NGHFC Key Requirements

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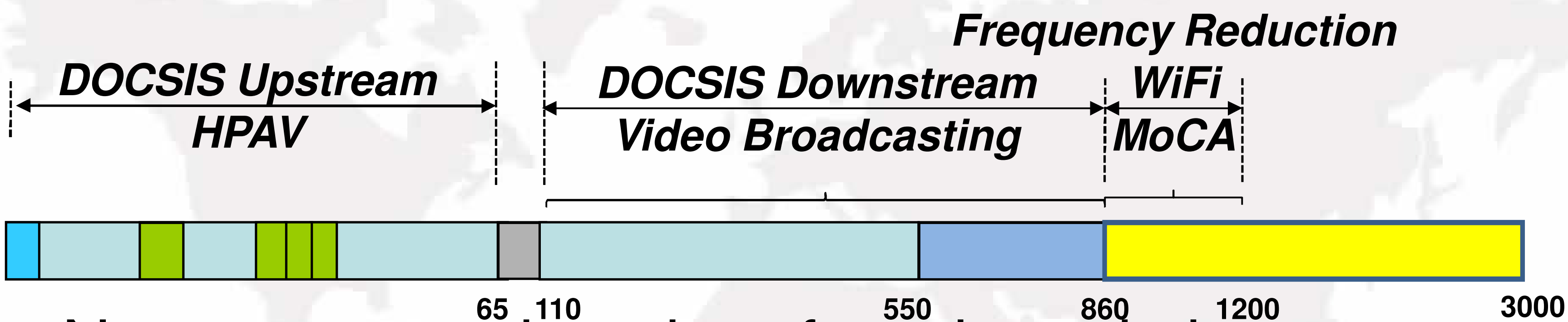
Basic Requirements

- E2E Ethernet System
- EPON MAC
- OLT: not change or a little S/W modification（MAC layer MPCP extension）
- ONU and CNU mixed networking in existing deployed systems and coming deployed EPON systems
- Supported Terminal number: 1G-128, 10G-1024（based on real application, in principle, 1G: 32-64 user，2-4 terminals per user）

Spectrum Adaptation

- Meet the existing spectrum plan and adapt to the future various spectrum plans



- Not occupy and not interfere the existing application spectrum, and guarantee to coexist with the existing DOCSIS and EoC
- Gradually extend (existing spectrum adjustment, new spectrum extension)
- Backwards compatible (CO spectrum changes, Terminal can auto-adapt to this change)

Compatibility

- On service layer, guarantee to IOP with deployed systems
- NMS and Operation maintenance retain compatibility after system upgrade
- QoS：Take generic and unified QoS policy
- Backwards compatibility: 1G—Asymmetric 10G—Symmetric 10G, the deployed CNU can work well without replacement
- Compatible to FDD/TDD（can implement static configuration for US and DS BW)

China MSO network Nature different from NA's

- High-density residence, N+0 can cover 50-500 homes. Reflection delay and reflection loss are less than NA's.
- Over 90% HFC is the single way (NA is reverse)
- FTTB development surpass NA and Europe, and now it is >20%, and in some areas, it reaches 100%. It is the key network reconstruction direction and the first option. The amplifiers will not be upgraded again, and will gradually be eliminated.
- N+0 is the application scenario that HiNoC (China NGB access network EoC) is designed for, and also is the best application scenario.
- China building power line "0" line mostly is connected together with protection ground.

China Application Scenario 1
- Raise Residental Building (128 homes)

