China Communications

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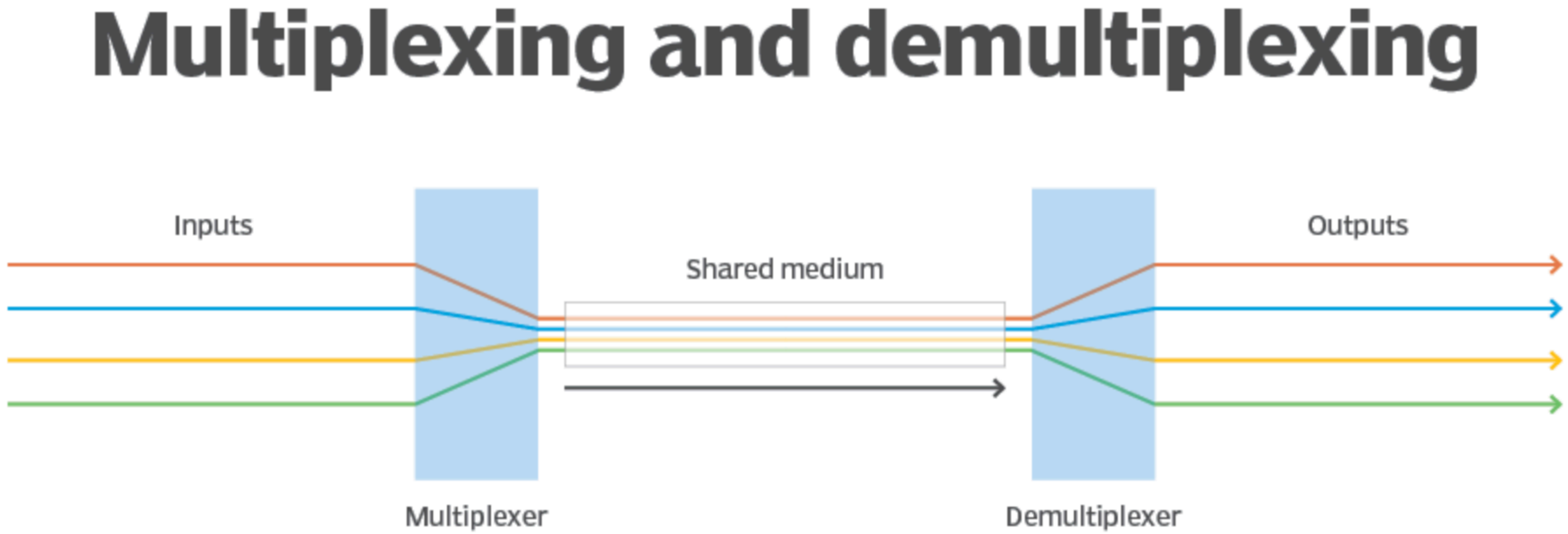
Chapter 4:
Cellular Networks

Overview of Cellular Networks

Wireless Link

- Electromagnetic waves are used to carry information.
  - The frequency is the key!
- Radio propagation:
  - Multi-path, fade, interference
  - Received power is inversely proportional to the distance
- Spectrum are divided into multiple channels.

Multiplexing



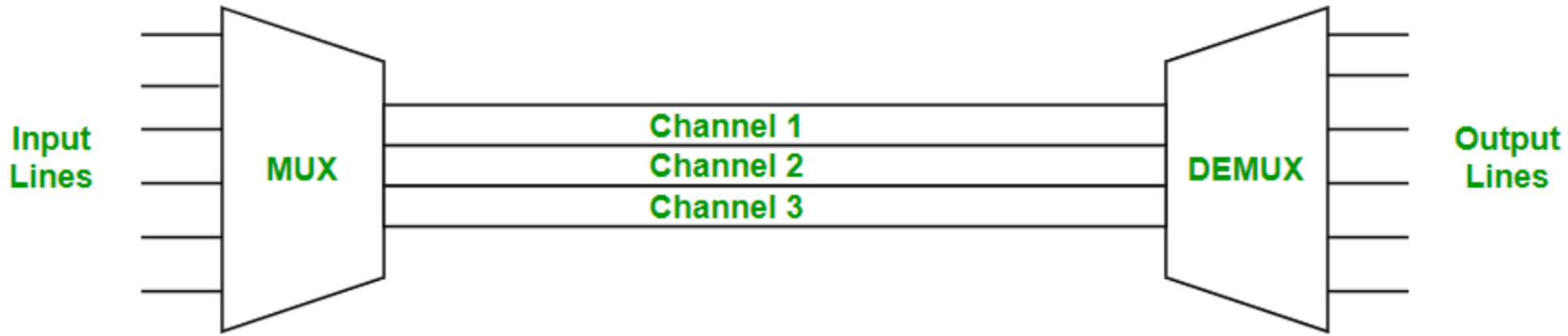
- Multiplexing, or muxing, is a way of sending multiple signals or streams of information over a communications link at the same time in the form of a single, complex signal.
- When the signal reaches its destination, a process called demultiplexing, or demuxing, recovers the separate signals and outputs them to individual lines.

