Passive Design for RFOG Networks

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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!

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?

**Headend**
- 54 - 1,002 MHz
- Rest of headend (CMTS, etc.)
- 1550 nm

**ODN**
- 1310 or 1610 nm
- Other RFoG and HFC networks
- WDM

**Subscriber**
- Standard CPE
- Split 32X
- R-ONU

Source: SCTE
What are the RFOG Elements?

**Headend**
- 1550 nm
- Rest of headend
- Switch (no CMTS used)

**ODN**
- Still 1550 nm down, except no DOCSIS component
- Other RFOG and HFC networks

**Subscriber**
- RF looks like HFC, data on 10/100/1000Base-T, POTS

**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

- HFC
- TAP
- TAP
- TAP
- AMP
- TAP
- Headend
- Node
- Coax – one shared conductor
- Splitter & opt’l house amplifier
- One cable, 4-12 fibers/terminal
- ONU, Splitter
- Terminal
- Terminal
- Terminal
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