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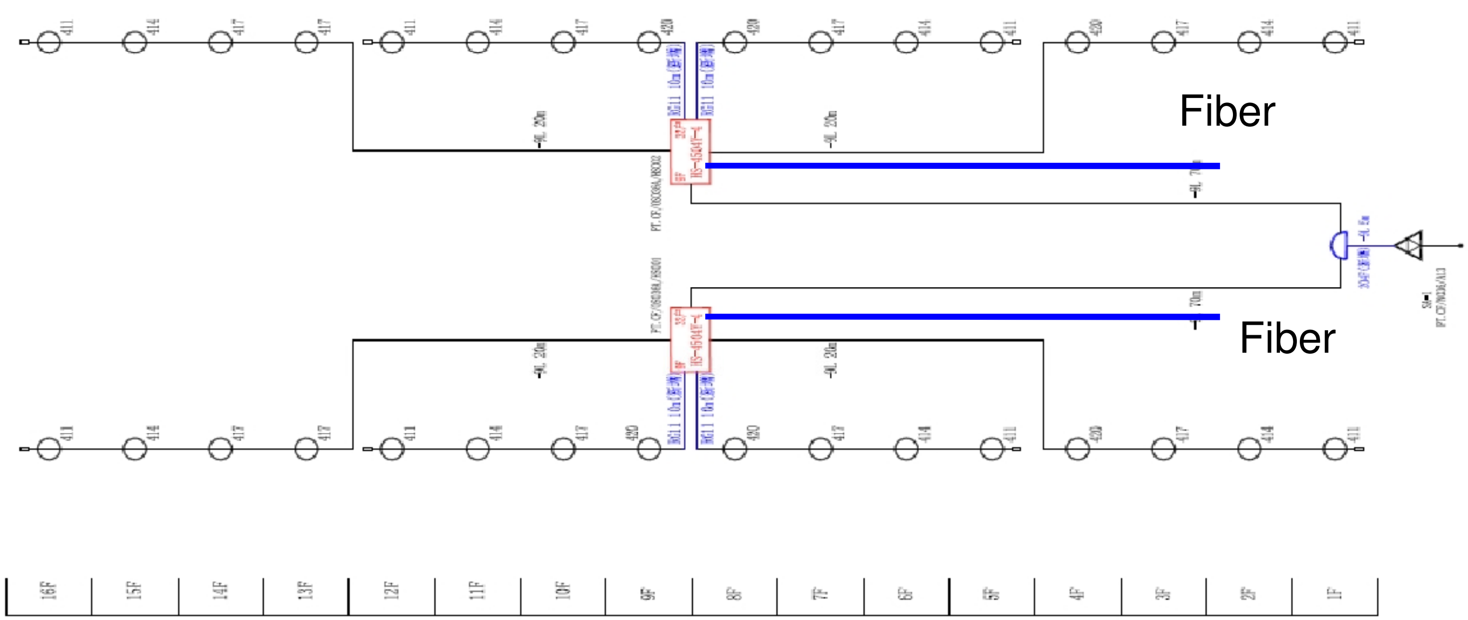
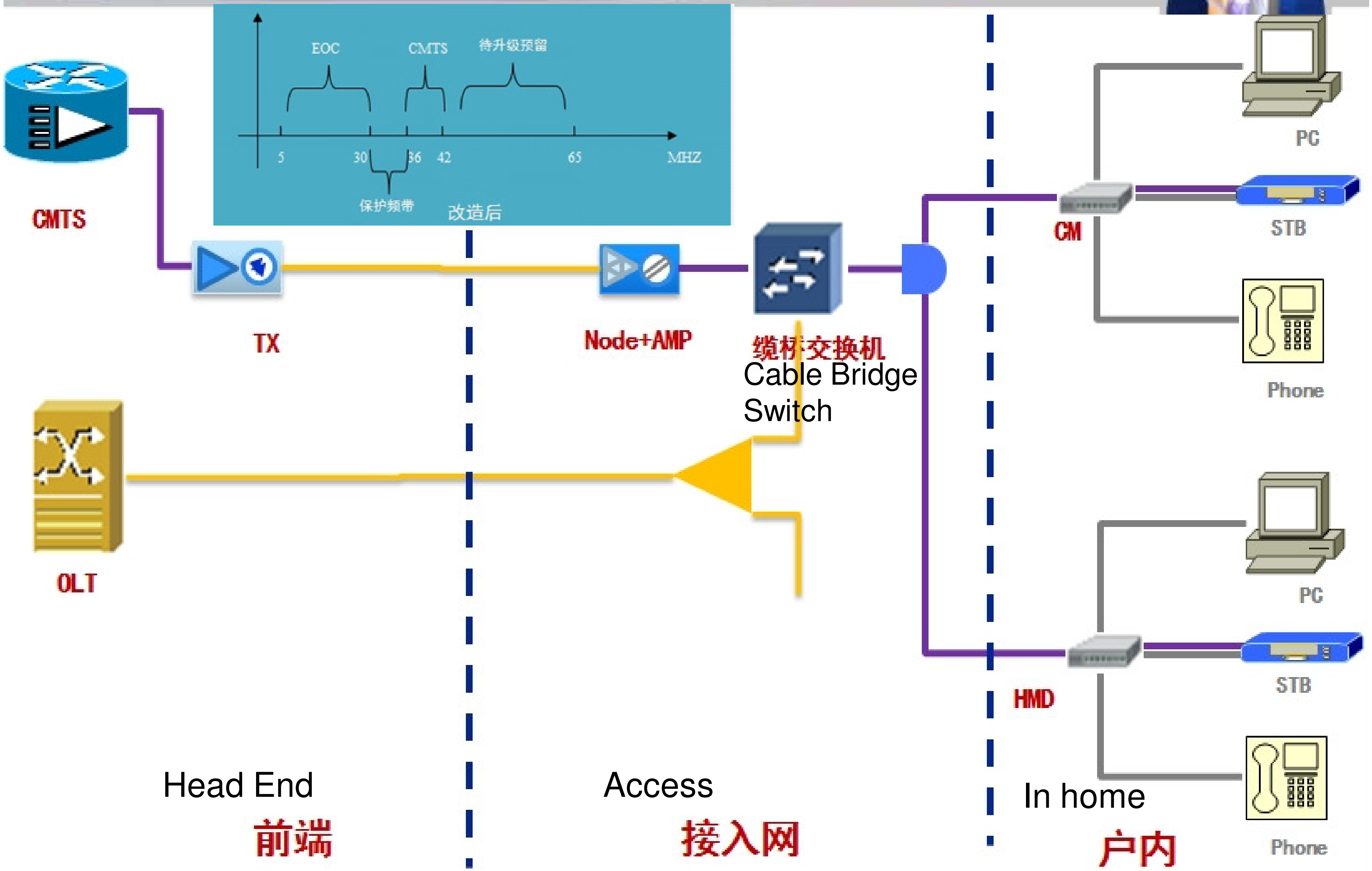
MSO Real Network Diagram, Red block is “ONU+ 4 channels HomePlug AV EoC Master after network upgrade

