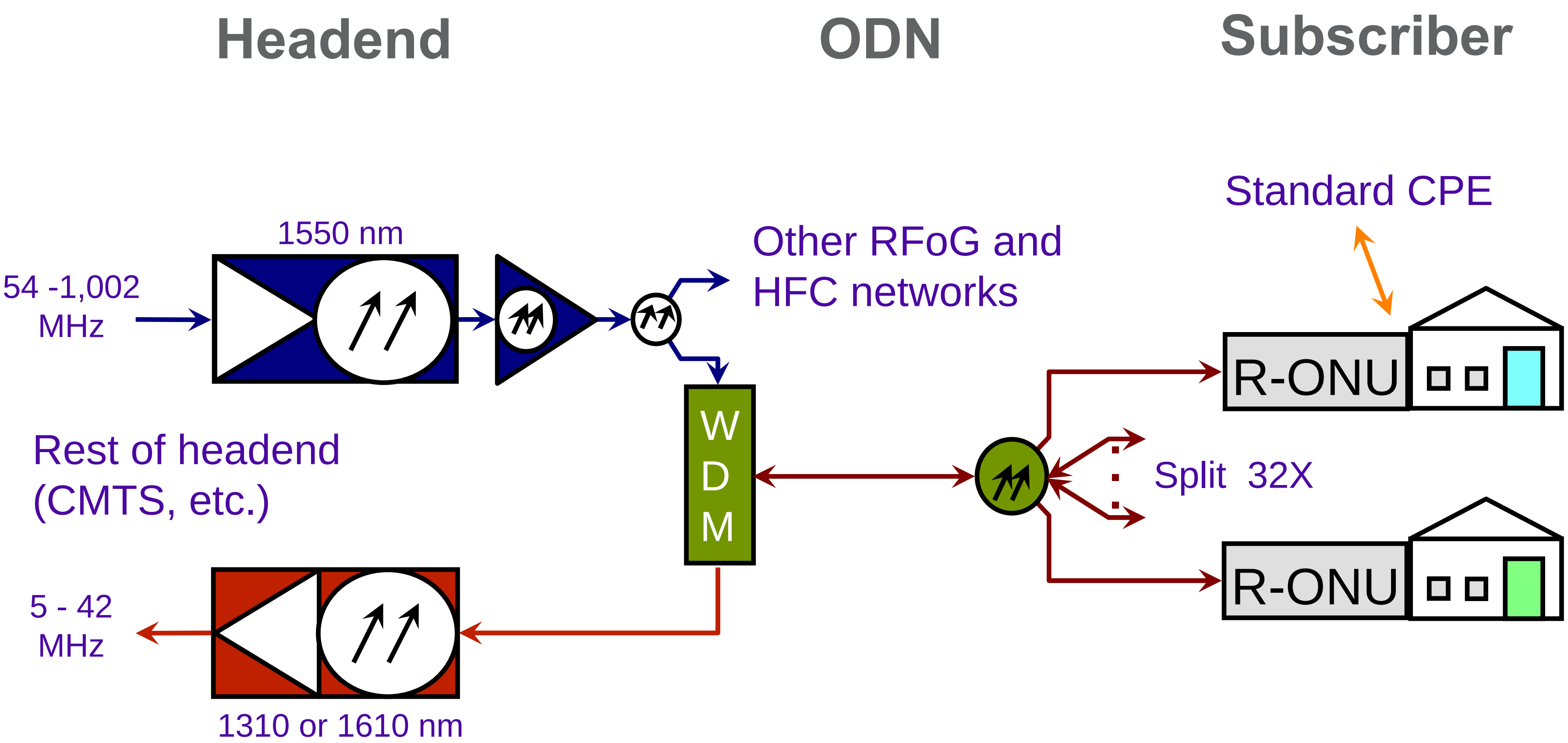
Source: Technology Futures, Inc.

Data Source: FCC. Speeds are based on DSL & FTTL data. Excludes mobile wireless broadband

What & Why RFoG?

