

# **Mobile Computing**

**COMP5216**

**Assignment Project Exam Help**

**Week 05**

**Semester 2, 2020**

<https://powcoder.com>

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Dr. Kanchana Thilakarathna  
School of Computer Science

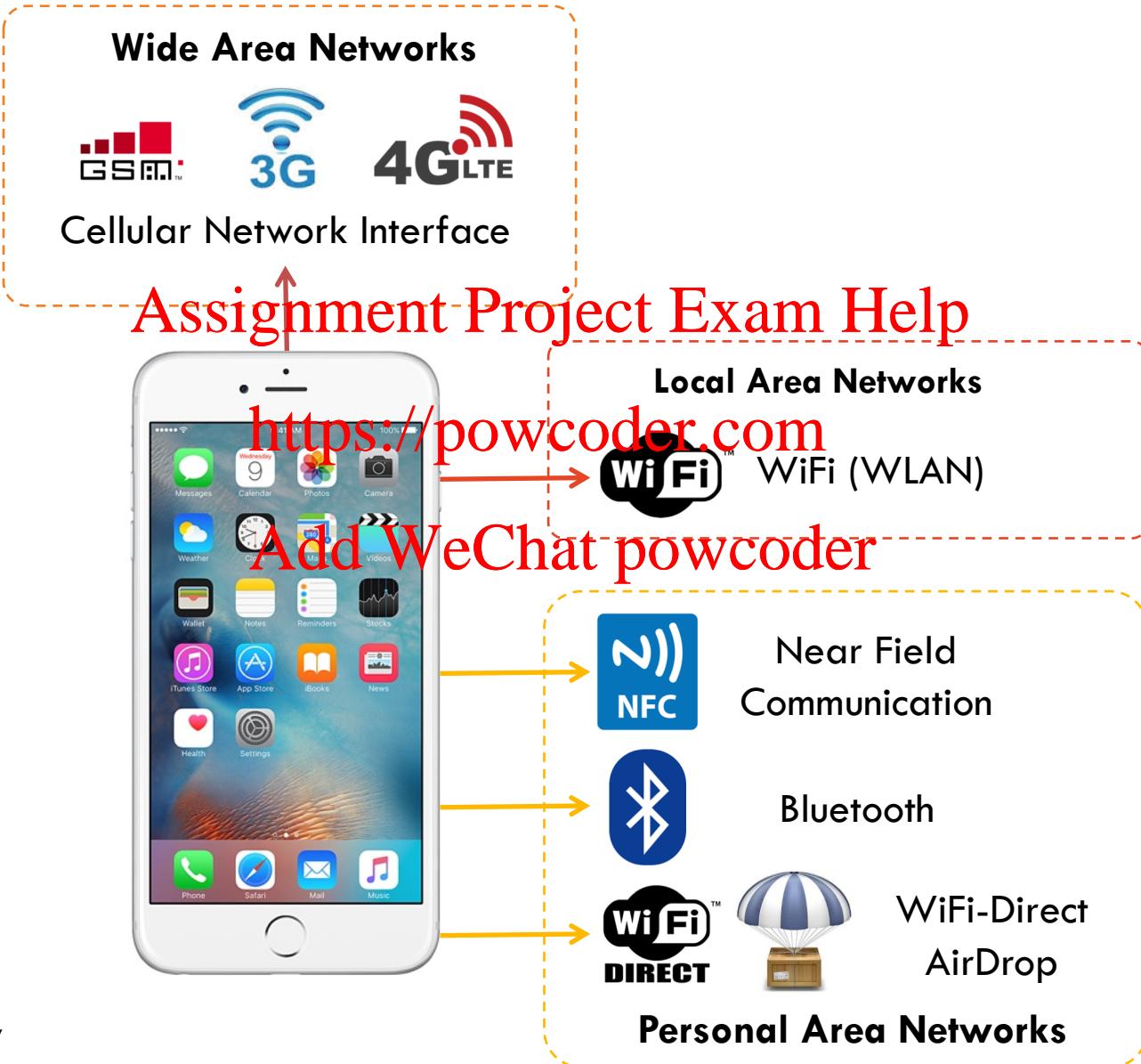


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# Outline

- Overview of available networks
  - Cellular, WiFi, Bluetooth, NFC, Ad-Hoc
- What we can do as developers to optimize networking cost ?
  - Selecting the right content
  - Offloading to cheap networks
  - Reduce data usage
  - Reuse data
- Tools for Network Debugging
  - Android Profiler
  - Wireshark

# Networking Challenge



# Which interface ?

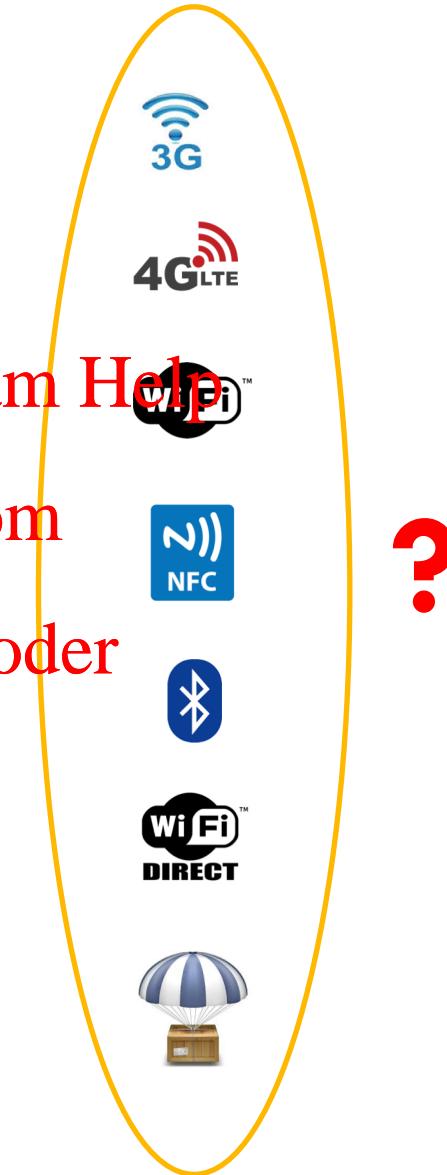
Factors to consider

- **Range**
  - Location of the end hosts
  - Mobility
- **Cost**
  - For the network operator
  - For the consumer
- **Speed**
  - Real time or delay tolerant
  - User expectations
- **Privacy and Security**
  - Public content or personal data
  - Location of the end hosts
- **Energy**
  - Smartphone energy consumption

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## E.g. Sharing accelerometer data from smartwatch to smartphone

- What options we have?

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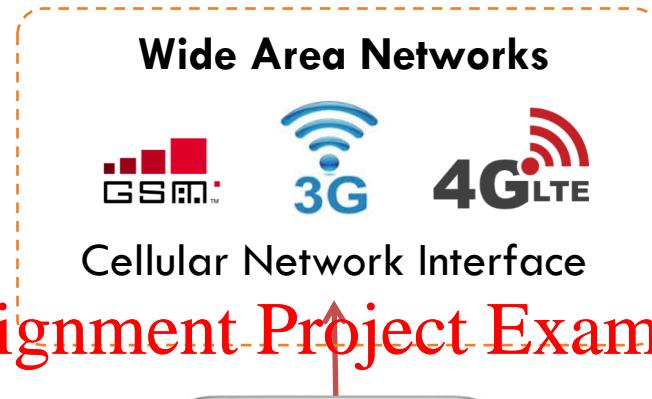


