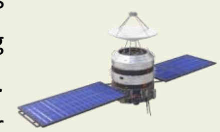
QUESTION/

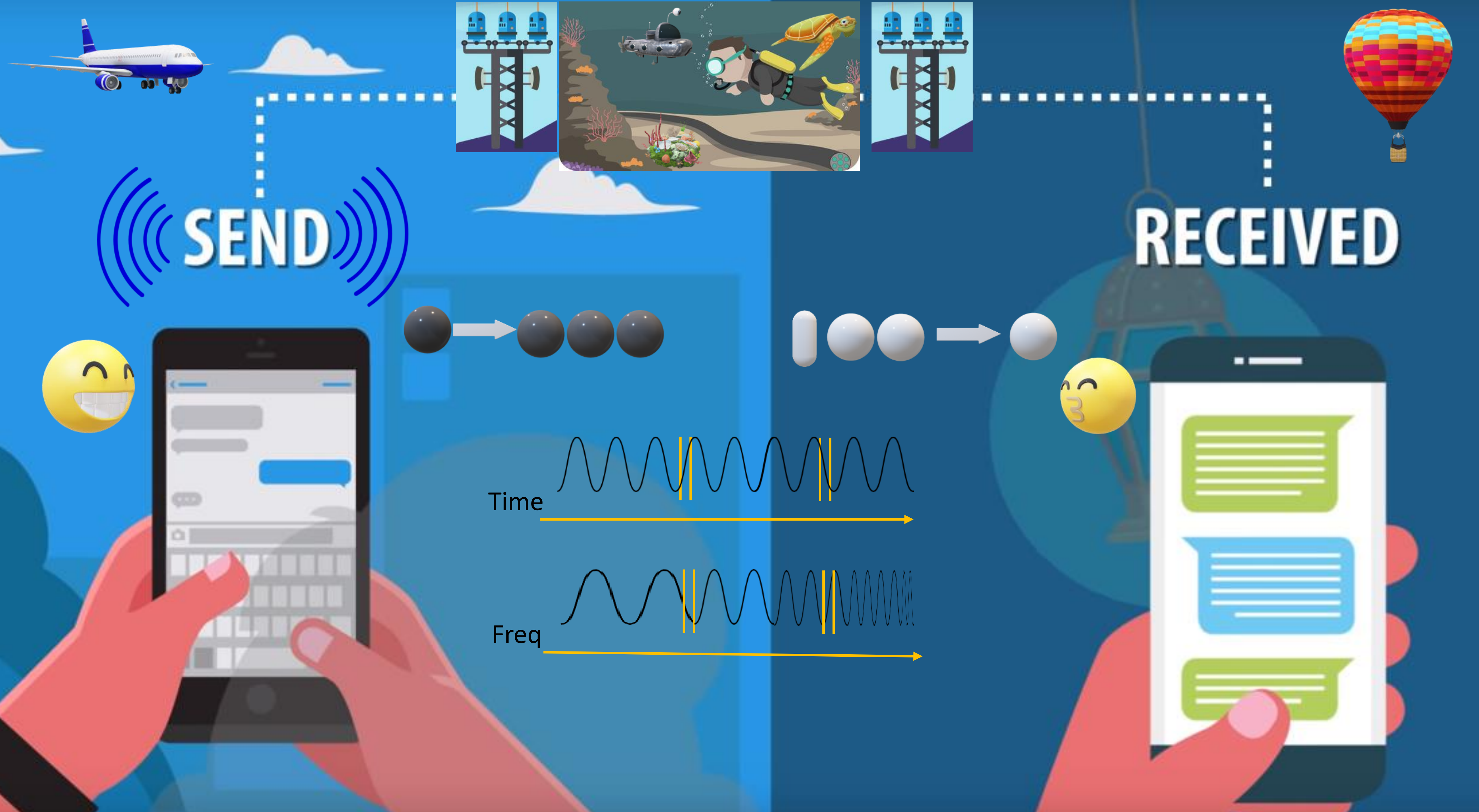
What Happens When You Send Information Wirelessly

What really happens when you text your friends across the ocean, and they get your message, almost instantaneously, without error? At the moment you press the “send” button on your messaging app, you actually send instructions to your mobile processor, which first encodes your message into a careful designed electron flow. Your phone then converts the electron flows in the circuit board to radio waves in the invisible part of the wave spectrum, using a device called an antenna. These waves fly away into the air at light speed towards the cell tower. Unlike visible light, these waves can bend around corners or pass through walls. However, how does your phone know where the cell tower is? Actually, it doesn’t know, and it doesn’t need to know. Your phone simply broadcasts these waves in all directions. The receiving antenna on the cell tower detect these waves on its conducting surface, which are then decoded by the hardware at the cell tower. Your decoded information is then carried by high-throughput cables, called submarine communication cables, across the ocean towards a cell tower near your friend. The transmission from the cell tower to your friend’s phone is again a wireless jump. Finally, your friend hears the familiar ping sound. However, there are a couple of questions during the process. How does the cell tower know that the message is from you? How can the cell tower decode your message when there are various obstacles between you and the cell tower? To differentiate messages from different users, the phones all agree on a protocol to talk to the cell tower at either different times (called Time-division multiple access, used in 2G), different frequencies (called Frequency-division multiple access, used in 2G), or using different codes (called Code-division multiple access, used in 3G). More advanced algorithms, such as orthogonal/non-orthogonal frequency-division (OFDMA/NOMA), are developed in 4G and 5G. To overcome the side effects of the channel, e.g., noise, randomness and interference, we need to carefully design what we transmit. This is where “channel coding” comes into play. The core idea of channel coding is to add redundancy (extra information). One simple solution is to repeat your message several times, such as encode $0 \rightarrow 000$, and the cell tower will make a majority vote based on the received bits. Say 001 is received, the cell tower will then decode it to $001 \rightarrow 0$. This is known as the simplest channel code – repetition code. Of course, there are more powerful and intelligent channel codes, such as turbo code, LDPC code and polar code, which are the current research focus and candidates in future communication generations.



Written By
Yuxin Liu
PhD Student
California Institute of Technology

Caltech



References: 1. https://disruptive.asia/submarine-cable-most-direct-australia-china/ 2. https://caymanconnected.ky/blog/submarine-cables-faq 3. Microsoft built-in icons