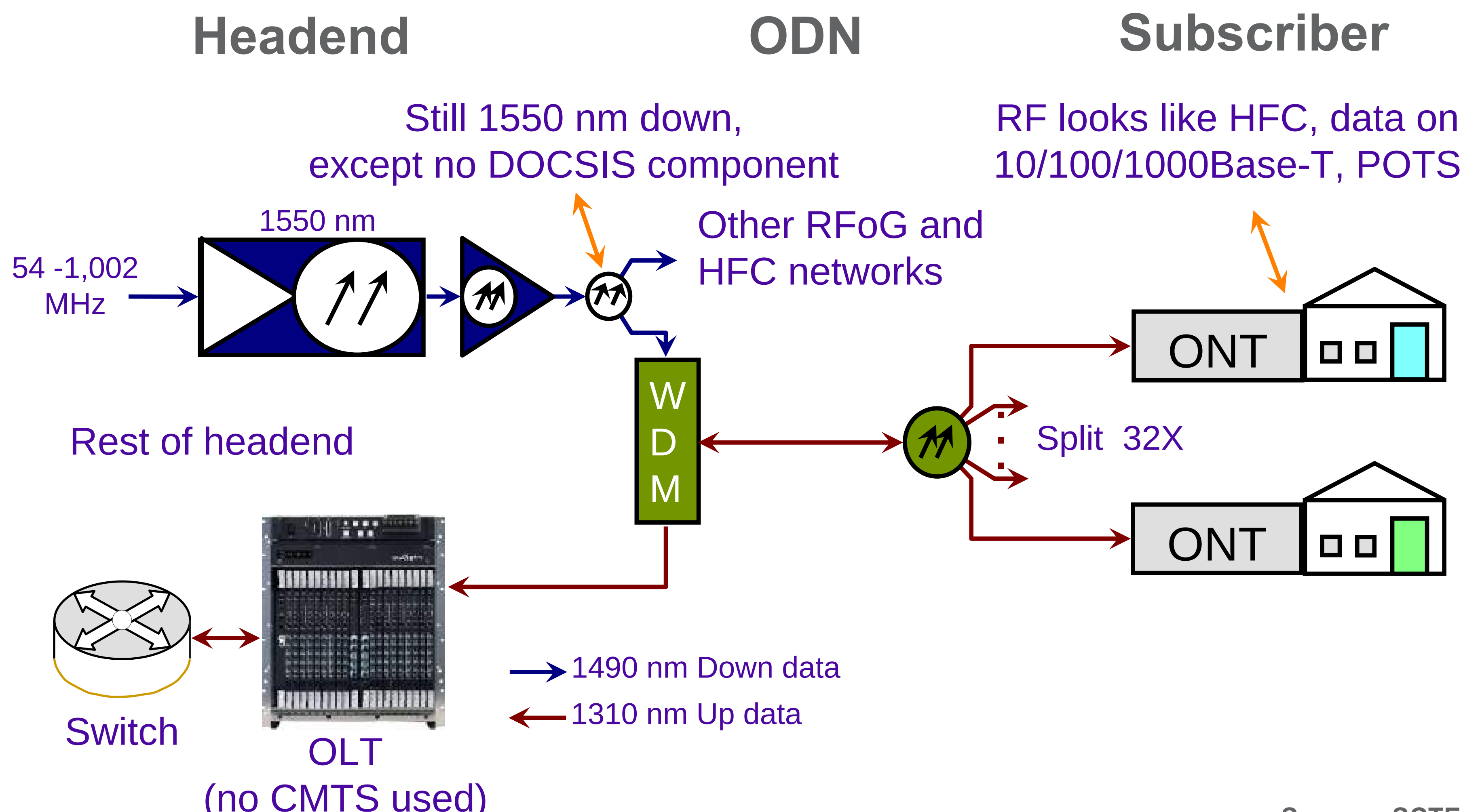
- RFoG is …
  - All-fiber access technology that leverages fiber to the subscriber and is compatible with the MSO back office / equipment
- RFoG leverages the MSO framework
  - Same headend gear
  - Same CPE
  - Designed to allow co-existent overlays
- RFoG simplifies & reduces costs such as …
  - Minimizes/eliminates system power bills, outages due to power failures
  - No “adjustments” needed in the outside plant (i.e. amp balancing)
  - Eliminates annual proof performance (fly-overs, leakage testing)
  - Return path ingress issues no longer apply

What are the RFoG Elements?



