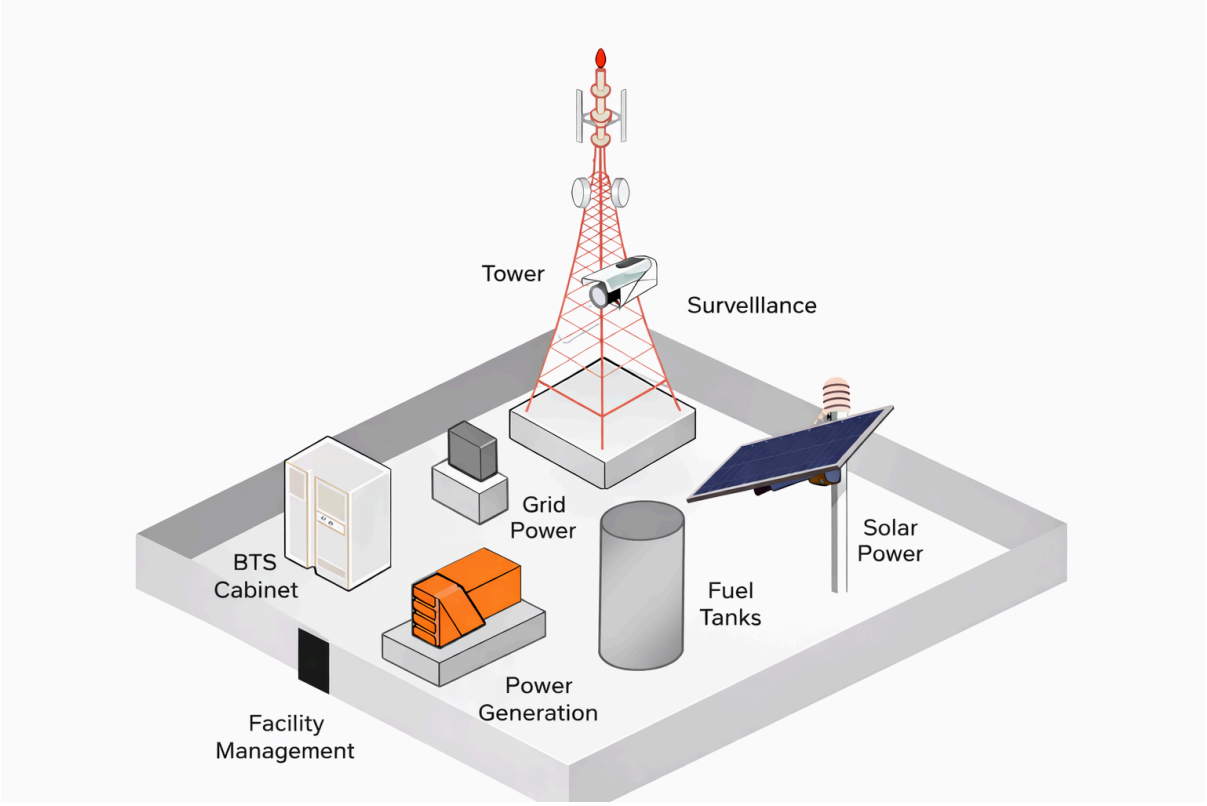
Mobile Networks

A **mobile network** is a wireless communication system that allows users of devices such as mobile phones, smartphones, tablets, and other mobile devices to connect to one another and to the rest of the world through radio signals.

Mobile networks are built using a combination of communication infrastructures.

A fundamental component of a mobile network is the **base transceiver station**, commonly referred to as a **BTS**. A BTS includes the equipment used to transmit and receive radio signals.

Its antennas may be installed on towers, masts, building rooftops, or other physical structures.



The following steps take place when a packet is sent from a device:

- The device converts digital data into radio signals, which are transmitted through its built-in antenna.
- These radio waves allow data—such as voice, text, or images—to travel through the air without cables.
- The data is received by an antenna on a mobile tower, which converts the radio waves into electrical signals.

