Assignment 1

-u6826541 Yixi Rao

Q1

The reasons why the Last mile is an important issue in networking and communications are that families in the 21st century require high quality network which means that people are demanding a high speed and low delay network to satisfy their entertainment needs, so the 'last mile' problem must be solved properly to construct a reliable and robust network. Another reason is that as we are in the information era and increasingly focusing on IT area, more and more businesses profit from the high-speed network and some even require decent upstream speed to support their application, and also a good connection can reduce the operation capital because of the decrease of the maintenance fee. All of this will influence the layout or arrangement of the last mile delivery, we have to consider the capital and the efficiency.

The reasons why it is a complex issue are:
1. everything cost, the materials, equipment, labour and also the exchange cost make the balance between the cost and efficiency extremely complex in the 'last mile' problem, as we need to design an efficient and cheap topological structure with the limited budget

2. we have to consider the limitation of the transmission media, all the media are imperfect due to their characteristic such as coppers have attenuation and loss because of the noise and the resistance, fibers have mode distortion and it is hard to change direction. All of this limitation increases the complexity of the problem as we want to guarantee the bandwidth and the speed to the end-users.

3. as the optical fiber commonly used in worldwide communication and networking, the replacement progress that replace the old copper landline phone cable to the fiber cable is very hard to implement, and the old copper cable is proved that is not enough to satisfy the requirement of the end-users, what makes it complex is that upgrading is expensive and it is huge progress which will affect the families near it, as well as we have to decide which segments should be changed due to the limited budget, the distance will determine the efficiency and the families it covers.

Q2

The main, typical, options for delivering Last Mile networks in Australia are the FTTx, Fixed wireless, Satellite, and the HFC.

1. Using the FTTx approaches. The widely use of FTTx approaches in Australia is the FTTN, the analysis said that the FTTN built by the NBN had already covered 98% of the Australian families or premises. In some of the dense city like Sydney and

Melbourne, the FTTB is used, it is similar to the FTTN, except the node is in the communication room of the building or the basement. The FTTN will keep what is already in the ground/on the poles and will set the cabinet less than 300m far from the premises. FTTP is another main approach for delivering Last Mile networks in the undeveloped land, and FTTP is the future tendency in au as it provides high speed, low maintain fee and can avoid attenuation. The GPON is widely used by using the FTTP in Australia. The FTTC is connecting the fiber to the curb in the street, it is used when the fiber cable is close to the families or business. The majority of the HFC was replaced by FTTC in 2017.

2. using the Fixed wireless. It is common to deploy it in the rural area, and this requires the families in rural area to install an antenna in the roof of the house which can receive the data from the tower, the tower uses the A 4G LTE fixed wireless network to cover 500,000 families in the rural area.

3. The satellite communication. In order to transmit the signal to the island or some area where the fiber cable cannot cover in Australia, the NBN built and launched two geostationary satellite to space which is the Sky Muster satellite, each satellite offers eighty gigabits per second of bandwidth. So, the premises on the ground are required to install a satellite dish, which can send data to the satellite then the satellite sends back to someplace to deal with the data.

Q3

Some typical Last mile networks use the copper wire to transfer signal, like the xDSL…the inherent limitation of copper is the resistance which will cause heat and that will lead to insertion loss, eventually cause the signal loss and influence the data-rate. The resistance is related to the length and cross-section of the material, even with the frequency which will cause the skin-effect. Another attenuation is the noise, one characteristic of the copper is it will act as an antenna to receive and transmit other signals, this will lead to Electro-Magnetic Interference and Radio-Frequency Interference which will slow the speed. The cross-talk is another physical limitation on data-rate, as in the last mile network, it is inevitable to have neighbor adjacent cables, that will affect each other and lose some data. Copper is a metal, it will rust and oxidize after a long period, it will damage the cable and lose speed, it even loses the ability to transmit the data in the worst case.

FTTx approach uses fiber. Fiber consists of glass and some impurities, attenuation will happen because of the Inherent absorption of the glass and the impurity, the impurity will absorb the light and transfer it to the heat. Another attenuation is the Scattering, this is because of the heterogeneity of the material structure and will let the Index of refraction change that will Causes scattering of transmitted light. This limitation is inherent and cannot be avoided. Chromatic dispersion is another loss in fiber that is caused by the own characteristic of the fiber material, as the index of refraction of the

glass will differ according to the wavelength.