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# Wide area networks



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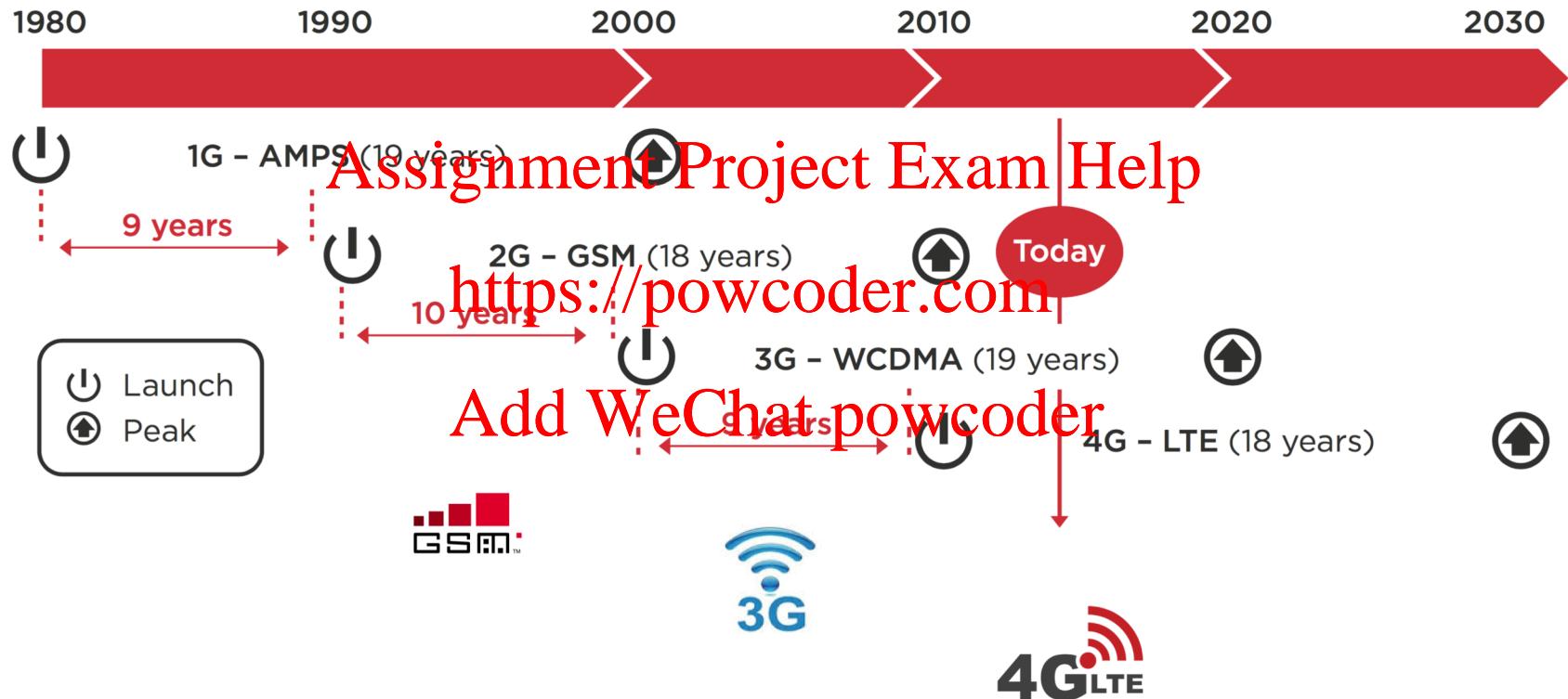
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# Wide Area Networks

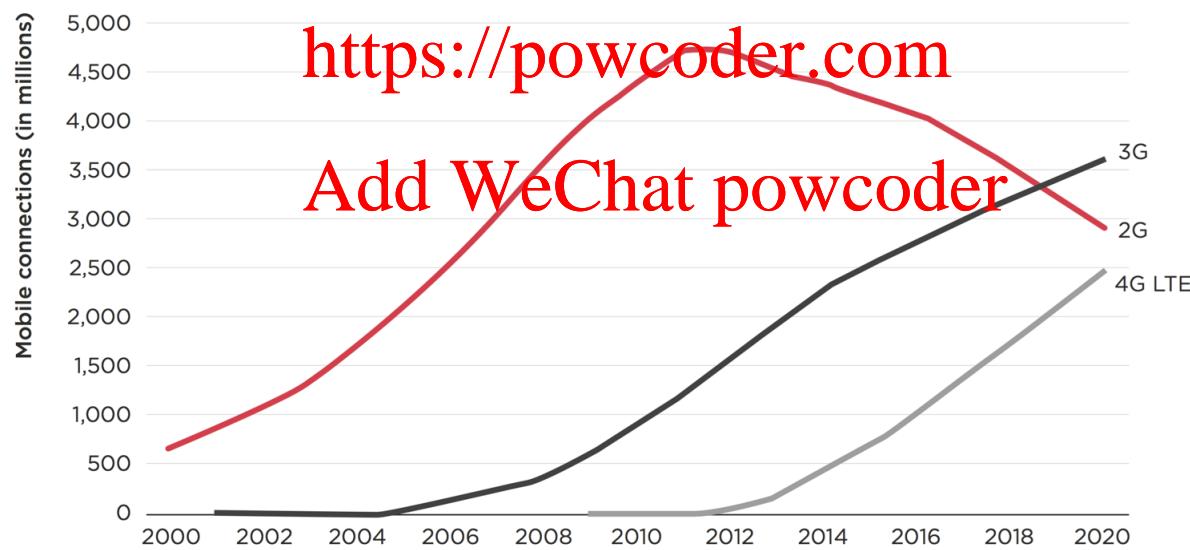
## Cellular Networks



- Source: GSMA Intelligence - <https://www.gsma.com>
- Cellular network standards are governed by 3GPP - <http://www.3gpp.org>

# Cellular Network Evolution – 2G

- Global System for Mobile Communications (GSM)
  - GSM is originally designed for voice.
  - Introduced **SIM** (Subscriber Identity Module).
  - Mass adoption of mobile phones started with GSM.
  - Even today GSM is the leading mobile communication technology.