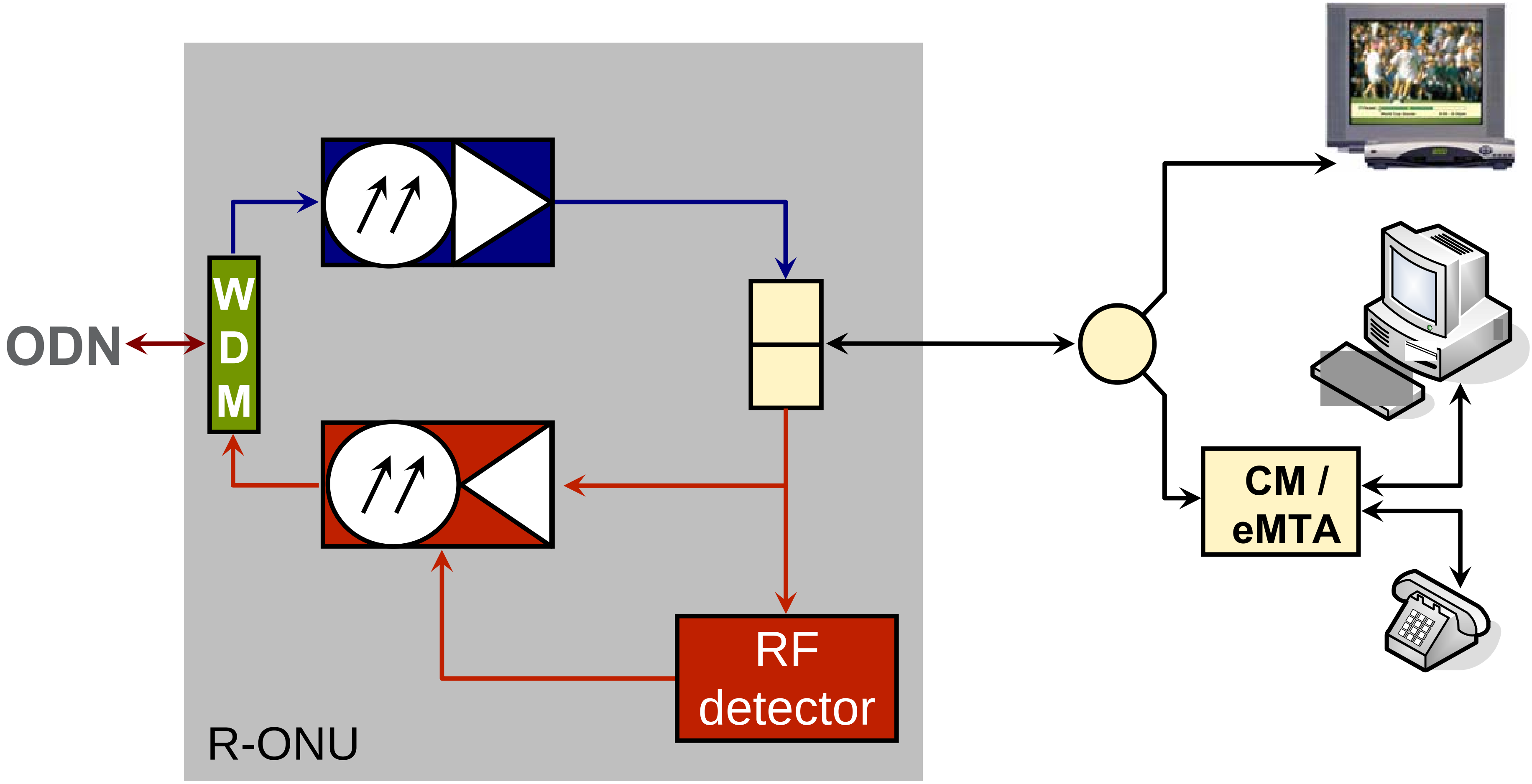
Source: SCTE

What are the RFoG Elements?



Source: SCTE

R-ONU Close-Up



Source: SCTE

Wavelength Line-Up

- EPON (IEEE 802.3ah) and GPON (ITU-T G.984)
  - Downstream: 1490 nm
  - Upstream: 1310 nm
  - Video (RF): 1550 nm
- 10GEPON (802.3av):
  - Downstream: 1577 nm
  - Upstream: 1270 nm
  - Video (RF): 1550 nm
- RFoG
  - Downstream (Video): 1550 nm
  - Upstream: 1310 nm or 1610 nm

Source: SCTE

RFoG Wavelength Selection

- Downstream is straightforward
  - Same 1550 RF wavelength used with GPON and EPON
  - RF carriers video, data and voice
- Upstream has several options
  - 1310 is least expensive, but does not allow coexistence with xPON
  - 1590 was an early choice to allow coexistence, but was also in 10GEPON standard
  - 1610 is the primary wavelength
    - 1310 recognized as option

Source: SCTE

What's Next in SCTE IPS WG5?

- Key Work Streams
  - Wavelength and isolation
    - Filters, laser performance
  - System loss budget
    - Loss budget analysis, impact on performance
  - R-ONU downstream
    - Output levels
  - Upstream parameters
    - RF levels, OMI, CNR, trigger levels
  - R-ONU physical characteristics
    - Temperature, humidity, powering & more
  - Extended reach/transition nodes
    - Beyond 20 km