Wireless is another typical last mile network. The limitations are that the gases, vapours, dust, pollution are hard to avoid in the air, all of them will absorb the signals, as well as the noise which can be extraneous noise from outside. Another limitation is the Reflection, refraction, diffraction caused by the Temperature differences and Turbulence. When the signal penetrates some medium, it will be absorbed and attenuated which slow the speed a lot. In the last mile network, wireless transmission tower will have coverage and in the edge of the coverage, the data-rate is very slow because of the characteristic that is the long-distance then low frequency.

Q4

(a)
using the typical FTTN technology, the deployment is in figure 1, where the red dot represents the cabinet, it needs 86 cabinets. And it using the VDSL2 technology to reach the maximum speed is 100Mb/s download and 100Mb/s upload but this also has a limitation that its maximum distance to transmit at this speed is 400m, and that is why it needs so many cabinets. In the first ring, each ring segment has 588m, so the cabinet is set in the cross-road which can cover the left side and the right side, the maximum distance to a family is 521m so it will lose some speed but the 50Mb/s down and up requirement still holds. In the second ring, the average distance between two houses is 253m, so the cabinet can be set in the middle of the houses. In the third and fourth ring, the average distance is 471m so we have to let one cabinet serves for two houses, noticed that this is two touching concentric circles of roads, I decide to let one cabinet to serves four families at the junction of two circles. Except for the distance limitation I mentioned above, another limitation is that families are actually sharing the network with their neighbors, speed will be slow in the peak time, and the thing getting worst for the first ring families because one family have to share the network with others 7 people. Limitation about data-rate mentioned above in Q3. The capital and operating cost are not too bad. This is because the copper is cheap and we have the POTS so we do not need to trench the ground to install copper cable, the majority of the capital and operating cost is the fiber installation. If we want to run the network for the next 30 years, the maintenance cost is very huge, because we have 86 cabinet, we should often need to maintain it and even hire people to manage it, so extra capital for the management, labor and electricity is needed.

