Purchase List For 2.5 GHz LTE

1 or More eNodeBs:
The eNodeB is the main base station itself. These are somewhat interchangeable, and should run anywhere from $3-4K. The most important thing is to make sure the eNB transmits/receives in Band 41, which is the 2.5GHz band we've been talking about. Higher transmit power is generally better since you can usually program it to be less if you have to. I've generally had good success with Baicells. I usually buy their Nova-233 model but can't find it in 2.5GHz right now, recommend calling them for a quote.
Examples: https://www.ispsupplies.com/Baicells-NOVAR9-402-B41,
https://www.ispsupplies.com/Baicells-pBS11004,
https://www.ispsupplies.com/Airspan-HAR44-EF-U41-B06AP,
https://www.cambiumnetworks.com/products/cnranger/cnranger-rrh/.

Optional: 1 Antenna per eNB
More and more these days, eNodeBs come with their own integrated antennas. If not, you'll need to purchase an and attach it with an N-Type cable. Different antennas vary wildly in terms of how much they "focus" the signal, so I can't really give a recommendation without knowing the exact network context. Here's a list to get you started:
https://www.ispsupplies.com/products/3G-4G-LTE-CBRS/25-GHz-LTE-Systems/2-5GHZ-LTE-Antennas.

1 or More CPE Units:
The CPE (Consumer Premise Equipment) is the "other half" of the radio link and gets installed on each customer's house. Just like the eNodeB, the main thing to make sure of is that the CPE also works in Band 41. ispsupplies.com sells both "indoor" and "outdoor" CPE, but I generally prefer mounting units outdoor for better signal strength. It's always easiest to stick with the same equipment manufacturer as your eNB (this helps you get support if you hit an issue) but this is not strictly necessary; in my experience inter-brand compatibility in the LTE space is great. Just make sure you're both on the same band (Band 41, 2.5 GHz). Generally each CPE should cost approximately $100-200.
Examples include https://www.ispsupplies.com/Baicells-EG7035L-M1,
https://www.ispsupplies.com/Baicells-EG7035E-M1,
https://www.cambiumnetworks.com/products/cnranger/cnranger-sm/

1 SIM Card Per CPE:
Each CPE must have a SIM card inserted in order to connect to the LTE network. You can buy SIM cards a couple of places online, and most eNB manufacturers will also give/sell you some when you buy an eNB. Prices here vary dramatically but generally hang out around $4 or 5 per SIM if you're buying individuals. If you buy in bulk (1,000 or more) on alibaba you can get prices much lower, down to 50 cents/SIM, but you will likely need someone to help you with the order. Reach out to Althea or Spencer if you're interested in this.

Examples:
https://www.smartjac.biz/mobile-telecom/test-uicc-sim-cards/4g-lte-sim-cards/4g-open-multipurpose-uicc-card-2ff,
https://www.ispsupplies.com/Airspan-MySIM-EGF-SIM-T0,
https://www.alibaba.com/product-detail/Professional-LTE-USIM-Test-Card-TD_60075863536.html

1 EPC:
The EPC, also known as the "core network", refers to all the software you need to control and manage your entire LTE network. You have two basic options for your EPC: you can buy a subscription to a cloud-based one, or you can run your own.

Cloud Based EPCs:
There are many vendors (BaiCells, Cambium, Microsoft, Facebook) that sell a cloud-based EPC. These typically cost somewhere around **$1-5 per month per CPE**. In the case of hardware vendors like BaiCells and Cambium, I believe they create a vendor lock-in situation where the EPC will only work with equipment bought from that same manufacturer. The main trade-off with a cloud EPC is that it's much more reliable and you have someone to call if things break, but the downside is the monthly subscription fee, which can add up pretty quickly.

Running Your Own:
There are a couple of open-source EPCs, such as open5gs and CoLTE, that you can download and use yourself. These EPCs are quite stable by now, and I believe using an open-source EPC is a pretty good idea. This approach will take a little bit of work to setup, and will require you to have a computer on-site to run the software, but it gives you much more control and ownership over your network traffic and data. It's also the way to go if you want to run equipment from multiple vendors, or if you're worried about any of these companies changing their deals on you.

To run your own EPC, you'll want to buy a dedicated computer, but it can run on basically any mini-PC, from a Raspberry Pi to a laptop to whatever you want. Ideally, you'll want a computer with at least two ethernet ports, but up to 4 would even be best. Don't worry about processing power or storage or RAM, even the cheapest computer can handle everything easily. If you can buy a pc without a Windows license, great - it'll save you some cash.

Examples include https://www.raspberrypi.org/products/raspberry-pi-4-model-b/, https://www.amazon.com/T4-x5-Z8500-Processor-Computer-Ethernet/dp/B0899JKPRD/ref=sr_1_1_sspa?dchild=1&keywords=mini+pc&qid=1605813305&sr=8-1-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUFFVIJHNk9KTVhBUkkmZW5jcnlwdGVkSWQ9QTA3MDI4NjE1M1VaOFI3NzdSQVVkmZW5jcnlwdGVkQWRJZD1BMDYzMjMwNjNEOFpVNUlPNU1PT1omd2lkZ2V0TmFtZT1zcF9hdGYmYWN0aW9uPWNsaWNrUmVkaXJlY3QmZG9Ob3RMb2dDbGljaz10cnVl, https://www.amazon.com/CHUWI-Gemini-Lake-Quad-Core-processor-Expandable/dp/B082VZP76P/ref=sr_1_2_sspa?dchild=1&keywords=mini+pc&qid=1605813305&sr=8-2-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUFFVIJHNk9KTVhBUkkmZW5jcnlwdGVkSWQ9QTA3MDI4NjE1M1VaOFI3NzdSQVVkmZW5jcnlwdGVkQWRJZD1BMDUxNTUzNDNMQzVHTjVNMzZBUIY