Types of Multiplexing

- Frequency-division multiplexing (FDM)
- Time-division multiplexing (TDM)
- Code-division multiplexing (CDM)
- …

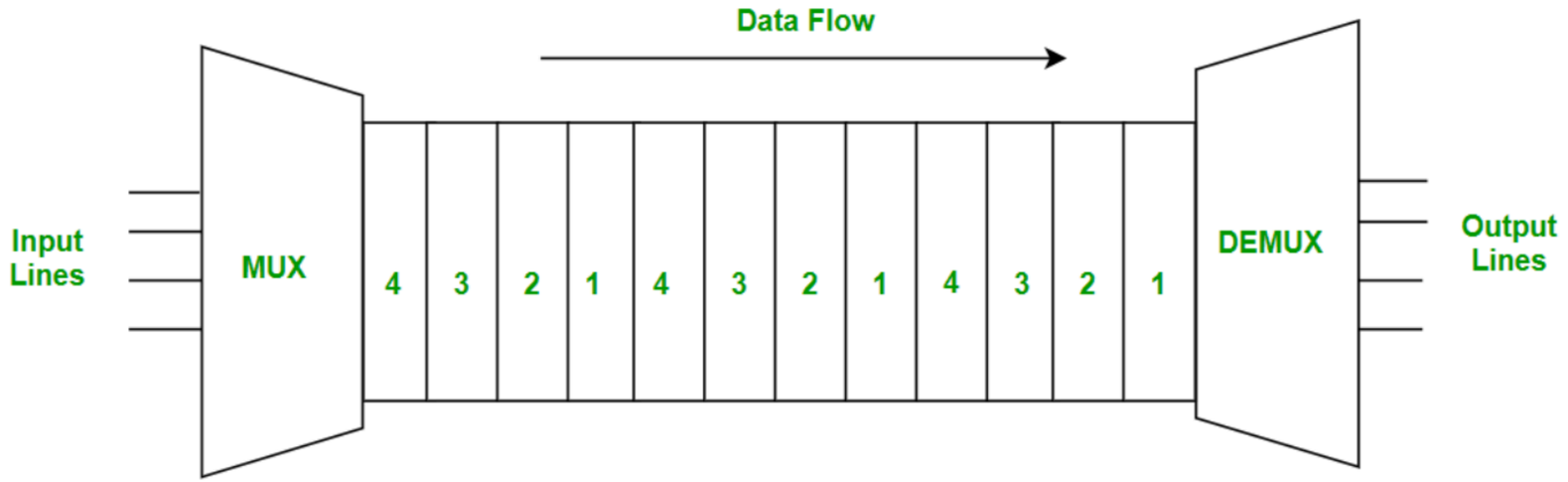
Types of Multiplexing

- Frequency-division multiplexing (FDM)
  - bandwidth of a single physical medium is divided into a number of smaller, independent frequency channels