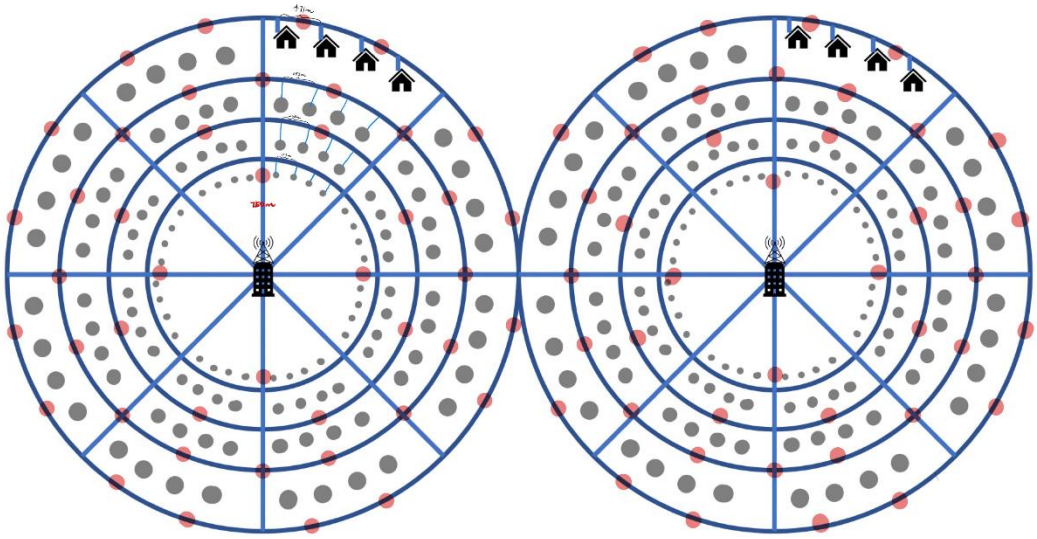

Figure 1

Using the FTTP technology, and the GPON. The deployment is in figure 2, and each red dot represents an ODN, and the yellow line represents the connection to the families, the ODNs can split into 16 ONTS, and one ODN can cover the two rings segment. The theoretical speed is 2.488 Gb/s on the downstream, and 1.244 Gb/s on the upstream. The limitation is that it is very expensive because we are using the fiber, besides, the ODN must have a good quality in order to reduce the splitting attenuation assumed we use the WDM mode, also we have to consider the split ratio as the more splits, the more power loss and less achievable distance and this is why I decide to use the split ratio at 16. Another limitation is that it is hard to solve the breakdown because the whole path is connected by the fiber so we only can diagnose the problem by checking the whole line. When using the TDM mode, the speed will be shared with others ONTs in the peak time so the data-rate will be slow down. The capital and operating cost are Huge overhead because lots of equipment and fiber need to be installed, also the popular way of installing fiber is using the aerial fiber drop cable which is expensive and every family need to install the ONT that consumes electricity. However, the future maintenance capital is reduced because the ODN do not consume electricity and it is very robust.

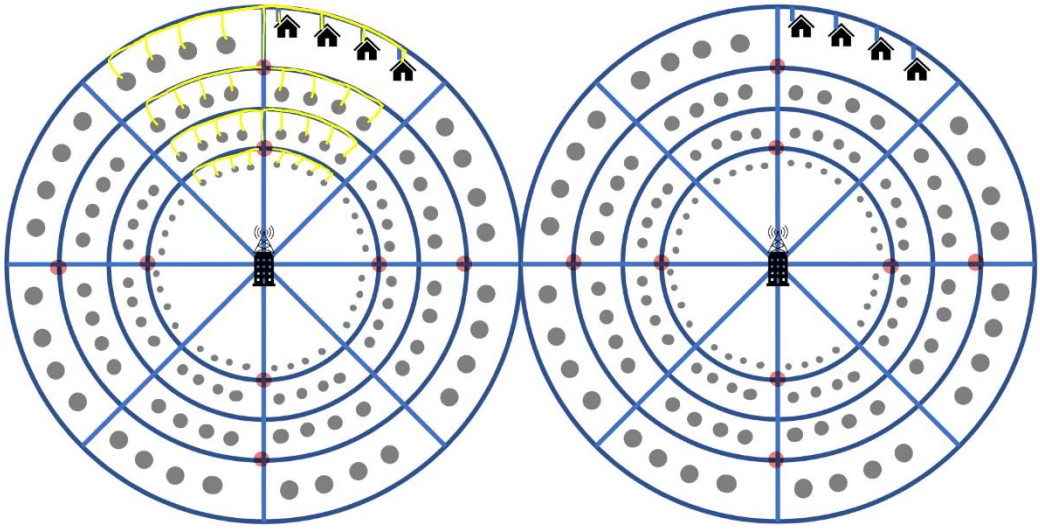

Figure 2

Using the HCF method. deployment is figure 3, the red dot represents the Fiber optic node, and the green dot represents the trunk amplifier or line amplifier, the yellow line represents the coaxial cable. The design is using two optic nodes to take care of the last ring families using the bus topology, one optic node for the third ring, and one node takes care of the first and the second ring. Coaxial cable is well protected so it has less attenuation than the twisted pair cable, so the farthest distance keeping the maximum speed is longer than UTP cable, namely, 5 times longer. That is why I decide to let the average distance between the two amplifiers be 800m. The HFC downstream speed is 1000Mbps and 50Mbps for upstream, this speed is for the situation where the one node serves for 500 families, and in our situation, it will be better because one node serves for 64 at most. The limitation is that it using the bus topology and tree topology which means everyone will share the speed on the trunk line and things getting worst in peek time, also every time the trunk branches, the bandwidth will narrow down. The connection of the HFC is also reported not reliable because of so many connections to the trunk line. HFC has a disadvantage in that it did worst when an outage happens, ACCC report said that HFC is the worst NBN fixed-lined technology when it comes to outages. Another limitation is that the cable is very thick, and it is hard to aggregate more coax into one cable because the coax cable is wrapped by a very thick Dielectric. The capital and operating cost are more than the FTTN because it does not use the existing copper wire (POTS), it needs to buy a new coax cable that is more expensive than the UTP. The trunk line of the HFC can carry AC power which can provide electricity to the optic nodes and the amplifiers, so we do not need to install an extra individual power source, which saves some money. However, the future maintenance cost is expensive, there is lots of amplifiers and optic node need to be maintained regularly, and also the total coax cables are very long, which also need to repair and maintain in the future.