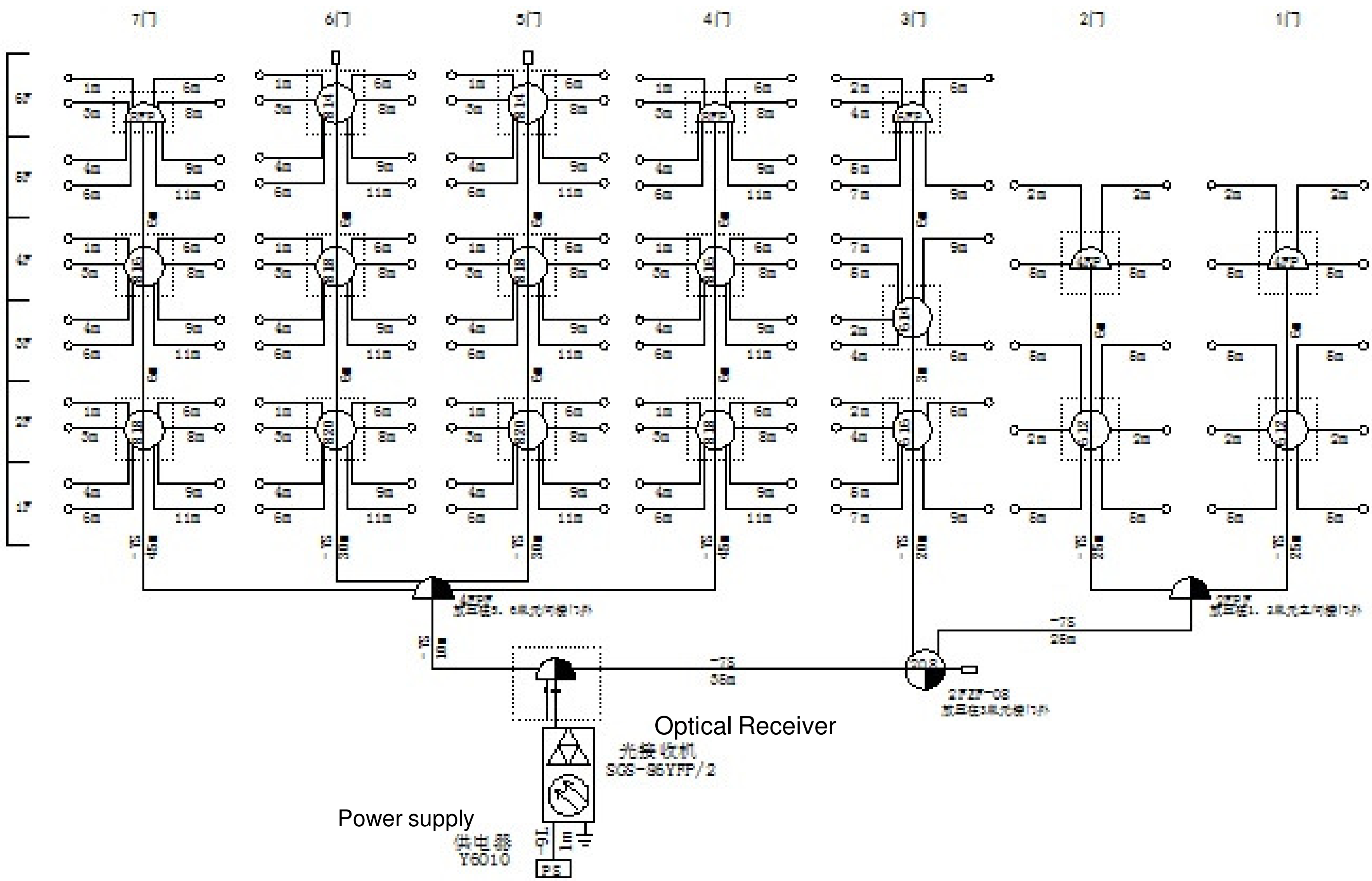


项目名称	冠龙家园NGB改造项目			材料清单	名称	数量	名称	数量	名称	数量	名称	数量	名称	数量	名称	数量	备注
图纸名称	冠龙家园用户分配网	所属光节点	PT.CF/N036		-9电缆	5	-9针头	10	-9F头	4	411J		814J		204F	1	[illegible]