Source: GSMA Intelligence

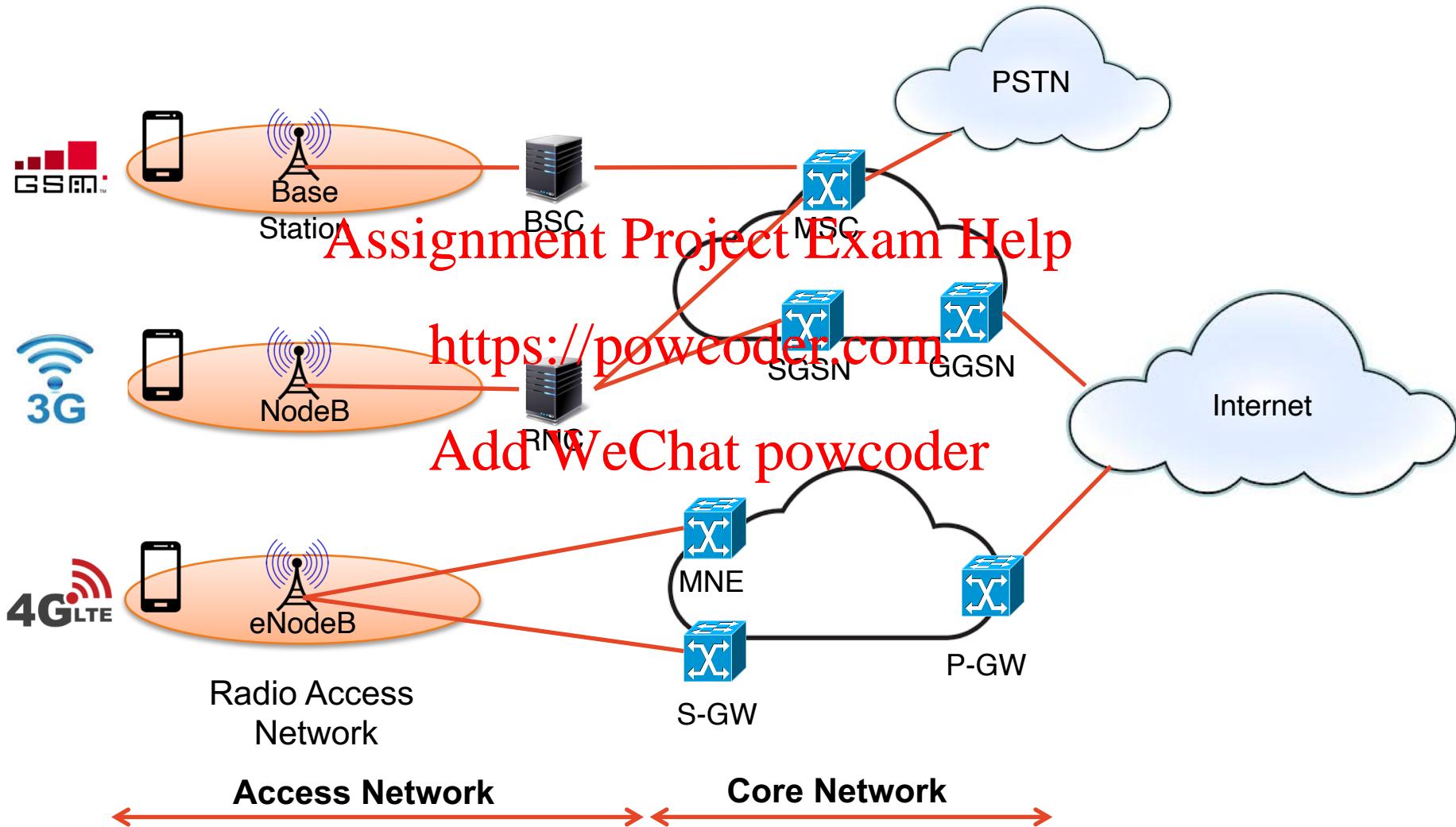
# Cellular Network Evolution – 3G

- Two main variants of 3G technologies
- **UMTS** (Universal Mobile Telecommunication Service)
  - W-CDMA, TD-CDMA, and TD-SCDMA (China)
  - HSDPA, HSUPA, HSPA+ are Data specific releases.
  - HSPA+ provides data rates up to 56Mbps
- **CDMA2000** <https://powcoder.com>
  - In North America and South Korea
  - EVDO are Data specific releases.
  - EVDO Rev B provides data rates up to 14.7Mbps
- Frequency bands
  - 850, 900, 1900, 2100MHz
- Tied to mobile specific architectures and protocols.

# Cellular Network Evolution – 4G

- **LTE Advanced:** 3GPP Long Term Evolution
  - <http://www.3gpp.org/technologies/keywords-acronyms/98-lte>
  - Downlink data rates up to 300Mbits/s
  - Uplink data 75Mbit/s
- E-UTRA (Evolved UMTS Terrestrial Radio Access)
  - High Speed OFDMA/Packet Access
- Similar frequency bands as 3G.
- All IP services including voice and messaging

# Cellular Networks

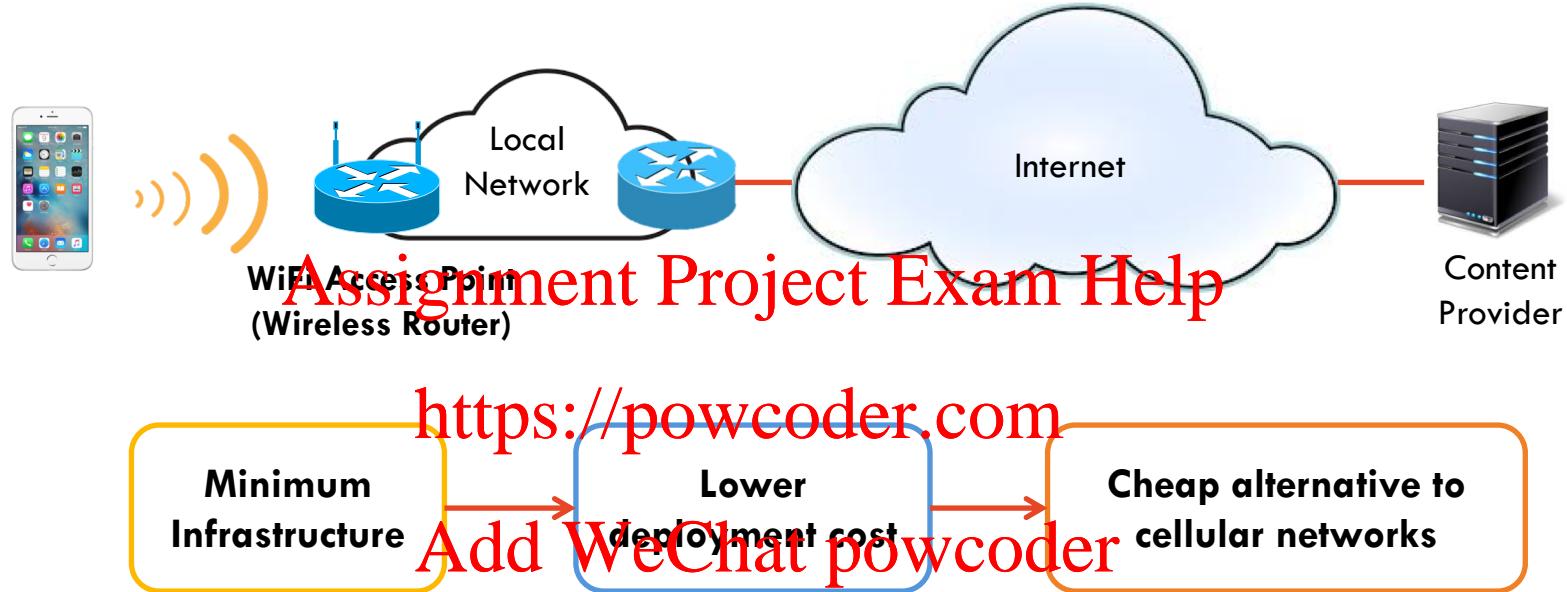


# Frequency Usage



- Licensed band - Cellular networks
- Unlicensed band - WiFi, Bluetooth, Zigbee, Microwave, etc.

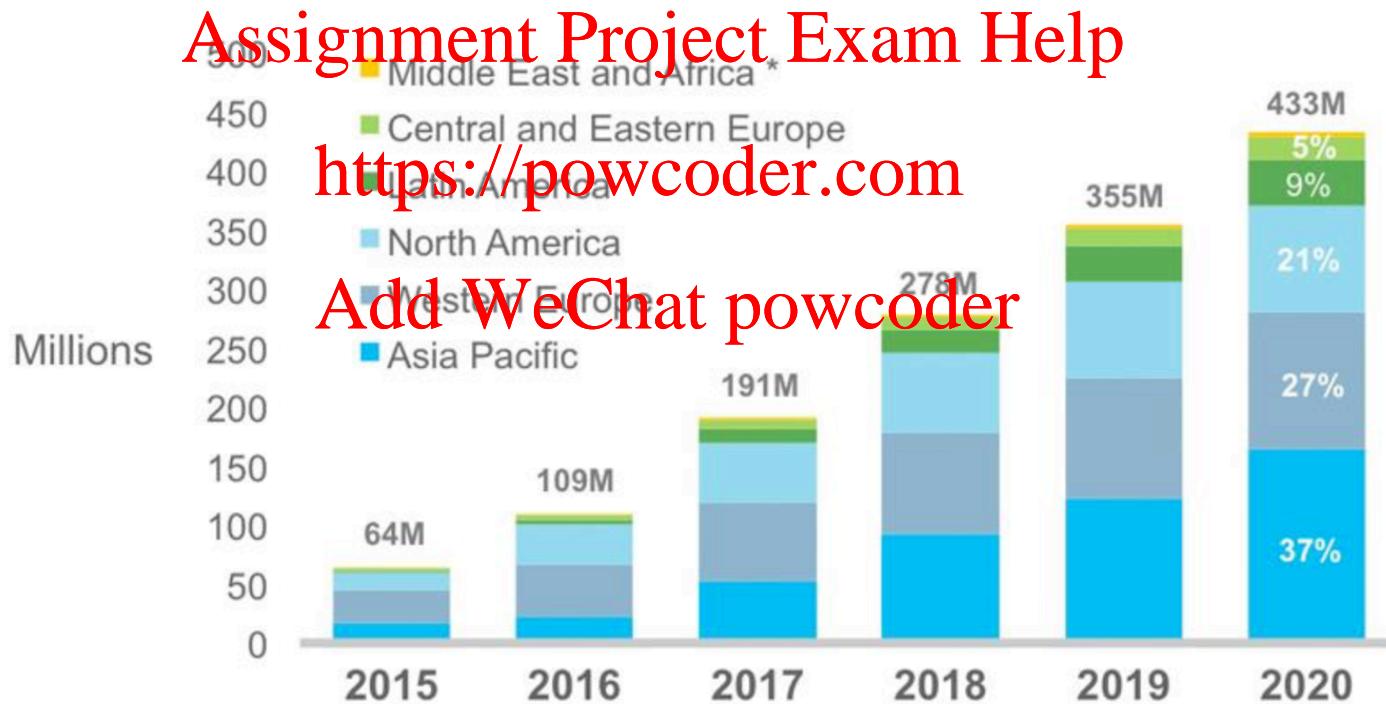
# Local Area Network - WiFi



- Current smartphones select WiFi over Cellular for data access by default.

