Assignment 1

COMP6331 – COMPUTER NETWORKS

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Question 1: Why is the Last Mile an important issue in Communication Networking?

Answer: The Last Mile issue in Communication Networking relates to the problem of how to finally deliver connectivity to the end users using the last 20% of the overall network infrastructure [1]. Although this may seem a small portion, it can be the dominant cost of up to 80% of the overall network value [1]. Delivering connectivity to the end user is a serious design consideration because not two areas are same. A number of factors determine the cost of using a particular method of delivering reliable and efficient connection such as weather, terrain, technology available and accessibility to the area.

Question 2: What are the main typical options for delivering Last Mile networks in Australia?

Answer:

Currently Australia has different modes of telecommunication for delivering Last Mile networks. The first of these is using DSL which stands for Digital Subscriber Line. It uses the pair of copper cable that connects landline phones of many Australian homes. The DSL will be delivered to most homes as ADSL or VDSL which stand for Asymmetric Digital Subscriber Line and Very-high-bit-rate Digital Subscriber Line respectively. For ADSL, A DSLAM at the telephone exchange and an ADSL modem at the customer home connects the end of the copper cable. The modem modulates data that it needs to send over the copper cable and demodulates the receiving data for the local device. A DSLAM is however connected to copper cables coming from different customers and connects them to a high-speed connection. With ADSL, you can get speeds of up to 25Mb/s depending on how close to the telephone exchange you are.

VDSL is another Last Mile networking option in Australia and it has exceptional speed advantage over the ADSL. VDSL is also based on the same copper cables but uses more carrier frequencies to send data and therefore end users get higher bandwidth. VDSL2 uses frequencies up to 12 MHz. With VDSL and VDSL 2 one can get 52Mb/s and 200Mb/s respectively. The first 4000Hz are designated to the phone line and consecutive 4kHz frequencies are used as carriers for up and down communication.

Alternatives to copper also exist and government has also announced plans of improving the current telecommunication network due to increased speed demands by replacing the existing copper with fiberoptic. HFC, Hybrid Fibre Coaxial is one such option where a coaxial cable runs between the end user and a NBN node (A fiberoptic node) and a fiberoptic cable from that point onwards to a point of interconnect. Fiber-to-the-curb and fiber-to-the-node, FTTC and FTTN are new methods of solving the last mile issue in Australia.

Some wireless techniques of delivering Last Mile networks also exist. These use 3G and 4G cellular networks which give users a bandwidth ranging from 1Mb/s to 25Mb/s depending on the technology. To connect to these networks, one needs a 3G or a 4G compatible device. In a 3G/4G network, the geographical area is divided into hexagonal cells each of them being served by a radio base station [7]. The group of these radio base stations from a Radio Access Network which connects to the Core Network [7].

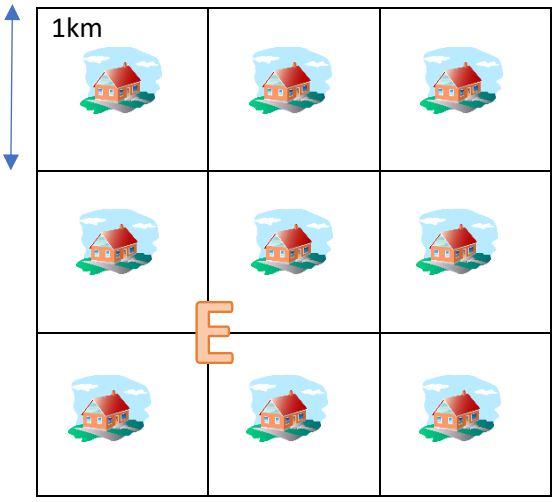
Question 3: Ignoring costs, what are the inherent (physical) limitations on data-rates across typical Last Mile networks?

Answer:

If the Last Mile solution being used is ADSL, one can expect to get a maximum of 24Mb/sec with ADSL 2+, depending on how far one is from the exchange. Bandwidth through ADSL are highly dependent on distance because signal to noise (SNR) worsens drastically after a few kilometers around 4km. It is for this reason that telephone companies prefer to keep the distances to end users less than or around 4km. ADSL also operates on frequencies to a maximum of 0.14MHz and theoretically this gives 41.4 Mb/s. VDSL 2 uses frequencies up to 12 MHz and thus provides more bandwidth for the end user. Fiberoptic gives the highest bandwidth as frequencies of 500 THz are possible. This can give bandwidth in excess of 1 Pb/s. However, electronics available today is not able to deliver at such high speeds and currently in Australia one can expect bandwidth of 1 Gb/s with NBN for FTTN. Fiber cable also comes in two forms which are single-mode and multi-mode. There is an attenuation of 0.4dB/km due to scattering and absorption depending on whether we are using SMF or MMF.

Question 4:

A variety of cabled and wireless methods are available to chose from to build a shared network for the rural community. There are 900 farms laid out in a grid fashion with each of them having a POTS connection that is at maximum 4 km away from the nearest exchange. The following figure depicts how a section of this grid will look like.