Upcoming Meetings

- 18 March - Call
- 22 April - Philadelphia

Source: SCTE

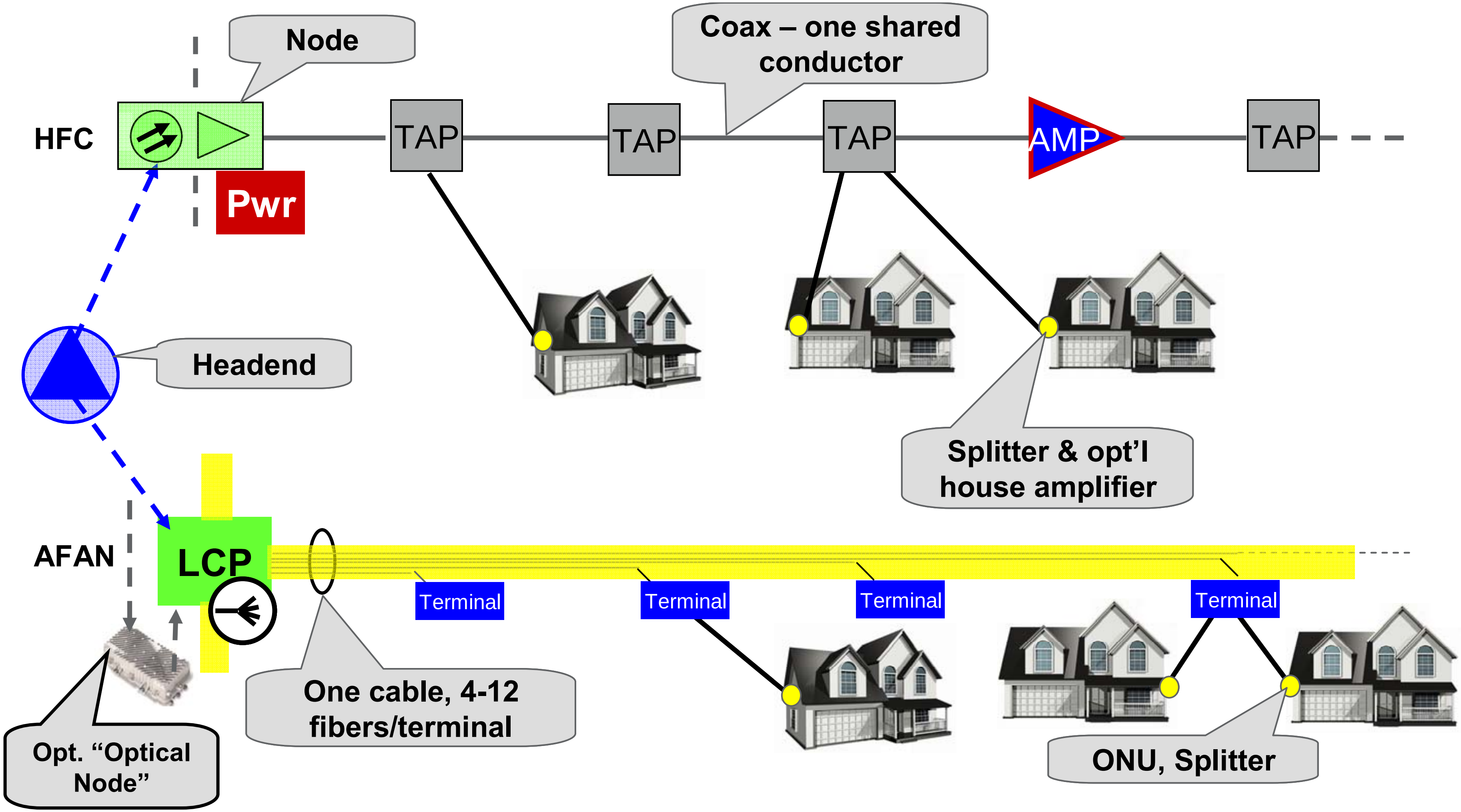
Mapping from HFC to All-Fiber

- RFoG Architectures
- HFC to All-Fiber Cross Reference
- All-Fiber Architectural Models

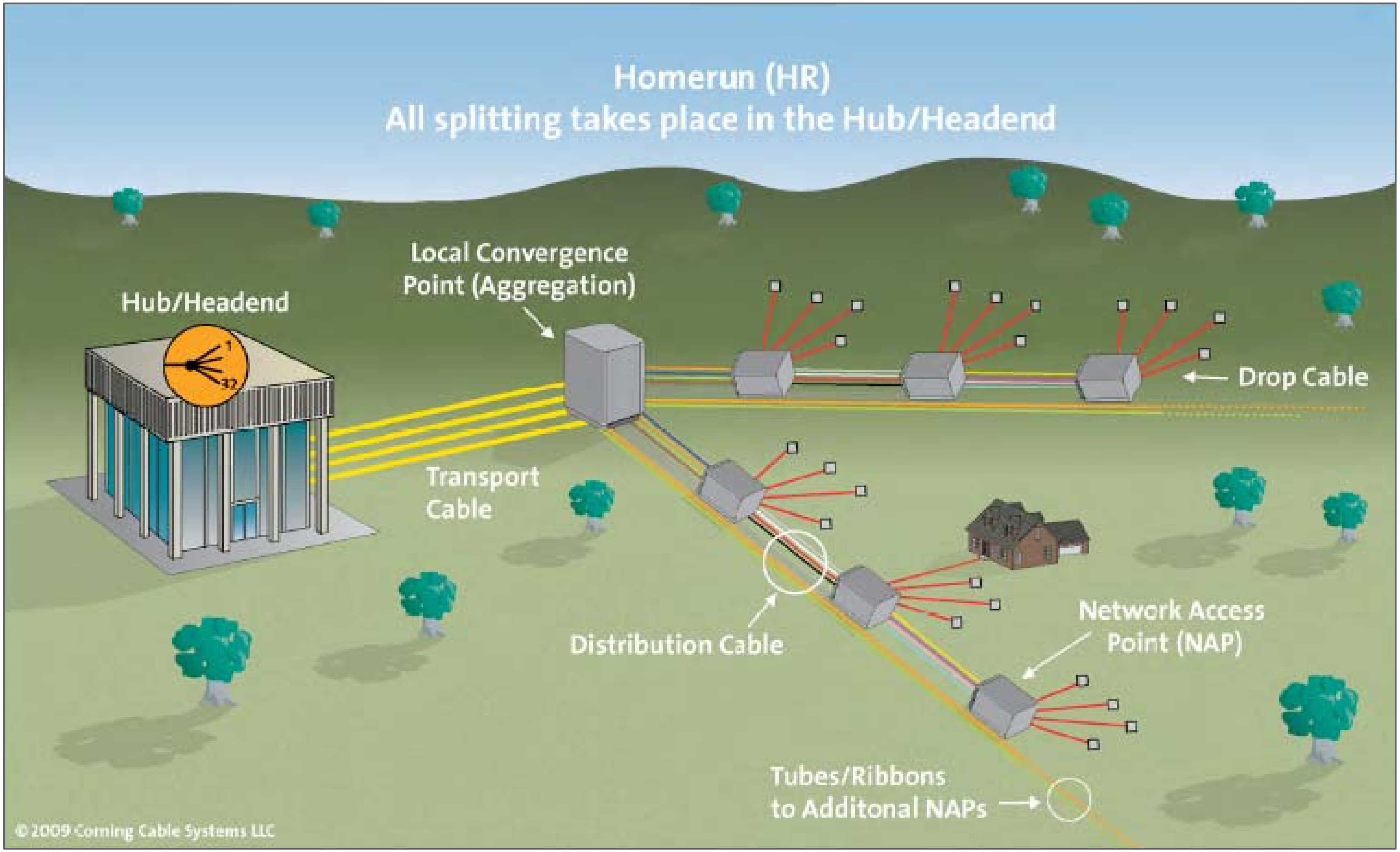
RFoG Architectures

- RFoG is architecturally agnostic
- ‘Optical Hub’
  - All electronics at head end means all-passive network
  - Some electronics in the field – all-fiber, but not all-passive network
- Key is the link specification
  - Loss budget (28 dB)
  - Reach (20 km)
  - Connectors (APC)
- Three main Splitting Strategies
  - Home Run (head end)
  - Centralized (field concentration point)
  - Distributed (multiple field locations)