# Local Area Networks - WiFi

- WiFi hotspots are everywhere !
  - In Australia - Telstra, Manly Ferry, Westfield, etc.
  - **433 million hotspots worldwide by 2020.**



\* Middle East and Africa represents 1 percent of global public Wi-Fi hotspots by 2020.

Source: Maravedis, Cisco VNI Mobile, 2016

# WiFi – IEEE 802.11

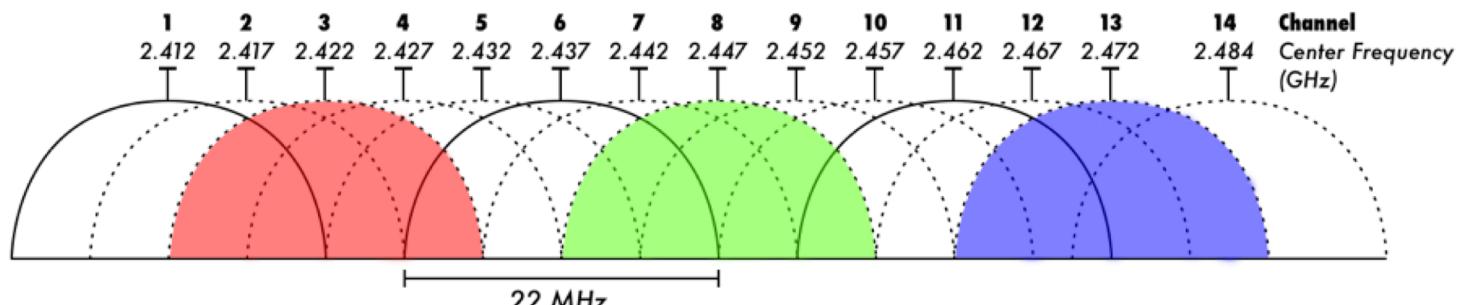
## IEEE 802.11 Standards

- First version is released in 1997.
- Often called invented at CSIRO, Australia.
- Wi-Fi Alliance (non-profit) formed in 1999.  
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- Medium Access Control (MAC) and Physical layer specifications.
  - CSMA/CA- carrier sense multiple access with collision avoidance (recall: Ethernet use CSMA/CD)
- Does not support global mobility
  - 5G heterogeneous networking supports seamless integration with WiFi hotspots.

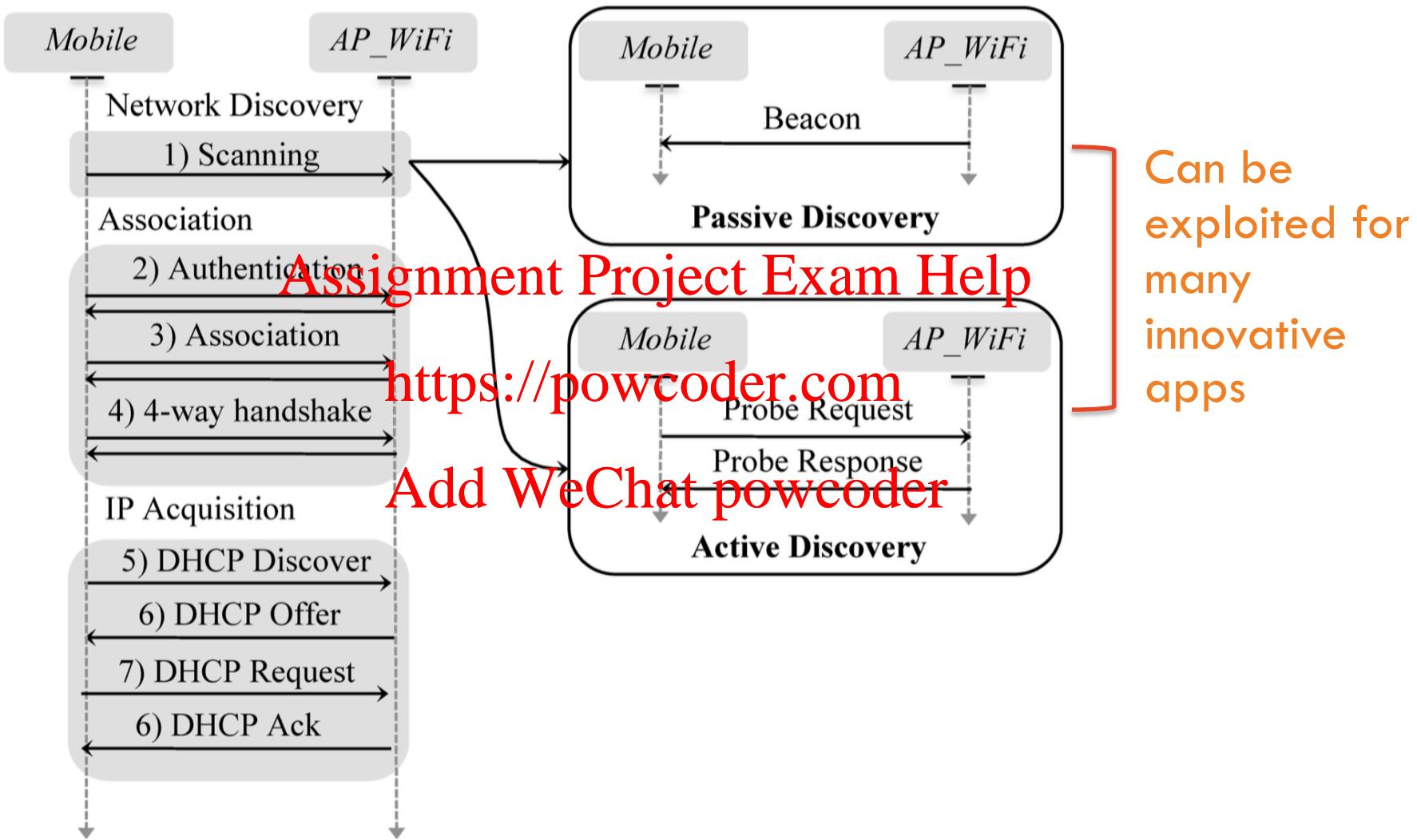
<http://www.ieee802.org/11/>

# WiFi

- ISM(industrial, scientific and medical) frequencies.
- **2.4GHz Band**
  - IEEE 802.11b, 802.11g, 802.11n
  - Range  $\approx$ 70m
  - 11/14 channels (non overlapping)
  - Very crowded frequency band
  - May suffer interference from Bluetooth, microwave oven, etc.
- **5.8GHz Band**
  - IEEE 802.11a, 802.11n, 802.11ac
  - Range lower than 2.4GHz  $\approx$ 35m
  - 23 channels (non overlapping)