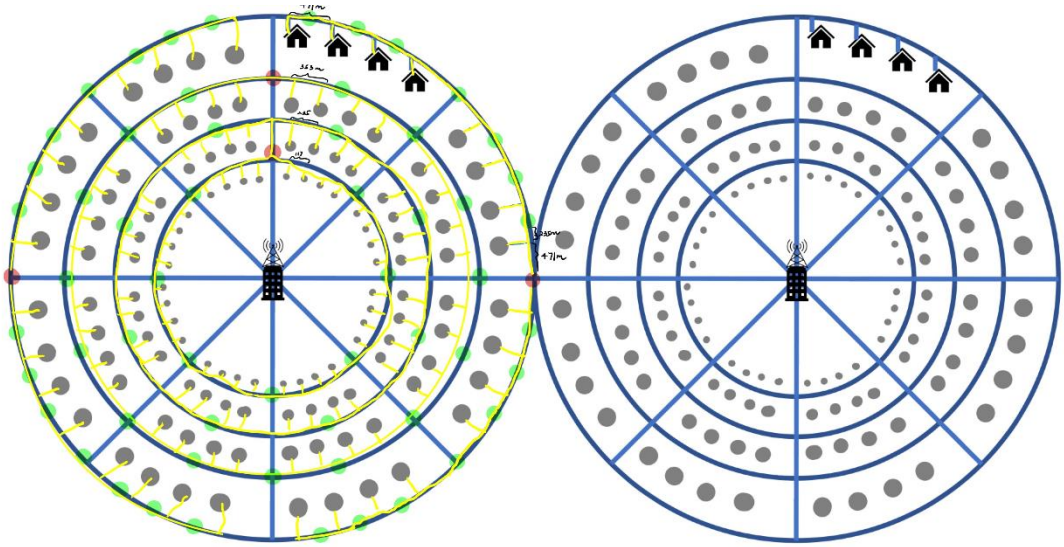

Figure 3

The advantage of using some reasonable off-the-shelf wireless options is that it does not need to install any cable, and this is quite helpful in some rural area without some phone line cable. Besides, the wireless methods have a low latency because signal travel faster in the air so it does better than the copper cable and Fixed wireless is much more reliable than the cable since we do not need to worry about the physical cable any more, it is also doing well in the peak time, every family will have less influence than the cable technology. The disadvantages of the fixed wireless method are it is not stable due to the weather conditions like rain, fog, snow will affect the signal, and the noise in your premise is also needed to consider because the signal and noise ratio will whether you will have the high speed, and the line of sight is also a problem, if the families are not in the line of sight of the tower, it will lose capacity and bandwidth while a copper cable will not have this kind of problem. At last, the upstream speed of fixed wireless is very bad, not like cable method which can guarantee to have at least 50 Mb/s, the wireless method developed recently like the NBN Fixed Wireless Plus will give a maximum speed 75/10Mbps or 60/20Mbps, it is very hard to reach the 50Mb/s upstream speed.

(b)

As the local Council is very supportive, so we do not need to consider the budget. The first recommendation is the pure FTTP – GPON deployment, the reasons why I recommend this are that using the pure fiber connection can guarantee the minimum strict requirement (50Mb/s down and up), and the special layout of the last ring families force the connection to have to be fiber because the average distance between families is 471m which is a quite long distance for copper cable to deal with without any repeater or amplifiers. Considering the future operating and maintenance cost, FTTP spends less money than the other deployment and it is very expensive to hire technicist to spend lots of time to go to this rural remote area. Besides, the fiber is very durable, and it is very robust therefore the fiber cable can be used for a long period, according to the

survey, Fiber optic material can last up to 40 years while copper-based lines need updating once every 5 years in order to remain operational.

My second recommendation is to use the Fixed 4G wireless network to cover the first and second ring families, and then using the FTTP – GPON to serve the third and fourth ring families, the deployment is in figure 4. The reason why I choose the 4G tower is that this rural area is in a circular ring layout and luckily the 4G tower is located in the center of the ring, and it can cover a lot of families. In order to guarantee the speed and quality of the network, the 4G tower only cover the first and second ring, others families will use the FTTP. The long distance to the third and fourth ring and the line of sight also limit the coverage of the tower. In such schema, the 4G speed can be the maximum upstream speed of 50Mbps and the Maximum downstream is 100Mbps.