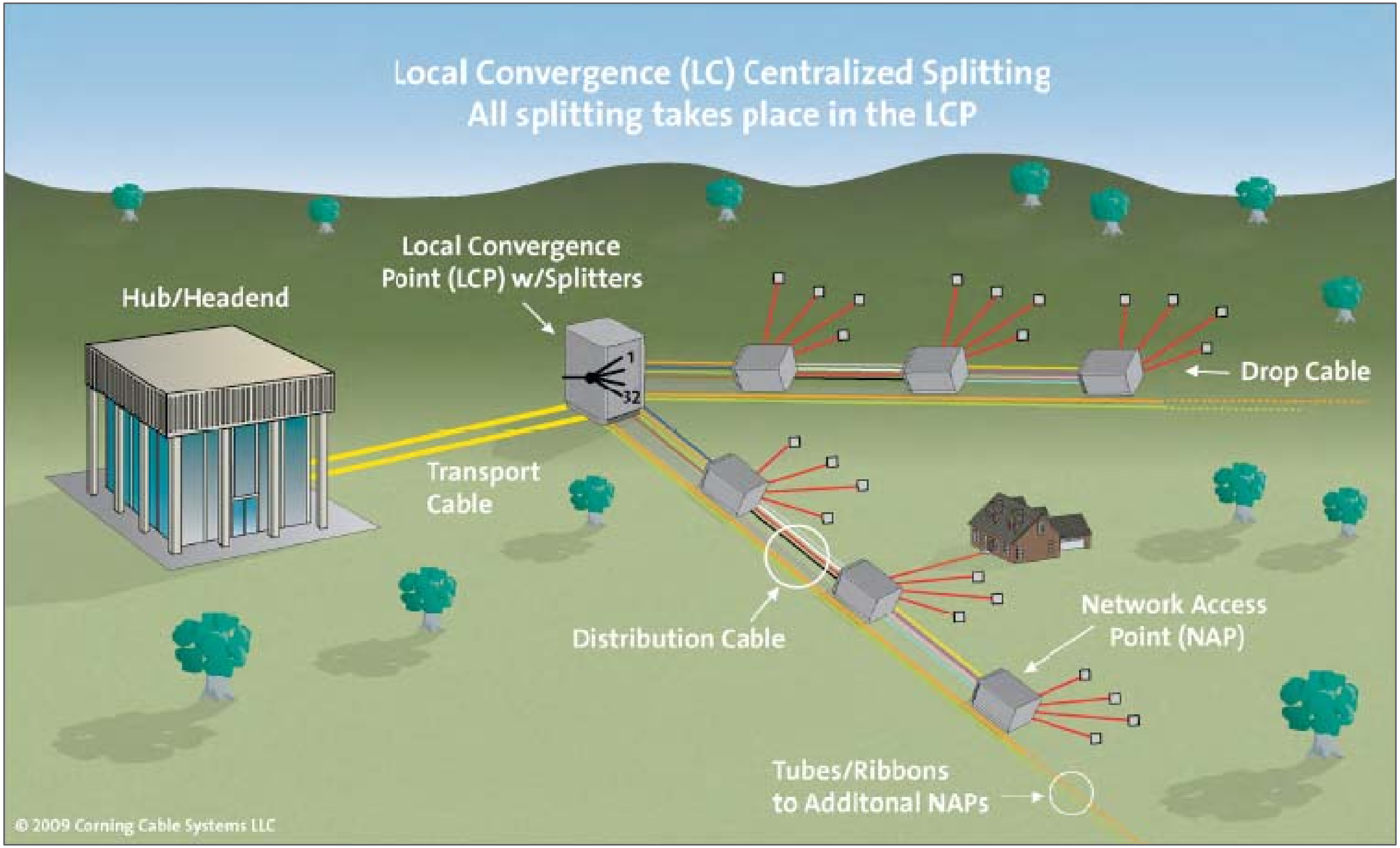
All-Fiber Access Network and HFC Cross-Reference