# WiFi



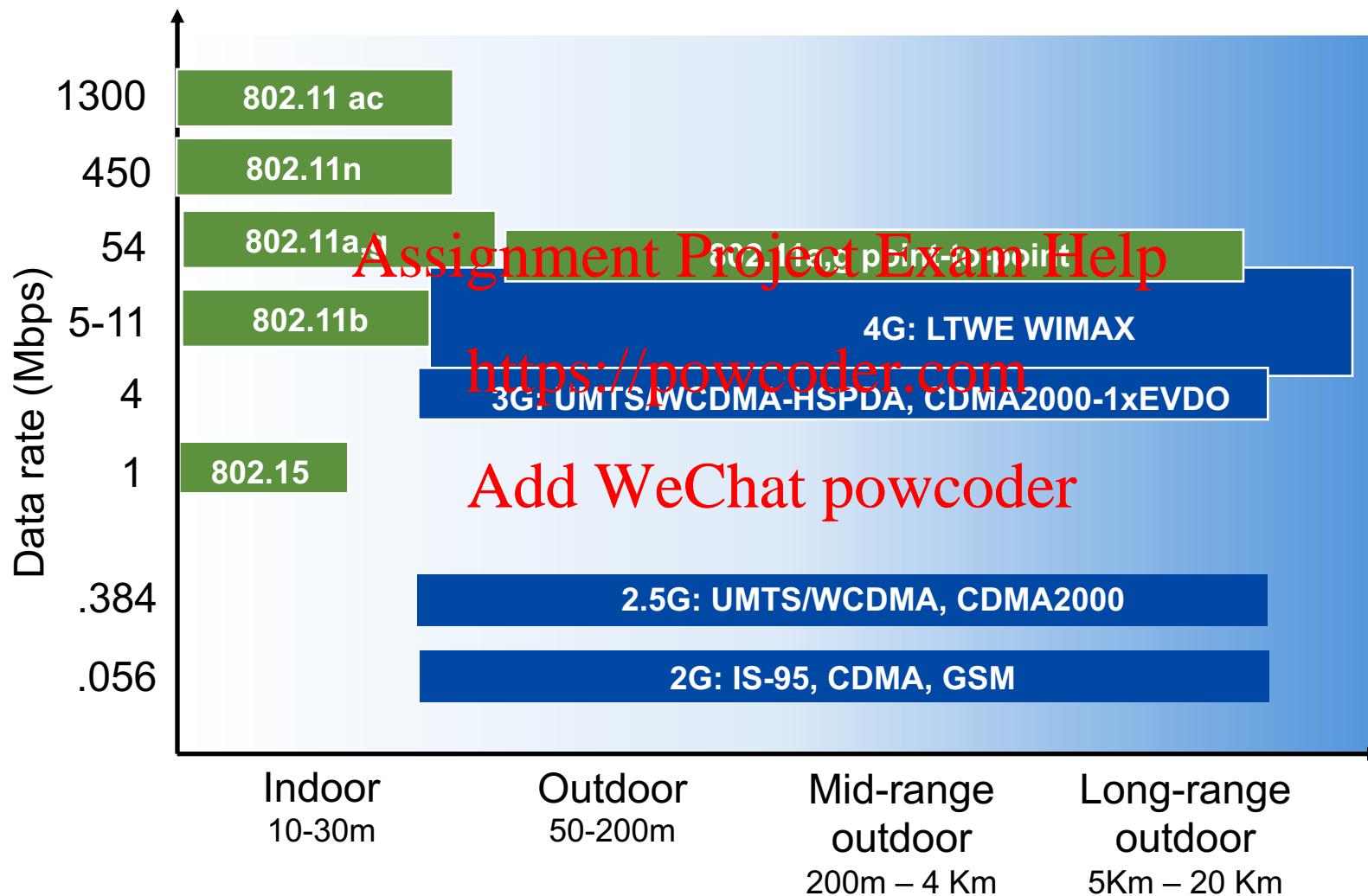
# WiFi

- Most of the smartphones supports IEEE 802.11 a/b/g/n/ac

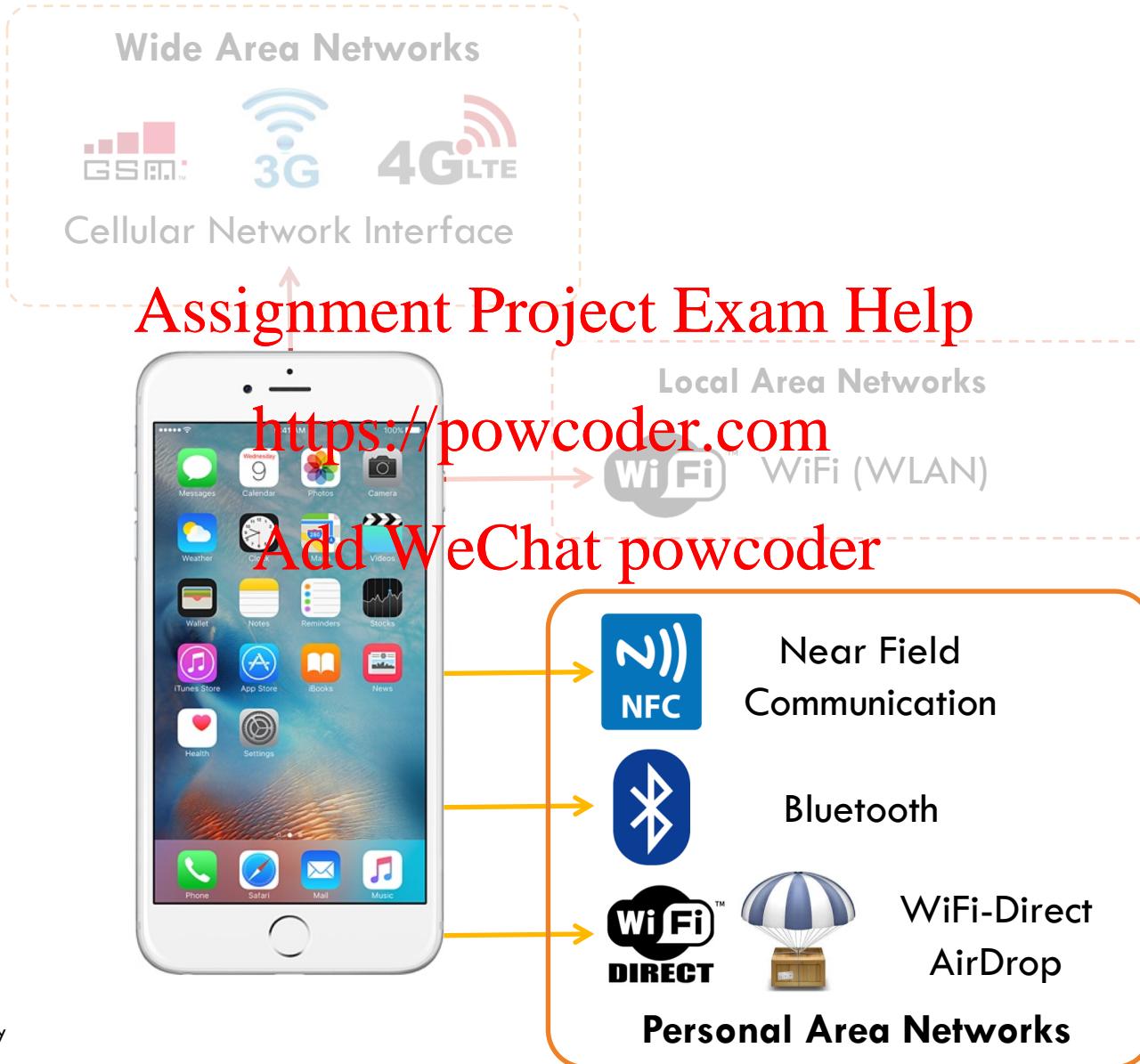
IEEE 802.11	Released date	Frequency band (GHz)	Bandwidth (MHz)	Max Speed (Mbits/s)	Range (m)
a	1999/2012	2.4/5.8	20	54	35
b	2000	2.4	22	11	35
g	2003	2.4	20	54	38
n	2009	2.4/5.8	20/40	72/150	70
ac	2013	5.8	20/40/80/ 160	96/200/4 33/866	35

- IEEE 802.11ad (60GHz) is coming...!**
  - Supports ~7Gbps data rate
  - But, requires line-of-sight → Point-to-Point connections