md2lkZ2V0TmFtZT1zcF9hdGYmYWN0aW9uPWNsaWNrUmVkaXJlY3QmZG9Ob3RMb2dDbGl
jaz10cnVl,
https://www.amazon.com/Gemini-Celeron-N4100-Processor-2-4GHz/dp/B07FTG1RH8/ref=sxin
_10_ac_d_pm?ac_md=1-0-VW5kZXIgJDEwMA%3D%3D-ac_d_pm&cv_ct_cx=mini+pc&dchild=
1&keywords=mini+pc&pd_rd_i=B07FTG1RH8&pd_rd_r=ab87703d-7c55-46de-b389-7989c3c05
f5d&pd_rd_w=rp8u5&pd_rd_wg=qJT7e&pf_rd_p=68f25c26-6854-442e-9296-f746545e76bb&pf
_rd_r=N5D38WCEX5XCH8B8NKYX&psc=1&qid=1605813305&sr=1-1-22d05c05-1231-4126-b7
c4-3e7a9c0027d0.

Other Approaches:
I recently learned of the "cnRanger" product line put out by Cambium Networks. They sell an
eNodeB that comes with an embedded EPC built in for $15,000 USD. I have not heard good
things about this product line and do not recommend it; I include them mainly for completeness.
https://www.cambiumnetworks.com/products/cnranger/

Setup/Quickstart Guide

This section is intended to be a quick "getting started" guide once you've purchased all your
equipment. In this section, I'm going to focus on the necessary software configuration, **not**
things like hardware/antenna mounting. I recommend setting things up in the following order.

Setup the EPC:
No matter what EPC you use (cloud-based or open source), you will have to configure a handful
of settings for your network:
- PLMN: This value is a 5-digit number that uniquely identifies your network. For this type
  of work, you can set it to whatever you want.
- MME or S1AP IP address: You may have to set this to the IP address of your EPC, to
  make sure that it is listening on the correct port/address.
- SGW/GTP IP address: The same as above. Both of these values should be the same IP
  address/network interface.
- General network configuration: Make sure that the IP addresses are up on the correct
  interfaces, make sure that this interface is the correct one that you're connecting to the
  eNB. I've seen lots of debugging boil down to this exact problem.
If you're using a cloud EPC, it should already be running and reboot itself as needed. If you're
using open5gs, you'll have to reboot the EPC yourself after changing any of these settings.1

Connect the eNodeB:
Often times, it makes the most sense to configure your eNB and get it connected to the EPC
before you mount it up on a tower or pole. As a big important note here: Make sure you have
attenuators or antennas or something attached to your eNB's antenna ports before you turn it
on! Otherwise, if they're just wide-open, you can severely damage the unit.

Usually, you can access the eNB using a web interface - plug your laptop into it using an
ethernet port, then navigate to the address of the eNB in your browser. Usually 192.168.0.1 or

something similar. Once you're in, the main configurations you'll have to set/change are as follows:
- PLMN: This has to match the value you put in the EPC
- MME IP address: set this to the IP address of the EPC
- Also, check any network configuration settings to make sure they're correct and make sense. For example, if the eNB's default IP address is something like 1.2.3.4, you'll probably want to change that to something that makes sense in your network. Remember that all you need is for the eNB to have an IP address that the EPC can reach it on, and vice-versa.

Once you've configured the eNB correctly, plug it into the EPC and turn it on. After it boots up (can take as long as 10-20 minutes in some cases), you should see it exchange a couple of messages with the EPC, and (ideally) the EPC's logs should show that there is now one eNB attached. Once you reach a state like this, congratulations! You can now turn everything off and start mounting the eNB.

Add Users:
Once you've connected the EPC and eNB successfully, you need to add an account for each user you want to connect. All the EPC Web interfaces will provide some way for you to do this, the big thing you need to understand is that users are identified via their SIM card. For any given SIM card, you'll need to know (and enter into the EPC) the following information:
- The IMSI is a 15-digit number that uniquely identifies the SIM card. It's often printed directly on the SIM, so that you know which one is which. Pro-tip, the first five digits of the IMSI should be the same as your network's PLMN identity.
- Each SIM card has a special KI, also known as the user's secret key. The SIM card vendor should have given this to you in a table or list or something.
- Each SIM card is also configured with a second key, known as OP. This is the network operator's key, and should be the same for each SIM in your network.

Connect A CPE:
Setting up a CPE should be relatively simple and straightforward. Right out of the box, you'll need to open it up and install a SIM card. Make sure it's the right one for the right customer, since this is how you're keeping track of them! Once you've installed the SIM card, you should simply be able to mount the CPE facing the eNB, power it on, and connect to the Internet!

One final word on CPEs: Some broadcast a local WiFi signal (so that you can get onto the Internet), whereas others don't. If your CPE doesn't make a WiFi signal, or if it's too weak to reach where you want, that's fine! You should be able to plug in an ethernet cable to the "LAN" port of your CPE, plug the other end of the cable into the "WAN" port of another WiFi router, and then get signal from that router. This is a very very common thing to do.