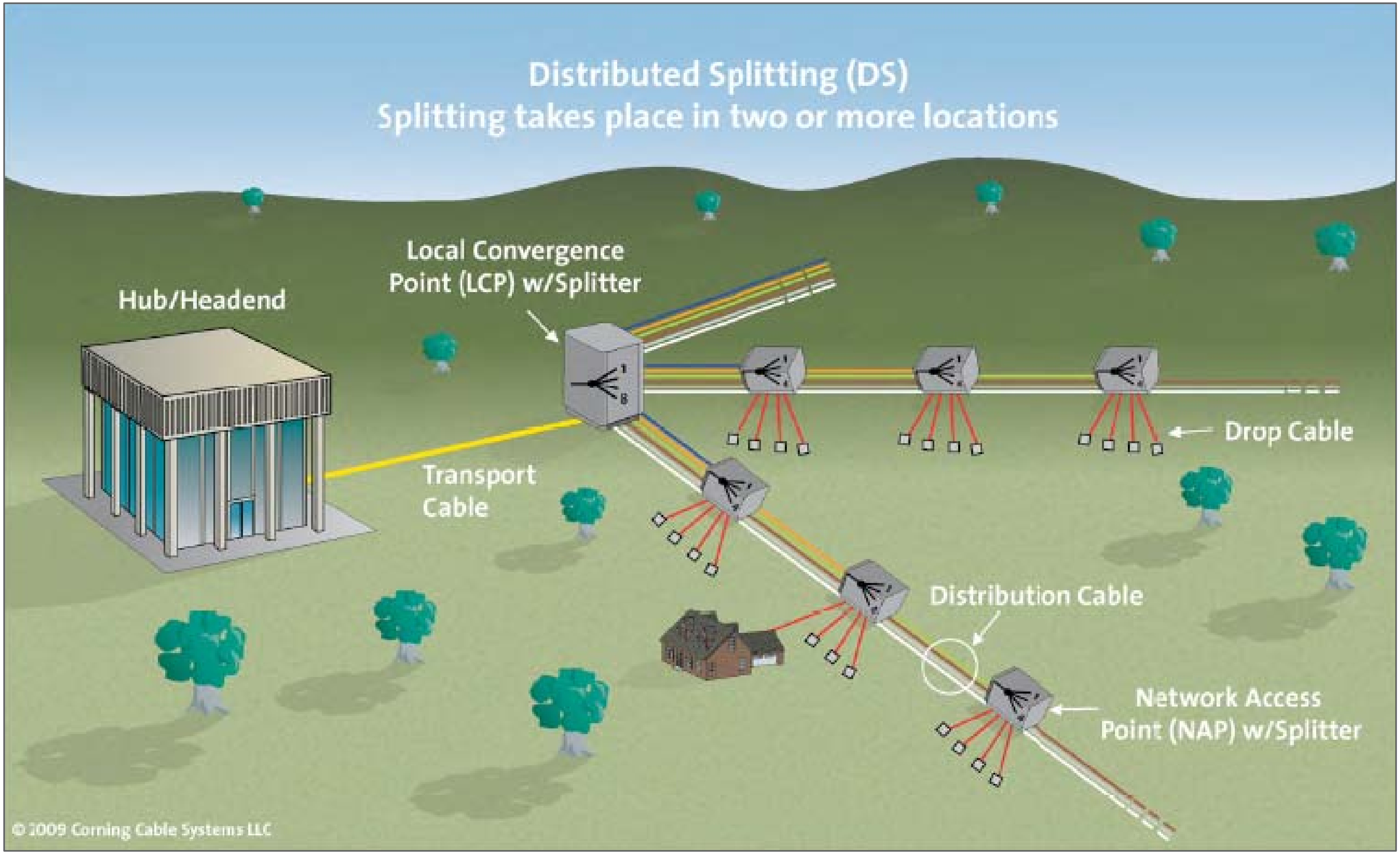
Headend - Home Run
Considered for Smaller Deployments