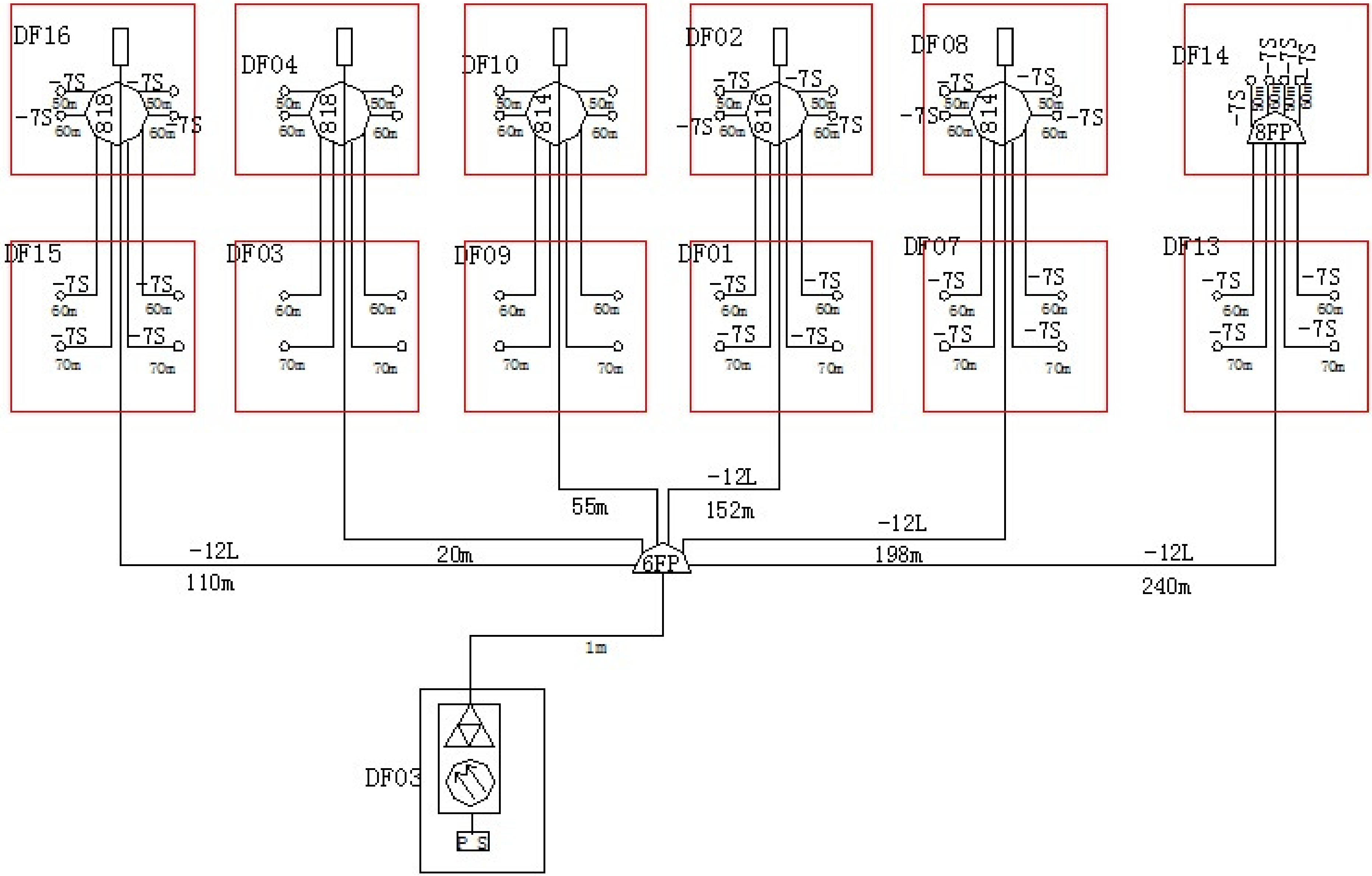
Coexistence of DOCSIS and EoC



China Application Scenario 2-板楼



China Application Scenario 3-Villa



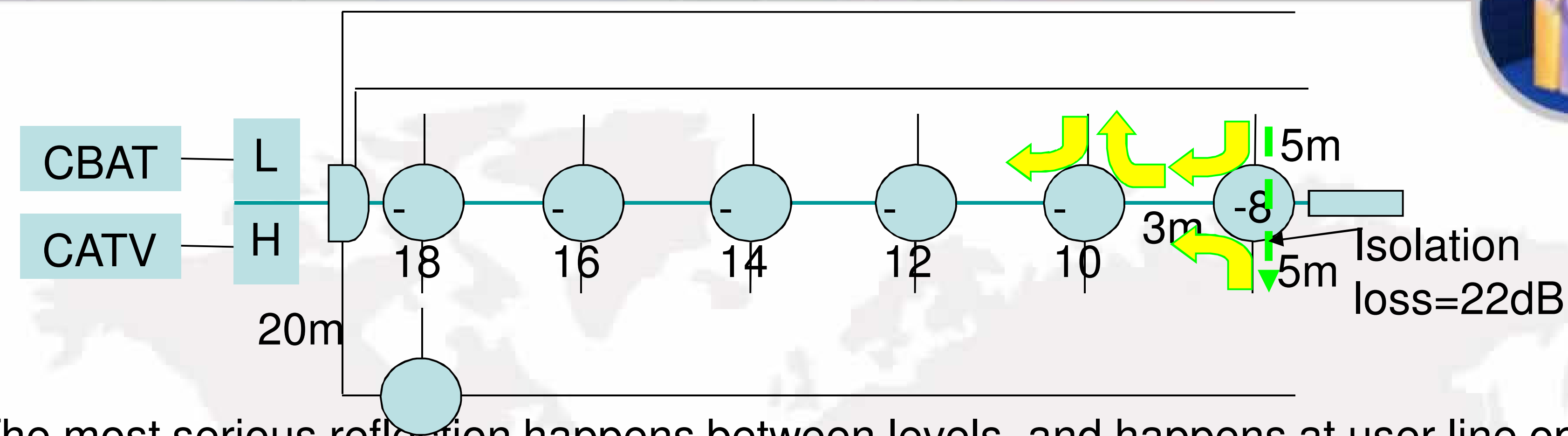
Performance

- Adapt to EPON rate before line coding
- GEPON: Bidirectional 1Gbps
- Asymmetric 10GEPON: US-1Gbps/DS 1-10Gbps (can be gradually extended per spectrum extension)
- Symmetric 10GEPON: Bidirectional 1-10Gbps, can be gradually extended per spectrum extension
- Delay: ≤20ms. 64Byet frame: min delay≤10ms
- Jitter: ≤20ms. 64Byet frame: min jitter≤10ms
- Packet loss: ≤1E-4

Performance (Continuous)

- At SNR≥39dB, guarantee 4096QAM modulation
- At SNR≥40dB and mix amplitude=+8dBc single freq interference, the rate has no clear drop (≤1%)
- At SNR≥40dB, 90% payload, mix amplitude ≤+8dBc, "width≤10μs, interval≥10ms" and "width≤100μs, interval≥100ms" pulse interference, no packet loss
- Normal Coax channel micro-reflection influence refers to the following table
- Support both IPV4 and IPV6

Two branches connected in series

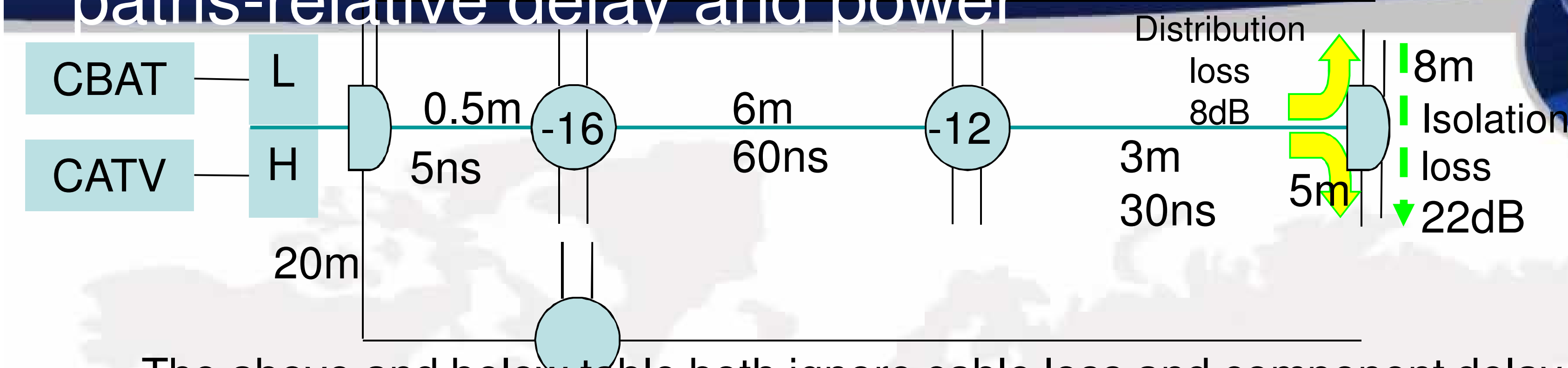


The most serious reflection happens between levels, and happens at user line open. Because the reflection loss min value of branch distribution and filter between levels is 16dB, the min loss is 32dB after 2 times of reflections (convert to the same direction) (in general, it is not impossible that the ports of 2 components at the same frequency point all are the worst points, so the actual reflection loss is over 32dB), the loss at 3m-5 coax 5MHz is around 3/100×2dB=0.06dB, and the round loss 0.12dB can be ignored. 'The end user open' impact on the users at the same level is "-22-10m cable loss=-22.2dB. The impact between corridors is equivalent to the one between 2 levels, the difference is that the delay between corridors is longer. The main impact is the reflection between distributor output and the bottom level branch input end, and the 'user open' impact is less than the top level, because the branch loss is bigger. The reflection from CBAT-end user transmission path is the same as the reverted path reflection. The following table respectively lists the main micro-reflection of 2 component reflection loss limits (10, 16dB).