Types of Multiplexing

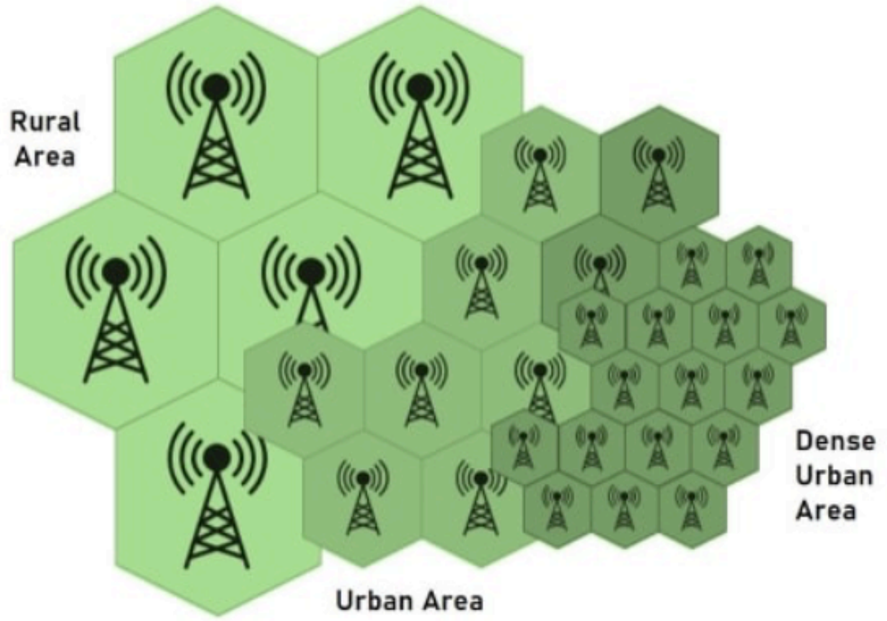
- Time-division multiplexing (TDM)
  - time is shared, each connection occupies a portion of time in the link.