Local Convergence – Centralized Splitting Excellent in Large-Scale Deployments



Distributed Splitting
Alternative for Low Density and Rural Deployments



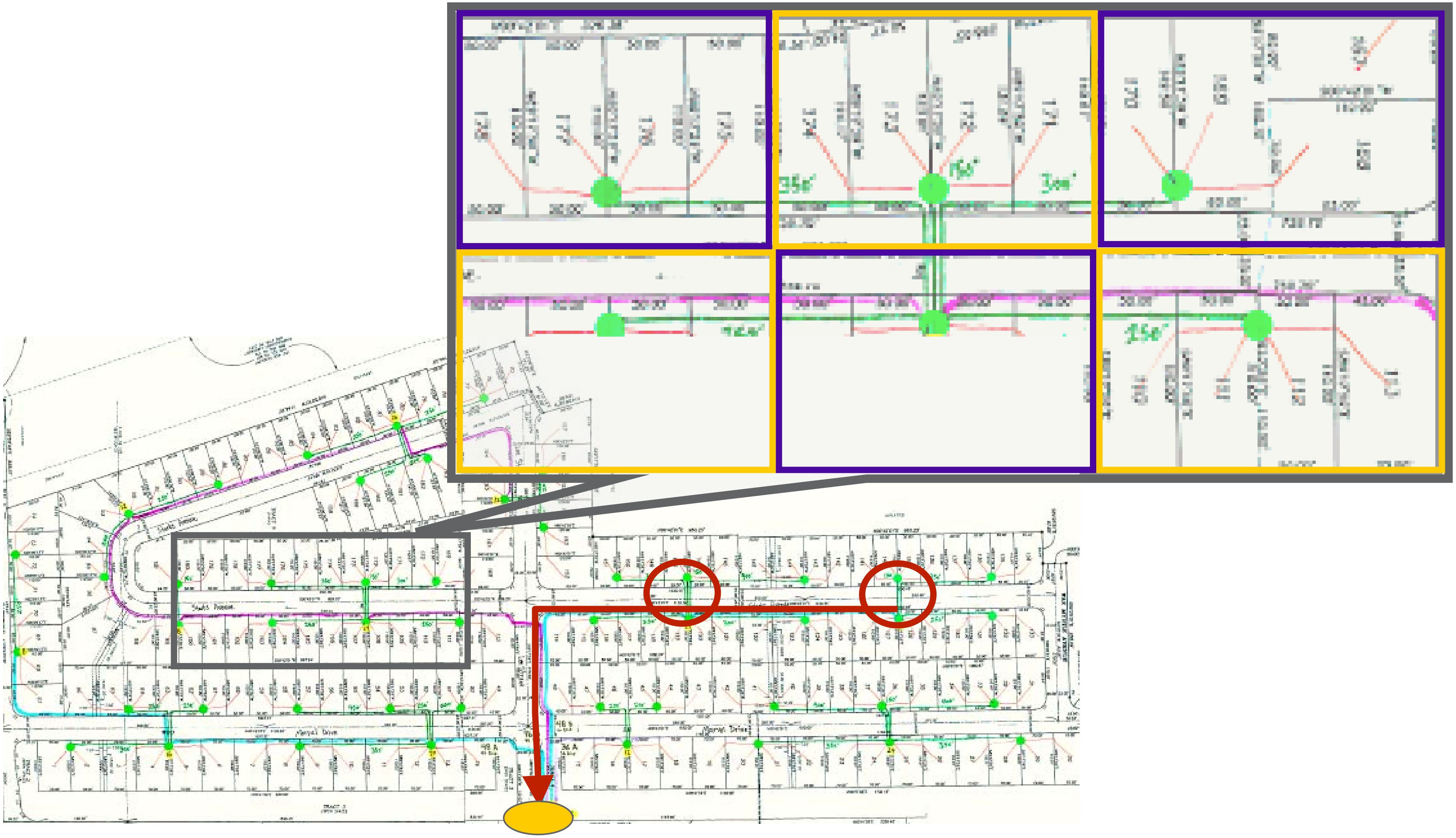
Design

- Bottoms-up Methodology
- Port Count & Drop Length

Bottoms-up Methodology

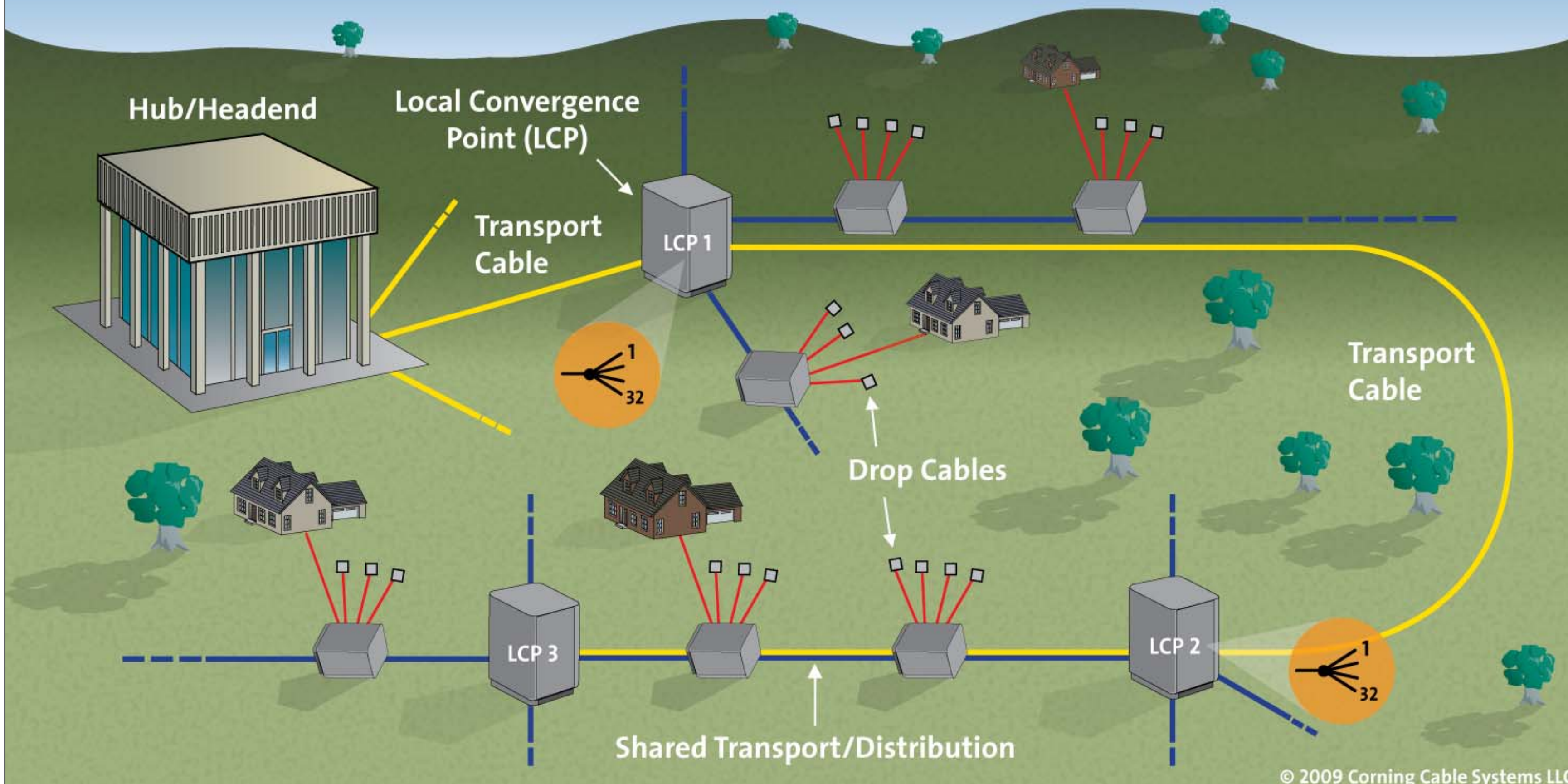
1. Define network access point (NAP) groups
   - Strive for symmetry and uniform size (“fours”)
   - Minimize drop length (reduce drop labor and material)
2. Join NAPs into distribution cables
   - Minimize number of cables (reduce placement cost)
   - Right-size fiber counts
3. Define local convergence point (LCP) service areas
   - Use multiple LCPs – small service areas
   - Small areas minimize cable lengths and fiber counts
   - Allocate space for future network growth
4. Determine transport path