"2 branches connected in series" structure multiple paths-relative delay and power

Component reflection loss 10dB Reflection Description	CBAT sending Downstream	Component reflection loss 16dB Reflection Description	One home at 6th level sending Upstream(6 levels)
4 distribution-branch 2 times reflection	5 ns @ -20dBc	4 distribution-branch 2 times reflection	5 ns @ -32dBc
Level 1 all open 2 ports	50ns @ -38dBc	Level 1 all open 2 ports	50ns @ -38dBc
2 times reflection between level 1-2	30ns @ -20dBc	2 times reflection between level 1-2	30ns @ -32dBc
Level 2 all open 2 ports	50ns @ -36dBc	Level 2 all open 2 ports	50ns @ -36dBc
2 times reflection between level 2-3	30ns @ -20dBc	2 times reflection between level 2-3	30ns @ -32dBc
Level 3 all open 2 ports	50ns @ -34dBc	Level 3 all open 2 ports	50ns @ -34dBc
2 times reflection between level 3-4	30ns @ -20dBc	2 times reflection between level 3-4	30ns @ -32dBc
Level 4 all open 2 ports	50ns @ -32dBc	Level 4 all open 2 ports	50ns @ -32dBc
2 times reflection between level 4-5	30ns @ -20dBc	2 times reflection between level 4-5	30ns @ -32dBc
Level 5 all open 2 ports	50ns @ -30dBc	Level 5 all open 2 ports	50ns @ -30dBc
2 times reflection between level 5-6	30ns @ -20dBc	2 times reflection between level 5-6	30ns @ -32dBc
Level 6 all open 1 port	50ns @ -22dBc	Level 6 all open 1 port	50ns @ -22dBc

"4 branches connected in series" structure multiple paths-relative delay and power



The above and below table both ignore cable loss and component delay

Component reflection loss 10dB Reflection Description	CBAT sending Downstream	Component reflection loss 16dB Reflection Description	One home at 5th level sending Upstream(6 levels)
4 distribution-branch 2 times reflection	5 ns @ -20dBc	4 distribution-branch 2 times reflection	5 ns @ -32dBc
Level 1 all open 2 ports	80ns @ -36dBc	Level 1 all open 2 ports	80ns @ -36dBc
Level 2 all open 2 ports	50ns @ -36dBc	Level 2 all open 2 ports	50ns @ -36dBc
2 times reflection between level 2-4	60ns @ -20dBc	2 times reflection between level 2-4	60ns @ -32dBc
Level 3 all open 2 ports	80ns @ -32dBc	Level 3 all open 2 ports	80ns @ -32dBc
Level 4 all open 2 ports	50ns @ -32dBc	Level 4 all open 2 ports	50ns @ -32dBc
2 times reflection between level 4-5	30ns @ -20dBc	2 times reflection between level 4-5	30ns @ -32dBc
Level 5 all open 1 port	75ns @ -22dBc	Level 5 all open 1 port	75ns @ -22dBc

Some Questions

- Whether MAC needs to extend?
- EPON MAC efficiency is not high, EPON MAC is not the most suitable for Coax. EPoC is supported due to E2E concept and simple
- CMC (some propose to call “ECB” (EPON Coax Bridge) or “OCU” (Optical-Coax Unit)) is the specific ONU, which is not one terminal, only playing the role for forwarding data, so OLT management for it sure is different. It is not defined in EPON standard.
- CNU also is different from ONU (though we hope both is completely same), because all data is converted and forwarded via CMC, and CMC cooperates every time when CNU receives or sends data, CMC. That is, CNU and CMC work at the same time, and OLT must have both cooperate working. It also is not defined by EPON.
- “Only control fiber segment time allocation” also meets the requirement for “synchronously control 2 segments’? Especially the control time and delay on Coax generally are longer than on Fiber.