Introduction to Cellular Networks

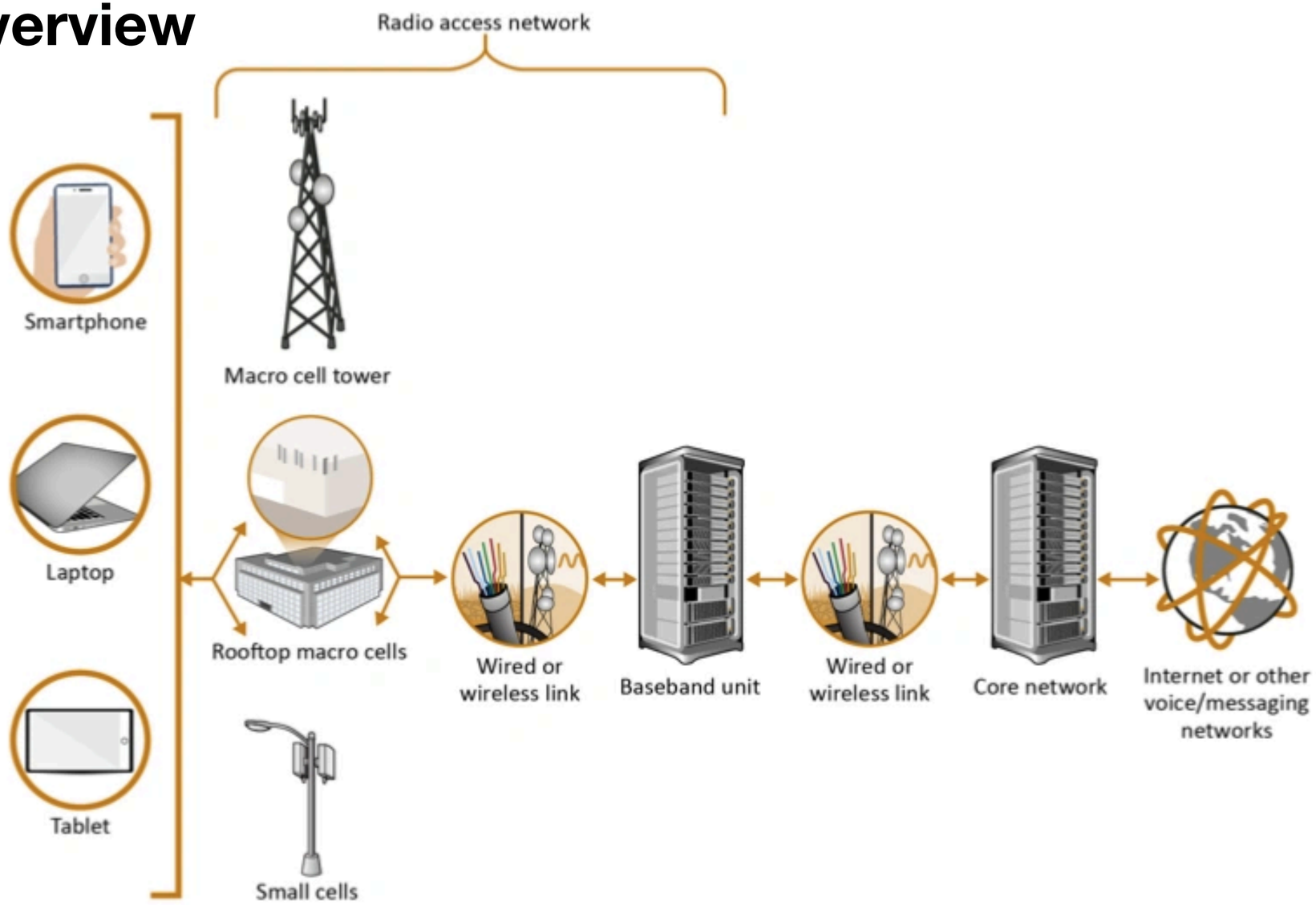
What are cellular networks

- Cellular networks enable wireless communication over large geographic areas
- Cells: A land area to be supplied with radio service is divided into cells
- Each of these cells:
  - has multiple frequencies
  - supported by radio base stations



Cellular Networks

System overview



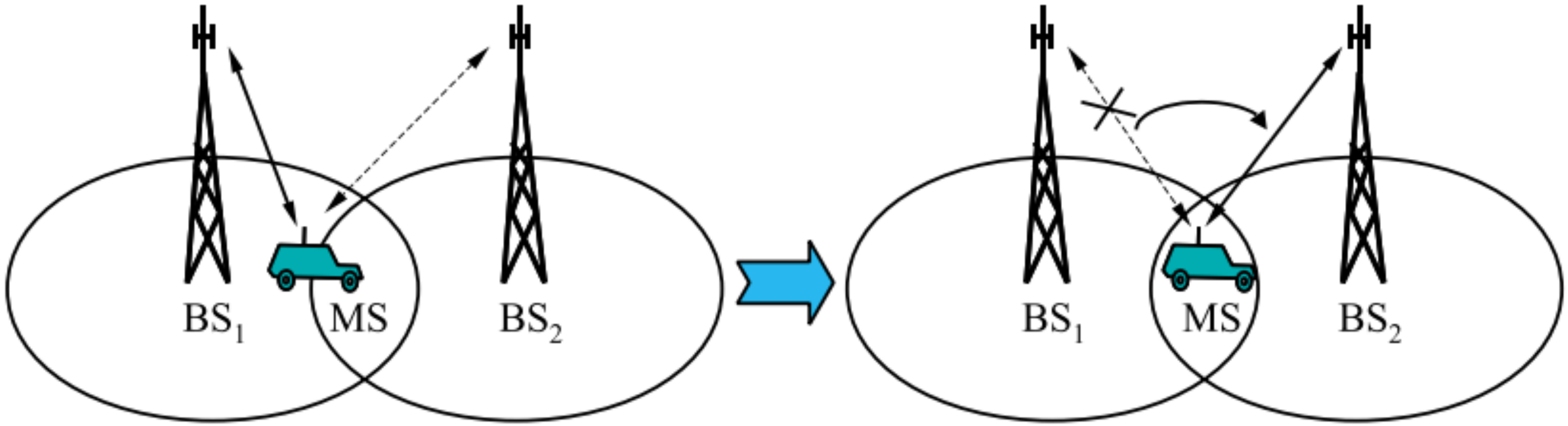
Base Station (BS)

Key component of cellular networks

- phone -> BS -> phone (two slightly different frequencies)
- BSs are linked by central switching centers
- BSs are also linked to the main telephone network, allowing mobile calls to be routed to landline phones.