Bottoms-up Methodology



Mapping All-Fiber Design to HFC

- **Reduce LCP serving area size**
- **Resembles N+0, N+1**
- **Capture ≤ 128 homes/businesses**



Deployment Scenarios

- RFoG Only
- Overlay
- Managing the Network
- Residential & Commercial Services

RFoG & More

- Initial deployment as RFoG only
  - Standard RF capability
  - Voice, video and data
  - DOCSIS 2.0 or 3.0
- Overlay with EPON, GPON or 10G version
  - xPON adds data capacity
  - Coexists w/RFoG
  - RF continues to deliver video, voice
  - Commercial and residential opportunities
- Evolutionary Scenarios
  - Low cost & swap
  - Pre-provision (wavelength, expansion port)
  - Premium – all upfront

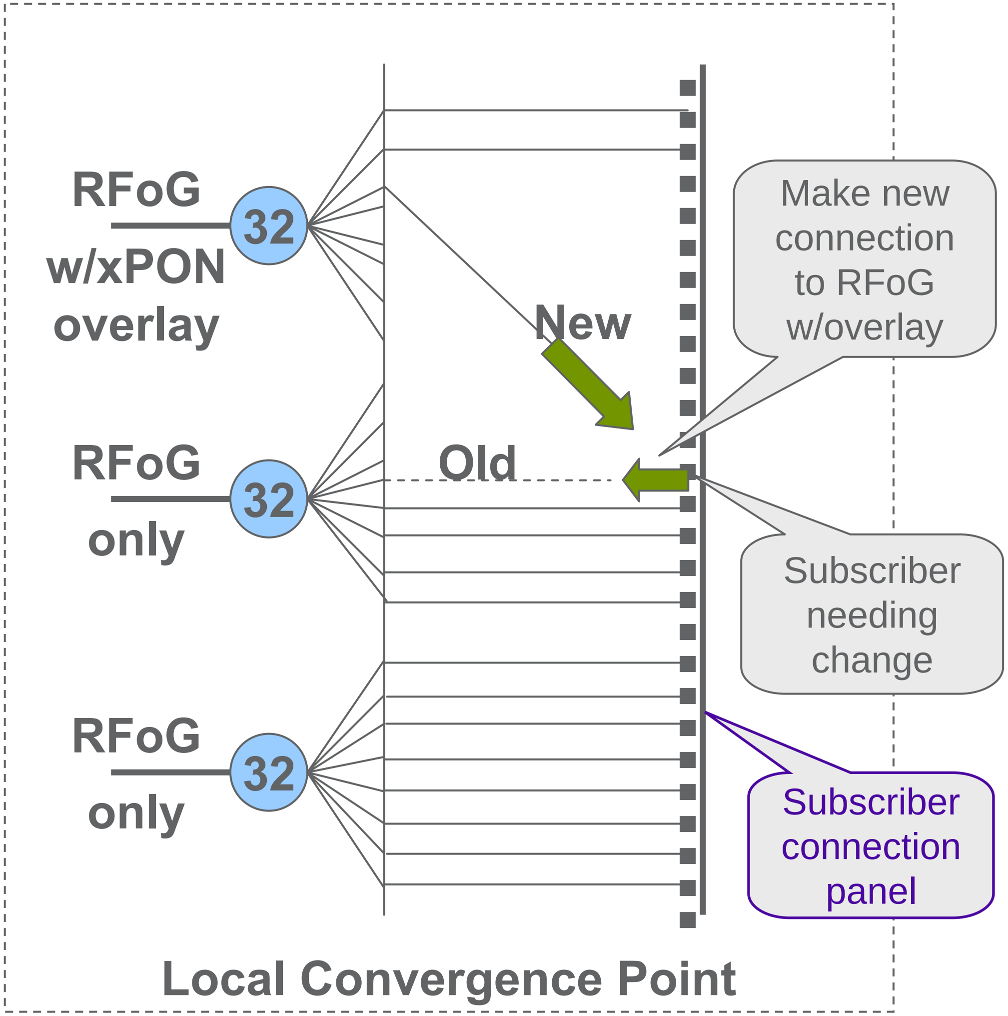
Managing Evolution

- Objectives
  - Subscriber management
    - Requires only basic skills – no splicing
    - Migration to expanded data in one truck roll
  - Technology migration
    - Change just the active devices at the ends
  - Change from optical splitting to wavelength multiplexing
    - Subscriber location
    - One field location

Moving from RFoG to RFoG with Overlay

- Disconnect from RFoG-only splitter
- Make new connection to splitter w/RFoG **and** xPON
- Proceed to customer's house and make any equipment changes

- Architecture/splitter placement strategy is key enabler for future network flexibility



Migration

- Leverage existing fibers to extend all-fiber services
  - Requires one fiber per 32 homes

    OR
  - add local hub in the case of limited fiber availability
- HFC first, all-fiber future
  - Provision at least one fiber per 32 homes passed
  - Build distribution from node to homes
  - Convert node to LCP

Conclusion

- RFoG leverages existing MSO equipment while building an all-fiber foundation
- Eliminate/minimize powering, testing and maintenance costs
- Select splitting architecture for best flexibility
- Build once; design to standard passive parameters
- Evolve capacity through technology overlay
  - EPON, GPON; future 10GEPON, 10GPON
  - Residential and commercial
- Program for migration – provision optical fibers for all-fiber access