- These electrical signals are then carried through the network, often using underground fibre-optic cables.
- The data enters the mobile operator's network, which routes it towards its destination.
- In the case of a telephone call, the audio data is sent to the base station closest to the person we are speaking to. From there, it is transmitted through radio waves to the correct smartphone.
- When accessing a website, the request travels through the Internet using the network structures described previously. The response then returns to the device through the operator's network and the base station to which it is connected.

This infrastructure allows mobile users to make calls, send messages, browse the Internet, and use a variety of online services wherever mobile network coverage is available.

But how does mobile coverage work?

The geographical area covered by a mobile network is divided into smaller areas called **cells**.

A cell is the geographical area served by a base station, meaning a collection of equipment and antennas that communicates through radio signals with the mobile devices located within that area.

It is important to distinguish between a physical tower and the network of an individual mobile operator.

A tower is the physical structure on which the antennas and equipment of one or more mobile operators may be installed. However, not every operator is necessarily present on the same tower.

For example, a tower may contain WindTre antennas and equipment but no Vodafone equipment. In that area, a WindTre user may therefore have coverage, while a Vodafone user may have no coverage or a weaker signal because their device must connect to a more distant Vodafone cell.

As a smartphone moves, it can gradually pass from one cell to another. This process allows communication to continue while the user is moving, for example while walking, travelling by car, or riding on a train.

When no cell belonging to the user's operator is available in a particular area, the smartphone searches for another cell operated by the same company, even if it is farther away.

When no usable cell can be found, the phone may display **No Service**, although emergency calls may still be possible through available networks.

In general, a device attempts to connect to the cell from which it receives the best signal, which is often one of the nearest cells.

However, the choice does not depend only on distance. Other factors include:

- signal quality;
- physical obstacles;
- the frequencies being used;
- network congestion;
- the operator’s network configuration.

The **signal bars** displayed on a smartphone provide a simplified indication of the quality or strength of the radio connection to the mobile network.

Mobile coverage therefore depends on the presence of towers in the area, the operators using those sites, the available frequencies, physical obstacles, and the configuration of the network.

Each antenna operated by a mobile network provider uses one or more radio **frequency bands**, meaning specific ranges of frequencies, to transmit and receive signals.

Radio frequency bands are assigned and regulated by the relevant public authorities to prevent interference between services and operators.

Users’ devices must also support the frequency bands used by their operator. Otherwise, they cannot connect to the network.

Under normal conditions, a phone containing a SIM card from a particular operator connects to that operator’s network.

However, it may also connect to other networks when **roaming agreements** exist. These are commercial and technical agreements between mobile operators and are commonly used when travelling abroad or in other specific circumstances.

As a result, within the same geographical area, a Vodafone user may have better coverage than a TIM user if there are more Vodafone cells or if Vodafone's network is configured more effectively.

Internationally standardised rules and protocols are used so that mobile phones produced by different manufacturers and transmitters operated by different providers can communicate with one another correctly.

Mobile networks have developed through several generations of standards, including **2G, 3G, 4G, and 5G**. At present, 5G is one of the most recent and advanced mobile network generations.

The main features of 5G include:

- **High speeds:** 5G can provide significantly faster download and upload speeds than 4G. This supports rapid downloads of large files, high-resolution video streaming, and other activities that require substantial bandwidth.
- **Low latency:** Latency is the delay between sending and receiving data. 5G aims to reduce latency to extremely low levels, enabling almost instantaneous communication. This is important for real-time applications such as online gaming, virtual reality, augmented reality, and communication between Internet of Things devices.
- **Greater capacity:** Through advanced modulation techniques and the use of wider portions of the radio spectrum, 5G can support a much larger number of devices connected at the same time.
- **Stable connections while moving:** 5G is designed to maintain a stable connection even when users are moving at high speeds, such as when travelling by car or on a high-speed train.
- **Support for advanced applications:** 5G is seen as an enabling technology for new services and applications, including autonomous vehicles, telemedicine, industrial automation, smart cities, and many others.

5G can use different frequency bands. Lower and mid-range frequencies generally provide wider coverage, while higher frequencies, such as **millimetre waves**, can offer very high performance but cover a more limited area.

To compensate for these limitations, 5G may require a higher density of base stations. This results in a larger number of smaller and more closely spaced cells, helping to provide adequate coverage and high performance, particularly in urban areas.