Handoff

Concept of handoff: Transition between cells



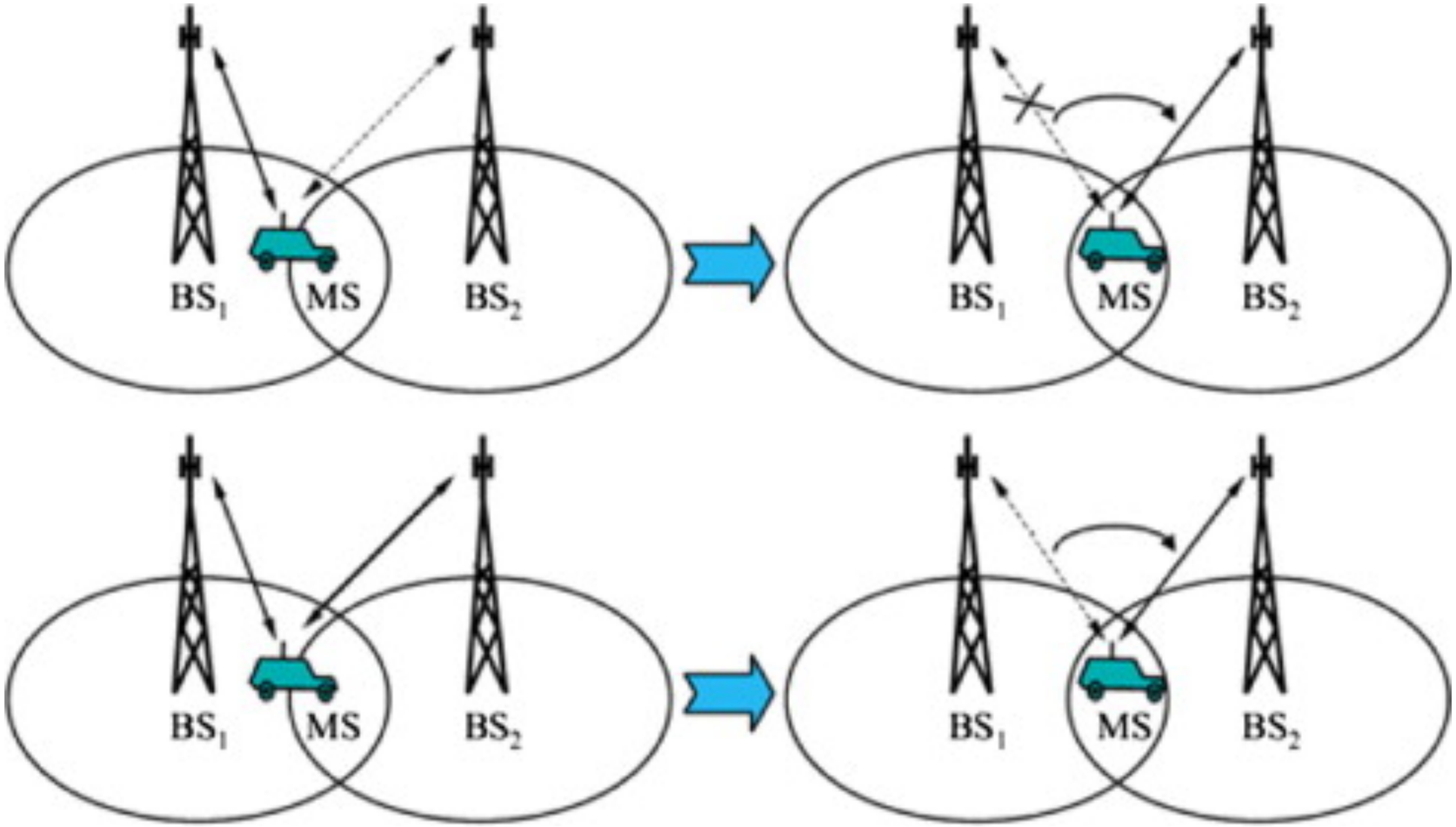
a. Before handoff

b. After handoff

Handoff

Types of handoff

Soft handoff and hard handoff



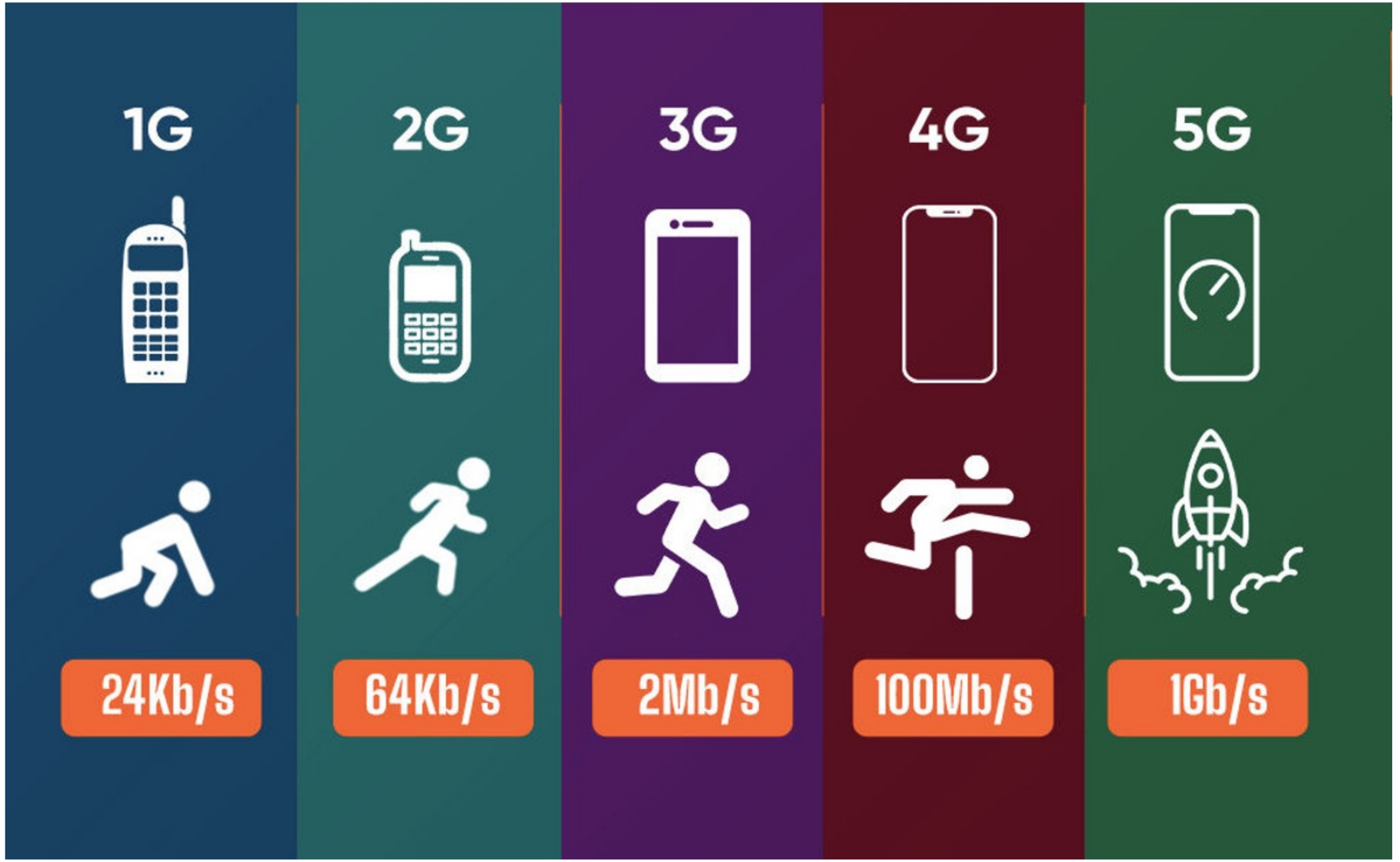
hard handoff

soft handoff

Evolution of Cellular Networks

From 1G to 5G

From 1G to 5G



From 1G to 5G

- 1G (1980s): Analog voice, low quality.
- 2G (1990s): Digital voice, SMS.
- 3G (2000s): Mobile data, web access.
- 4G (2010s): High-speed internet, streaming.
- 5G (2020s): IoT, AI applications.