An exchange on the above diagram is depicted with E and there are several of these across the grid with each one of them equally spaced apart.

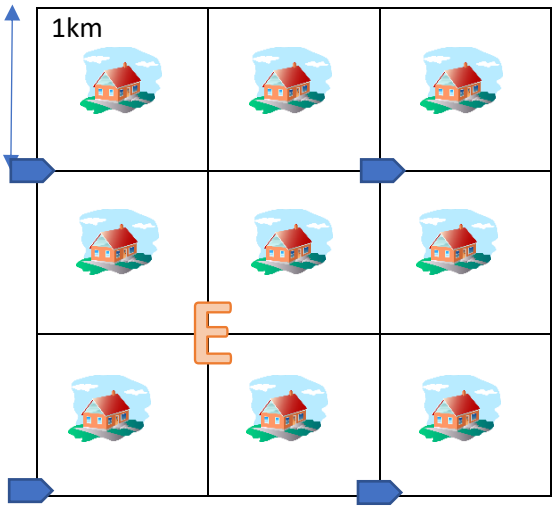
1. DSL technologies:

We cannot use any of the ADSL technologies because the maximum bandwidth that a farm may get is 24Mb/s. VDSL and VDSL 2 can provide bandwidth of 52Mb/s and 200Mb/s respectively and use the same copper cable. They would have been very good solutions, but their range is limited to a few 100 meters. VDSL2's performance quickly deteriorates, and its speed becomes comparable to ADSL2+ [6]. This can be overcome by using repeaters and extenders but will be a cost for all the 900 farms.

2. Fiber technologies:

There are several fiber technologies available in Australia to choose from as well. These are FTTH, FTTB, FTTC and FTTN. These are really a measure of how close to the end terminal of a fiber cable one's copper connection is. Fiber-to-the-home eliminates the use of copper cable and a fiber cable runs inside the home whereas Fiber-to-the-node has fiber cable ending in a metal box and copper cable being used from that point onwards to serve between 500-2000 homes.

FTTN would be the best approach to connect farms where a fiber cable would need to be installed from the exchange to a node that would then connect the houses in an area using the existing copper cable. The cost involved would be of installing nodes, each of which will cater a few nearest farms, and of putting down fiber optic cable from the nearest exchange to these nodes. There are many advantages that fiber cable has over copper cable too. Fiber cable used to be twice as expensive as copper cable but recently the difference has narrowed down [2]. Unlike copper it does not act as an antenna to EM waves and thus it has greater SNR for same distance. This means it can carry signals to more distances compared to copper cable. We could place the node between 4 farms and the layout of the grid that we will get will be as follows.



There are some considerations that would need to be kept in mind though with the fiber optic cable. The first of these is that the equipment that is to be installed at exchange to receive signals via fiberoptic cable and at nodes to send these signals may be expensive. Secondly, fiberoptic cable does not bend easily and terrain matters. We are dealing with a rural setting where plain area is mostly expected so this must not be an issue. Another consideration is if we want to use a SMF (Single-mode Fiber) or MMF (Multi-mode fiber) as they give different bandwidth and different ranges. Usually MMF is chosen if the distance that needs to be covered is within 3-5 miles [3]. 3 miles translate to around 4.8 km and if we take Manhattan distance from the exchange to on of the nodes, it comes out to be 2km. This is in an ideal situation, but we would still have a tolerance value of 2.8km for the fiber cable to be greater than 2km. MMF will also not need to be regenerated and amplified for this distance as the SNR would not have deteriorated that much after 2km. The transmission system cost of using an MMF are cheaper too compared to SMF. Transmission system for MMF would cost between $500 to $800 whereas for SMF it will cost $1000 [3].

3. Wireless technologies

4G coverage is available in the area and we can use off-the-shelf wireless options as well. No equipment is needed except for the transceiver that would connect to the 4G network. 4G networks are continuously evolving and can deliver very high data rates. The three top 4G network providers in Australia are Telstra, Optus and Vodafone and their standalone download speeds amount to 23.60Mbps, 19.18Mbps and 18.49Mbps respectively [4]. In the future though, speeds greater than 50 Mb/s can be expected [5]. Thus, it really depends if we have the 4G network that can deliver bandwidth of 50Mb/s or not. In this case, wireless will be the most cost-effective solution to connecting the 900 farms.

Wireless has some limitations though compared to physical media connectivity. The first of these is that if the network goes down, all farms will be denied connectivity. Copper and Fiber solutions provide us with a more distributive approach wherein if a node is damaged, only the connections to that node will be affected. Also, in the case of wireless, weather affects the quality of signals that a farm would get.

4. Conclusion

In the end we can conclude that the best option out of all is the use of FTTC where part of the existing copper cable telecommunication infrastructure is used with new fiber cable. The fiber cable would provide higher bandwidth, is not too expensive compared to copper cable per meter length and long lasting. The assumption here is that the nodes, each of which will connect to 4 farms are not very expensive compared to the cost of fiber cable.

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