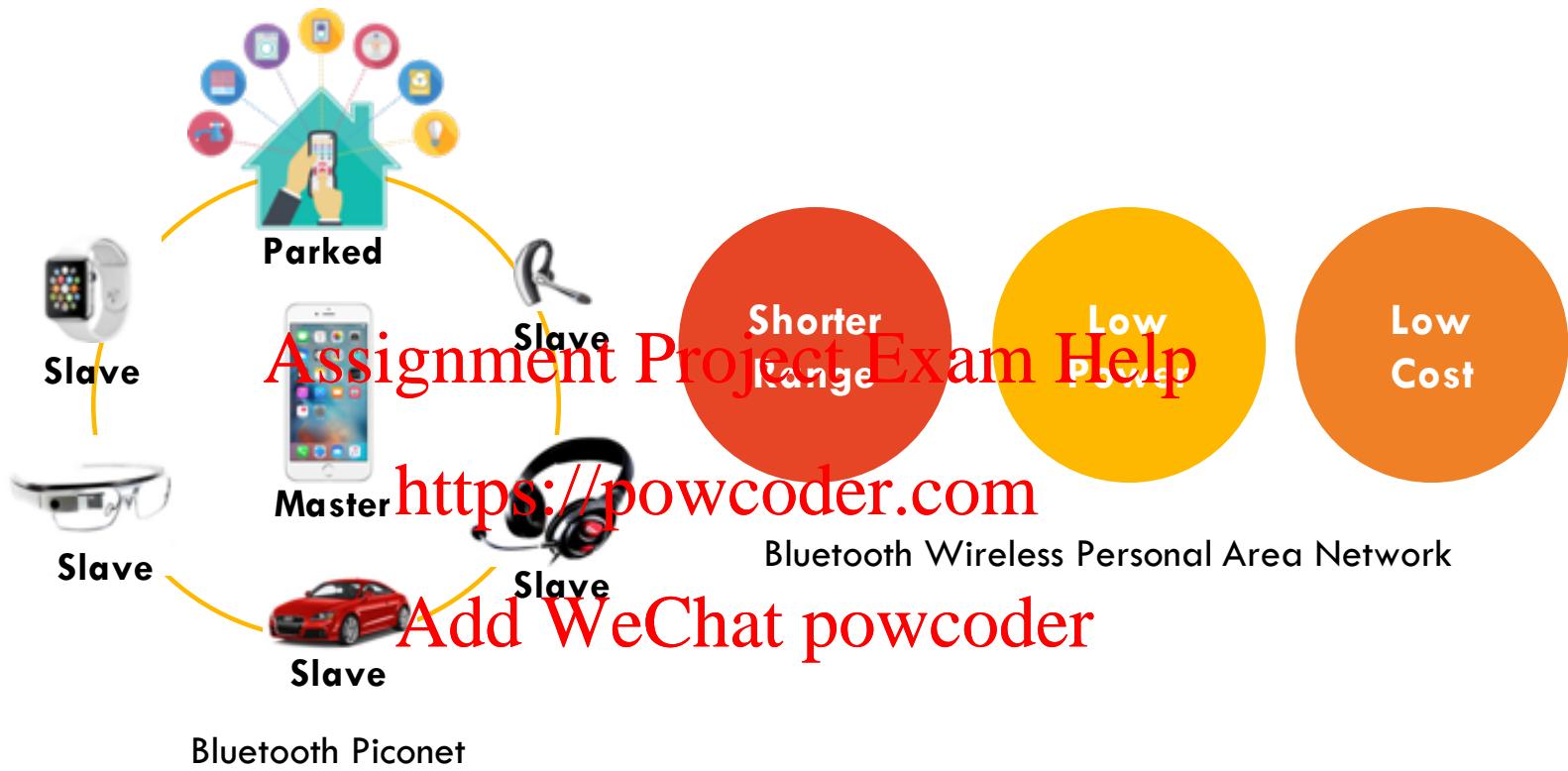
# Summary – WiFi vs Cellular



# Personal Area Networks



# Personal Area Networks (1) Bluetooth



- IEEE 802.15.1 - now maintained by Bluetooth SIG<sup>1</sup>
- ISM band - 2.4GHz

<sup>1</sup><https://www.bluetooth.com>

# Bluetooth

- Bluetooth device in discoverable mode transmits the following info on demand:
  - Device name, Device class, List of services, Some Technical information (e.g: device features, manufacturer, Bluetooth specification)
- Traditional pairing:
  - Needs user interaction.
  - If not, PINs are hardcoded in the device.
- **Secure Simple Pairing (SSP)**
  - Since Bluetooth v2.1
  - Works without user interaction.
  - Use other technologies such as NFC to bootstrap the authentication.
- Establish a shared secret key and if both device store the same key, they are paired after that.

# Bluetooth

- Infrastructure-less network → self-organized
- Time Division Multiple (TDM) access with random channel hopping 625 ns timeslot.
- 40 channels with 37 data channels and 3 advertising channels.
- Master – Slave approach
  - Up to 8 slave devices
  - Up to 255 parked devices (not actively transmitting data)

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# Bluetooth v5

- Bluetooth v5
  - **2x Speed, 4x Range, 8x Data** and less interference
  - Only available in new hardware iPhone 8, iPhone X, Galaxy S8
  - [https://3pl46c46ctx02p7rzdsqg21-wpengine.netdna-ssl.com/wp-content/uploads/2019/03/Bluetooth\\_5-FINAL.pdf](https://3pl46c46ctx02p7rzdsqg21-wpengine.netdna-ssl.com/wp-content/uploads/2019/03/Bluetooth_5-FINAL.pdf)
  - 3 PHY Layers to select

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Bluetooth v4.0      Bluetooth v5

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	LE 1M	LE Coded S=2	LE Coded S=8	LE 2M
Symbol Rate	1 Ms/s	1 Ms/s	1 Ms/s	2 Ms/s
Data Rate	1 Mbit/s	500 Kbit/s	125 Kbit/s	2 Mbit/s
Error Detection	CRC	CRC	CRC	CRC
Error Correction	NONE	FEC	FEC	NONE
Range Multiplier (approx.)	1	2	4	0.8
Bluetooth 5 Requirement	Mandatory	Optional	Optional	Optional

- LE Coded S=8
  - **Higher range**
  - **Low speed**
- LE Coded S=2
  - **Low range**
  - **Higher speed**

# Personal Area Networks (2) NFC



- Range  $\approx 4\text{cm}$  of each other.
- ISM band - 13.56MHz
- Data rates  $> 106-424\text{kbps}$
- Multiple standardization organizations
  - ISO/IEC, GSMA, NFC Forum<sup>1</sup>
- NFC is based on **RFID (Radio Frequency IDentification)**
  - Use magnetic field induction in close proximity

<sup>1</sup><http://nfc-forum.org>

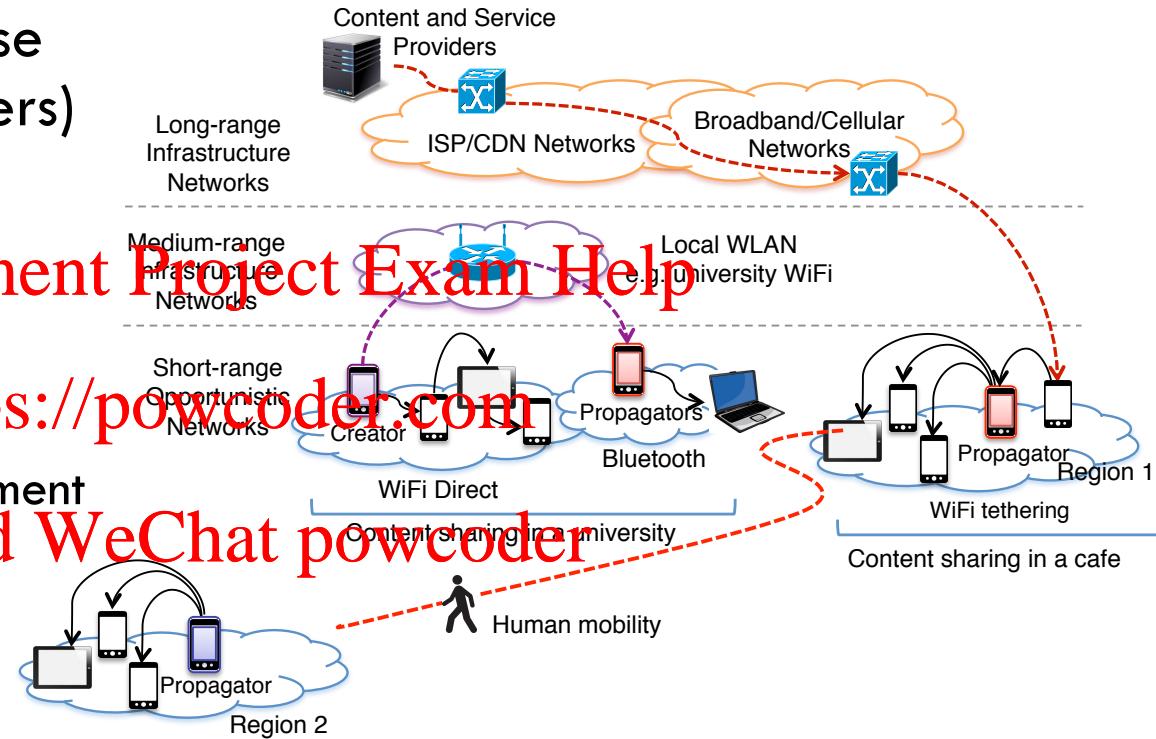
# Personal Area Networks (3) WiFi Variants