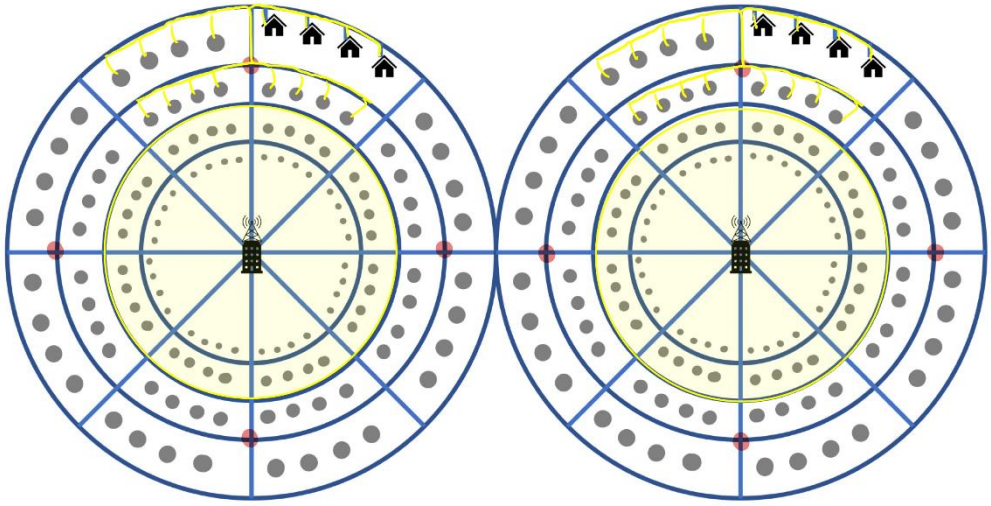

Figure 4

(c)

FTTN cost: total distance of fiber is 39460m, and total distance of copper is 29275m, so the total cost is 39460 * 10 + 29275 * 3 + 86 * 1000 + 500 * 256 = 696425$ with addition electricity cost for the cabinet and the installation cost, and labor cost, and future maintenance cost.

FTTP cost: total distance of fiber is 99264 + 256*50 = 112064m, the total cost is 112064 * 10 + 500 * 256 + 1000 * 16 = 1264640$ with extra 256 ONTs cost and labor cost to install fiber.

HFC cost: Total distance of coax cable is (4 * 750 + 3000 * 2) * 2 = 18000m, the total distance of fiber is 2 * Π * (750 + 1500 + 2250 + 3000) * 2 + 256*50 = 107000m, the total cost is 18000 * 10 + 107000 * 3 + 150 * 250 + 8 * 50 = 538900$ and extra cost is the optic node protection and electricity.

My second recommendation cost: total fiber distance is 77136m, the total cost is 77136 * 10 + 128 * 500 + 8 * 1000 + 20000 + 128 * 500 = 927360$, the operational cost is basically the electricity for the 4G power, and the fiber operational cost is equivalent to FTTP cost above.

Reference:

Q1: https://en.wikipedia.org/wiki/Last_mile
Q2: https://en.wikipedia.org/wiki/Telecommunications_in_Australia
Q2: https://www.dslreports.com/shownews/The-Challenge-of-the-Last-Mile-138492
Q2: https://en.wikipedia.org/wiki/National_Broadband_Network#2007
Q2: https://www.whistleout.com.au/
Q2: https://www.nbninformation.com/fttnvsfttp.html
Q2:https://www.lightwaveonline.com/fttx/article/16670533/gpon-at-full-speed-for-fttp
Q2&4: https://www.giga.net.uk/what-is-gpon/
Q2&4:https://marketing.pinecc.com/blog/bid/354191/gigabit-passive-optical-network-gpon-advantages-and-disadvantages
Q4 fixed wireless network speed: https://www.itnews.com.au/news/telstra-cuts-uplink-speeds-early-in-nbn-fixed-wireless-shift-531526 and https://www.bandwidthplace.com/fixed-wireless-internet/
Q4 HFC limitation: https://www.ciscopress.com/articles/article.asp?p=31276&seqNum=2
Q4 HFC: https://www.reviews.org/au/internet/hfc-nbn/
Q4 HFC: https://thenewdaily.com.au/life/tech/2020/03/11/hfc-outage-nbn-tpg/