Case Study: China’s Cellular Evolution

1G mobile network

- 1985: Mobile phones became popular among businessmen in Hong Kong.
- 1987: China mainland’s first 1G mobile service.
- Compared to other countries:
  - The car phones that were first commercialized in 1946 in USA by Bell System (considered as pre-1G or 0G).
  - The first commercial 1G mobile network in the world was launched by Japan in 1979.

Case Study: China’s Cellular Evolution

2G mobile network

- 1993: China mainland’s first 2G mobile service in Zhejiang.
  - But China didn’t hold any core standards or patents of 2G.
- The world:
  - 2G launched in Finland in 1991.
  - It was 1992 when 2G was introduced to the US.

Case Study: China's Cellular Evolution

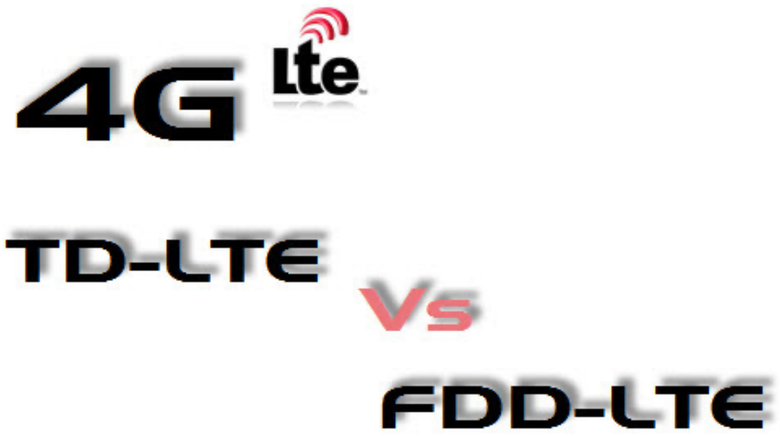
3G mobile network

- 2009: China entered to 3G era.
  - China has its own 3G technology, TD-SCDMA (Time Division-Synchronous Code Division Multiple Access). Treated as a local standard.
- The world:
  - Japan was the first country that entered to 3G era in 2001.
  - In the US, 17% of the population remained using 3G as at the end of 2019.

Case Study: China's Cellular Evolution

4G mobile network

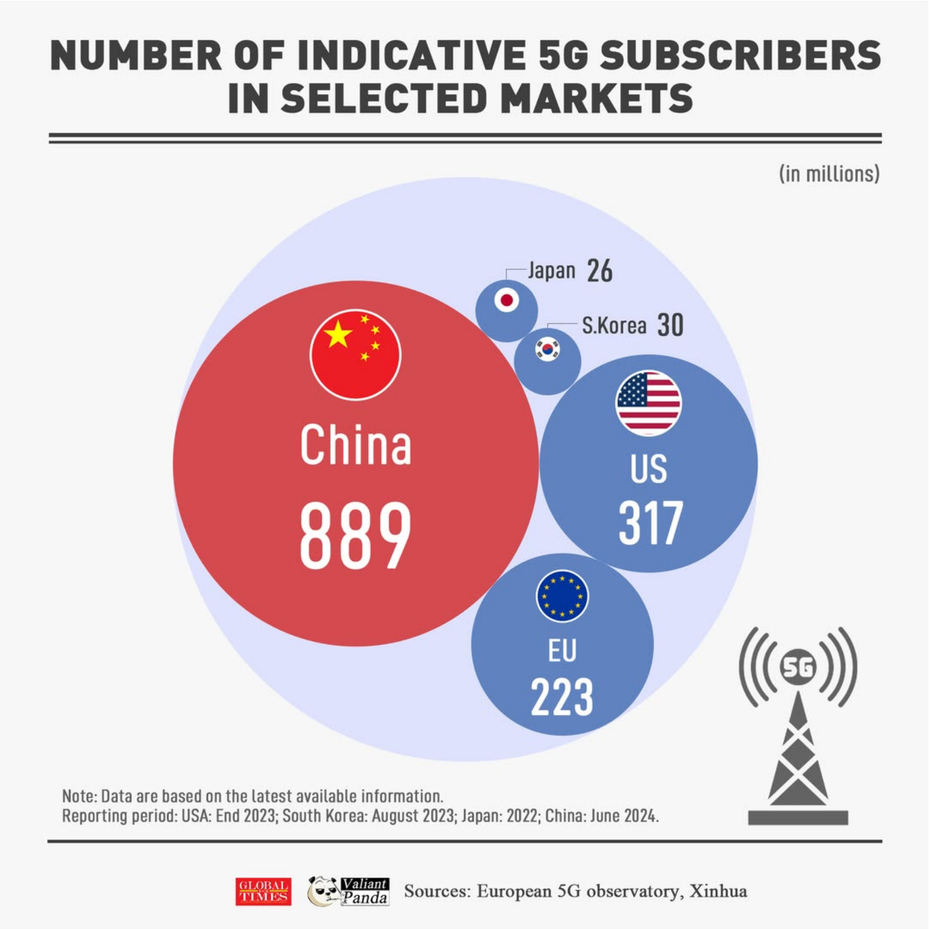
- 2013: China entered to 4G era.
  - TD-LTE (Time Division Long-Term Evolution) was proposed by China. Treated as a global standard.
  - Another standard is FDD-LTE (Frequency Division Duplexing LTE).
- The world:
  - Canada is the first country that introduced actually 4G for commercial use in 2011 (median download speed was 55.5 Mbps).
    - Norway has introduced 3.9G or 3.95G in 2009 (12.5 Mbps download speed)