- Use WiFi networking interface: Range and Data rates are similar to WiFi.
- **WiFi-Direct**
  - Activates Software AP within the device
  - Specifications are administered by WiFi Alliance<sup>1</sup>
- **AirDrop** by Apple
- **WiFi-Tethering** (Mobile Hotspot)
  - Some network operators block WiFi-Tethering
  - Can only connect up to 8-9 devices

<sup>1</sup><http://www.wi-fi.org/discover-wi-fi/wi-fi-direct>

# Ad-Hoc Networking

- No Infrastructure (base stations, routers, servers)
- Devices organize themselves
- Device to device communication
  - E.g. disaster management



# Ad-Hoc Networking - Android

- Network Service Discovery (NSD) API to discover available services/devices nearby
- WiFi P2P API to setup wireless connections

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- Devices that support NSD includes;
  - Printers, Webcams, HTTP servers, Smartphones  
<https://powcoder.com>
- Allows fast data transfer within the local network.
  - Low latency
  - No bandwidth cost
  - Useful in range of P2P applications
    - E.g. chatting, file sharing and multi-player games
- <https://developer.android.com/training/connect-devices-wirelessly/>

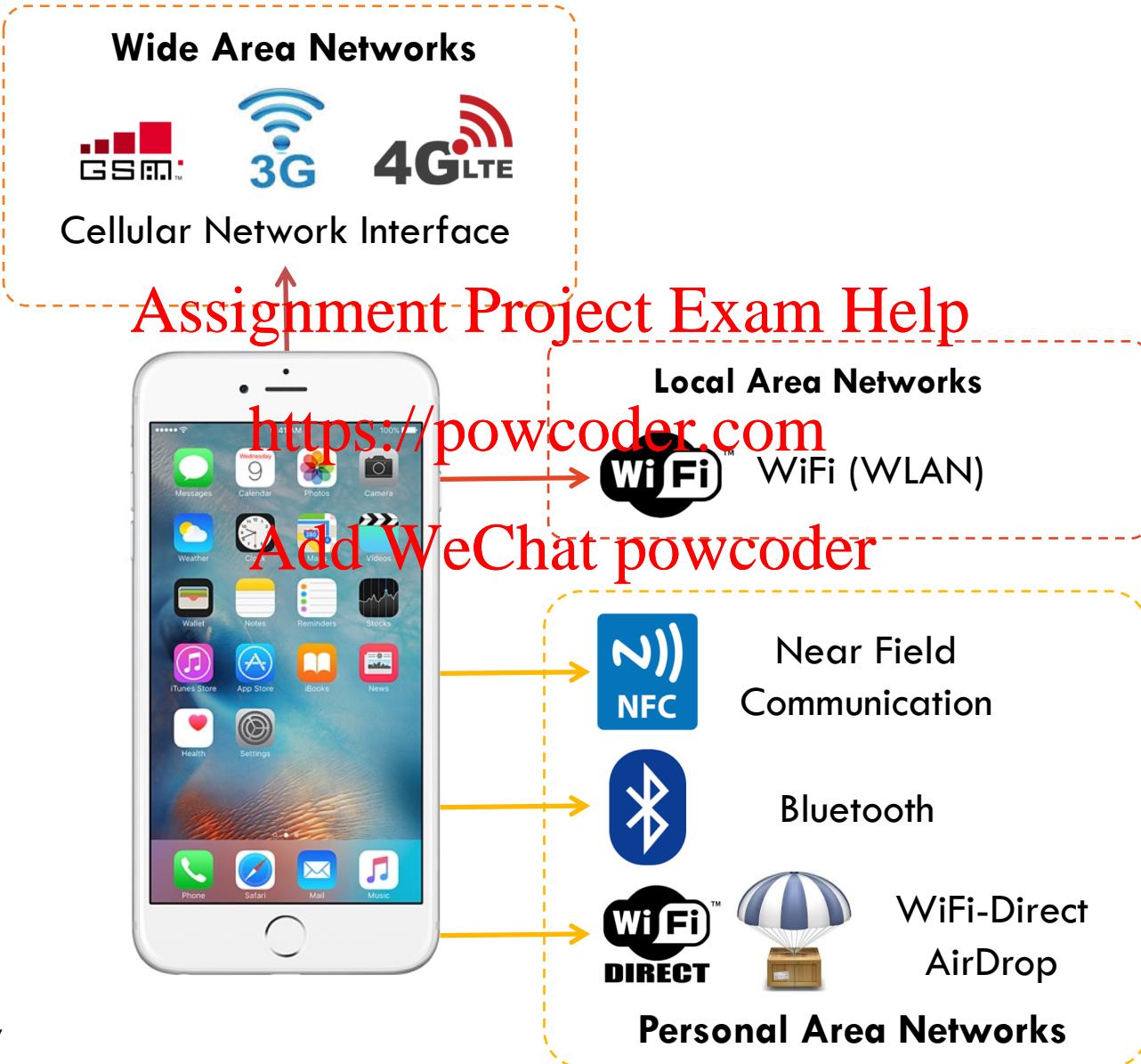
# NSD

- Rely on DNS-based Service Discovery (**DNS\_SD**) protocol
  - Allows your app to request services by specifying;
  - A type of service, and
  - The name of a device instance that provides the desired type of service
- What is DNS (Domain Name System) ?
  - Map between human readable addresses (google.com) and its IP address
  - For Internet there are 14 Root DNS servers.  
<https://powcoder.com>
- Multicast DNS is distributed (no central server)
  - Hostnames ending with **.local**
  - All devices in the same sub-net creates a directory of service exchanging IP multicast messages
  - i.e. NSD will not work if multicast traffic is blocked on the local network
- DNS-SD extends Multicast-DNS including service information
- You can register your service name at;
  - <https://www.iana.org/form/ports-services>

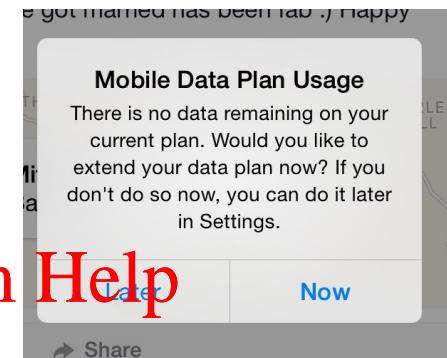
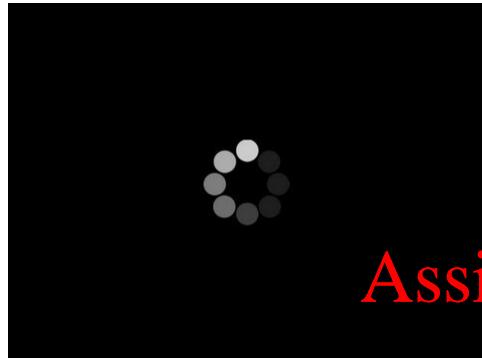
# WiFi P2P

- Allows apps to connect nearby device without a network or hotspot support
  - <https://developer.android.com/training/connect-devices-wirelessly/wifi-direct>
- Provides WPA2 encryption
- Steps:
  - 1. Ask for the correct permissions.
  - 2. Set-up a broadcast receiver & P2P manager.
  - 3. Peer Discovery & Fetch list of peers
  - 4. Connect to a peer
- WiFi P2P can also be used to discover services nearby
  - Recall NSD requires devices to be on the same WiFi network
- A higher level API for adhoc connections combining WiFi and Bluetooth –  
**NearBy API**
  - <https://developers.google.com/nearby/connections/android/discover-devices>

# Networking Challenge



# What to avoid ?



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<https://powcoder.com>  
Best Practices for Mobile Networking

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# What can we (developers) do ?