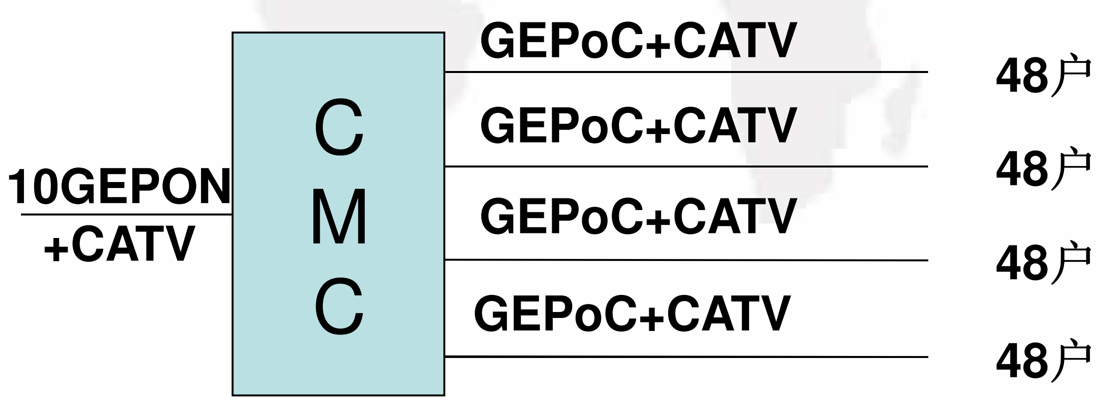
- Coax medium is far different from fiber. Anti-interference must be considered, so it makes its physical layer more complicated than fiber's, and the frame structure adapting to optical physical layer cannot adapt to coax PHY and needs to add predict frame, training sequence etc.
- Ranging and power control for 2 segments of fiber and coax obviously are different from pure fiber segment.
- If the rate levels of 2 segments are not consistent, it will bring to much more issues.
- How to solve these issues and implement E2E (OLT schedules and manage ONU and CNU in unified)?
- One of the solutions is to extend EPON MAC protocol, and on CMC (or OCU, or ECB, the name is not important), the frame format is converted, perhaps some predict frames are necessary to add, as well, data is stored and forwarded, but keep OLT control/management/scheduling for CNU.
- The 2nd solution is to extend EPON MAC protocol, and on OLT to modify MAC: via registration and discovery to distinguish ONU, CMC, and CNU, OLT implements the original basic MAC for ONU, to implement extended MAC for CNU. The extended MAC is completely suitable for Coax, so only PHY conversion is implemented on CMC. The key issue is whether OLT MAC extension is feasible? If feasible, it is the simplest and easiest solution.

- TDD or FDD？
- The spectrum for 10GEPON (bidirectional symmetric 10Gbps): 2×1GHz(4096QAM)/2×1.2GHz(1024QAM) physical frequency spectrum, how to plan? How to upgrade the rate per spectrum resource more?
- FDD is the simplest and most direct conversion, corresponding to wave division, is easier to process adjacent channel interference (similar volt level at the same direction), and has lower delay. However, FDD spectrum plan is more difficult, especially after frequency split point is fixed, it will not be easy to change in the future. The flexible spectrum configuration must directly sample the full spectrum (sum of US and DS), and implement variable filtering, so its complication, difficulty, and cost increase largely.
- FDD can implement bidirectional amplication, and improve distance adaptation. However, is amplifier upgrade with spectrum spread worthy?
- TDD can be relayed also, including RF relay.
- TDD MAC layer is different from EPON full duplex, but at static BW split (1:1 or 1:10), it has no nature difference, except that the operation BW increases by one time (US/DS 1:1) or 1/10 (US/DS1:10).

- TDD MAC layer is different from EPON full duplex, but at static BW split (1:1 or 1:10), it has no nature difference, except that the operation BW increases by one time (US/DS 1:1) or 1/10 (US/DS1:10). The adjacent channel interference is some difficult to process (transmitting crosstalk with receiving), but EPoC is the application with huge BW, in general, is not based on multiple channels. Only when the multiple branches (the later page) in the same channel (the freq is the same, the load is different) are used at the same time, transmitting crosstalk with receiving, but it can be solved by making the timing of different branches synchronous (receiving and transmitting at the same time). It can be achieved by using one clock.

The application with multiple branches at the same node in the same freq channel

- CATV Broadcasting Signal, different branches cannot crosstalk
- EPoC freq same but different signal, different branches have crosstalk
- This is China typical application scenario, which can largely save spectrum resource
- At beginning, one node can support 4 of 48 homes, then at the later time, one node support 4 of 12 homes.



谢谢！

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