Case Study: China's Cellular Evolution

5G mobile network

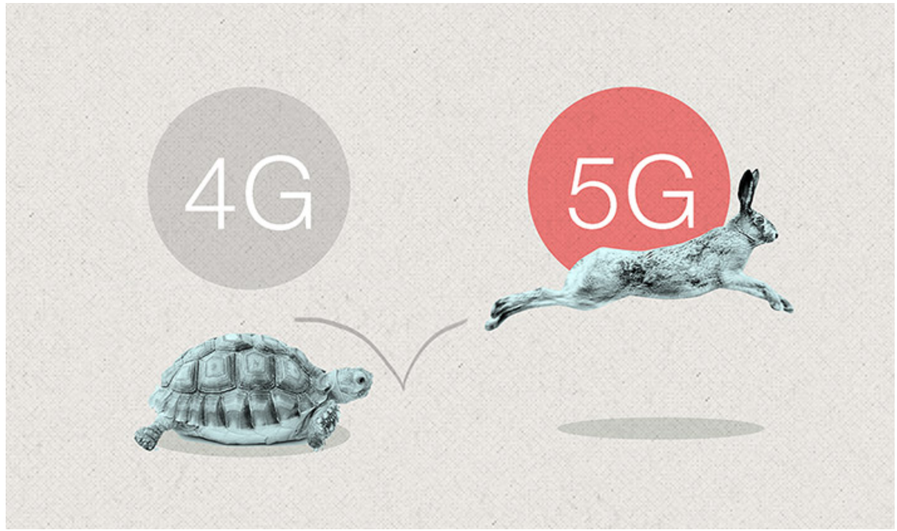
- Oct, 2019: 5G was launched in China.
  - China is on the leading place in 5G.
  - No. 1 in number of 5G patents (34% in 2019).
- The world:
  - South Korea was the first country to offer 5G in March, 2019.



5G Network

More than just faster Internet

- Compared to 4G:
  - 5G can provide much faster downloading speed:
    - It will be 20 times faster than 4G.
    - It’s already 10 times faster than 4G.
  - 5G latency is incredibly reduced:
    - 4G has an average latency around 50 ms.
    - 5G’s average latency is about 10 ms.



5G Network

A game changer

- Multimedia services:
  - AR, VR, cloud gaming, live 360º HD sports broadcasting
- IoT (Internet of things):
  - Smart cities, smart factories, machine-to-machine (M2M) communications
- Autonomous vehicles:
  - Automatic updates, real-time traffic updates, vehicle-to-vehicle communication

Group Discussion

How has cellular technology influenced your life

- Group size: 3-5 person
- Discussion time: 5 mins
- Discuss in groups and share examples. Explain how it impacts your life, e.g., what feature of the technology that influences your life.
- Write down your discussion conclusion.

Thank You