Do you really need this data ? Yes

1. Select the right content for the device, the user and adapt dynamically  
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2. Offloading cellular (default) to alternative networks  
**https://powcoder.com**
3. Reduce the amount of data  
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4. Reuse the data as much as possible
  - Secure networking [Week 6]
  - Energy efficient networking [Week 8]

# (1) Selecting the right content

- User expectation dependent on context;
  - Users' activity, e.g. running or sitting in the living room.
  - Time of the day.

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- Request appropriate content

<https://powcoder.com>

- Examples for bad practices?

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# (1) Adapting to the conditions

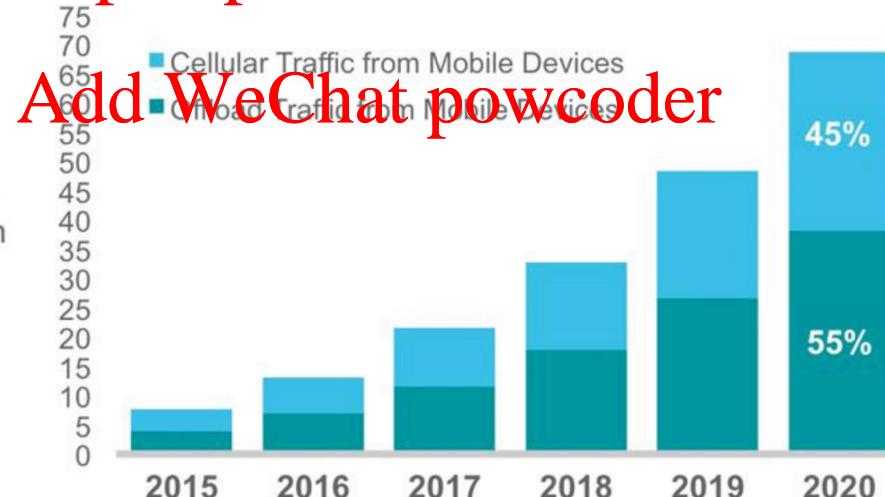
- Check before downloading/uploading
  - User activity
  - Connected network type
  - Available network bandwidth
  - Location
  - Time of the day <https://powcoder.com>
- Slow connection → Add WeChat powcoder  
Download lower resolution media
- DASH Video Players (Dynamic Adaptive Streaming over HTTPS)
  - E.g. YouTube – Varying video quality according to the available network bandwidth

## (2) Offloading

- Reactive offloading
  - Offload to another network when it is available.
  - Cellular to WiFi, WiFi to Bluetooth, Bluetooth to USB

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- **55% of global cellular traffic will be offloaded to WiFi by 2020.**



Offload pertains to traffic from dual-mode devices (excluding laptops) over Wi-Fi or small-cell networks.

Source: Cisco VNI Mobile, 2016

## (2) Offloading

- All most all current smartphones automatically prioritise WiFi networks over Cellular (3G/4G) networks

### Benefits of WiFi Offloading Project Exam Help

- Faster connections (depends on the location)  
<https://powcoder.com>
- Lower cost
- Lesser battery drain  
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- Overall improved quality of user experience
- Reduces cellular network capacity issues

## (2) Offloading - Reactive

- To automatically connect to WiFi, the available WiFi network has to be **in the previously connected list of networks.**
- **Reactive WiFi Offloading practices**
  - Wait until the device is connected to WiFi to transfer;
    - Large files <https://powcoder.com>
    - Delay tolerant content, e.g. software updates.
  - Push notifications to the user to connect to WiFi (after a timeout)
  - Scan the available WiFi networks and offer the user option the switch to WiFi

## (2) Offloading - Predictive

- **Predict** near future WiFi availability and **delay** the transmission.
- Only works for **non-real time content** (delay-tolerant content)
  - Social networking content.
  - Software updates.
  - Environmental monitoring, data collection.  
<https://powcoder.com>
- **Predict** future demand and effectively **pre-load** the content when the user is connected to WiFi.
  - News
  - YouTube, Facebook videos

## (2) Offloading - Predictive

- Regular behavioural patterns of users
  - Users have regular weekly patterns, e.g. 9:00am -5:00pm work hours.
- Long-tail content popularity
  - 10% of content accounts for 80% of views  
<https://powcoder.com>
- User and location targeted content delivery
  - Location based advertisement distribution
  - User targeted content, e.g. Facebook videos

## (3) Reduce Data

- Download only essentials
- Don't upload everything collected

## Data Compression Assignment Project Exam Help

- Specially for text based files. e.g. HTML, JavaScript, CSS, .txt
  - Files less than 1KB do not benefit from compression.
- The compression and decompression have to be supported by the end-points.
  - Common algorithms - GZIP, DEFLATE

### (3) Reduce Data - Image compression

- Trade size and color
  - More colors → larger size



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<https://powcoder.com>

- Adjust quality to around 75
  - Significantly smaller image size for insignificant visual difference
- **WebP** provides better compression than JPEG and PNG
  - <https://developers.google.com/speed/webp/>
  - WebP lossless images are 26% smaller compared to PNGs

### (3) Reduce Data - Image compression

- Use WebP whenever possible
- If not, use;
  - PNG – if image needs transparency or image is simple in color and structure **Assignment Project Exam Help**
  - JPG – if image is complex



JPG : 201 k

PNG : 636 k

<https://powcoder.com>



JPG : 82 k

PNG : 50 k

Same color better compression with PNG

### (3) Reduce Data - Other forms of data reductions

- **Minification** of JS, CSS and HTML
  - Remove unnecessary characters
    - JS – e.g. UglifyJS [<https://github.com/mishoo/UglifyJS2>]
    - CSS – e.g. CSSNano [<https://github.com/ben-eb/cssnano>]
    - HTML – HTMMinifier [<https://github.com/kangax/html-minifier>]
  - General minification tools. e.g. eMinifier
  - Compress: GZIP compression on server
  - Offline compression using Zopfli or 7-Zip.
- **Serialization**
  - JSON, XML are serialization methods, but bulky and slow
  - Use customized structure to minimize data
  - FlatBuffers - an efficient cross platform serialization library
    - <https://google.github.io/flatbuffers/>

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<https://powcoder.com>

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### (3) Reduce Data - Data Compression

- Samsung Max App (Previously Opera Max)



## (4) Reuse Data

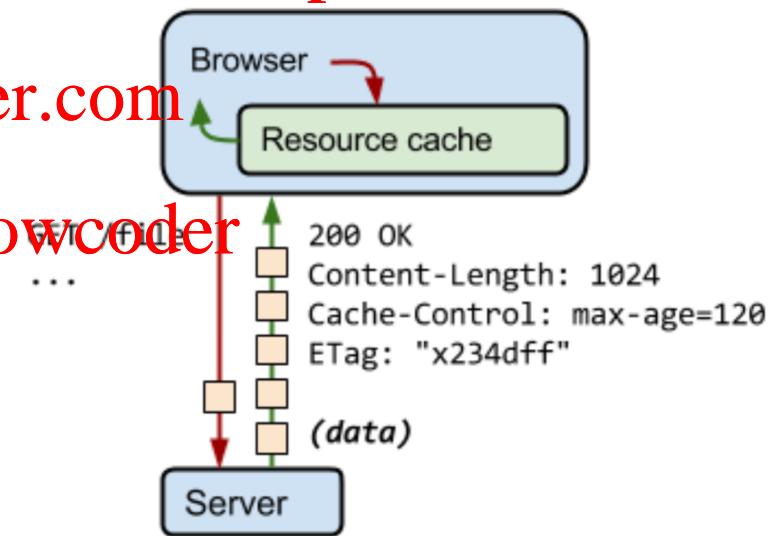
- Design the app and the communication protocol to reuse data, if you control both the client and the server.
  - **Static content** – Cache until updated
  - **Dynamic content** – Cache until expires

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- For web-content, HTTP provides number of flexible cache-control parameters.

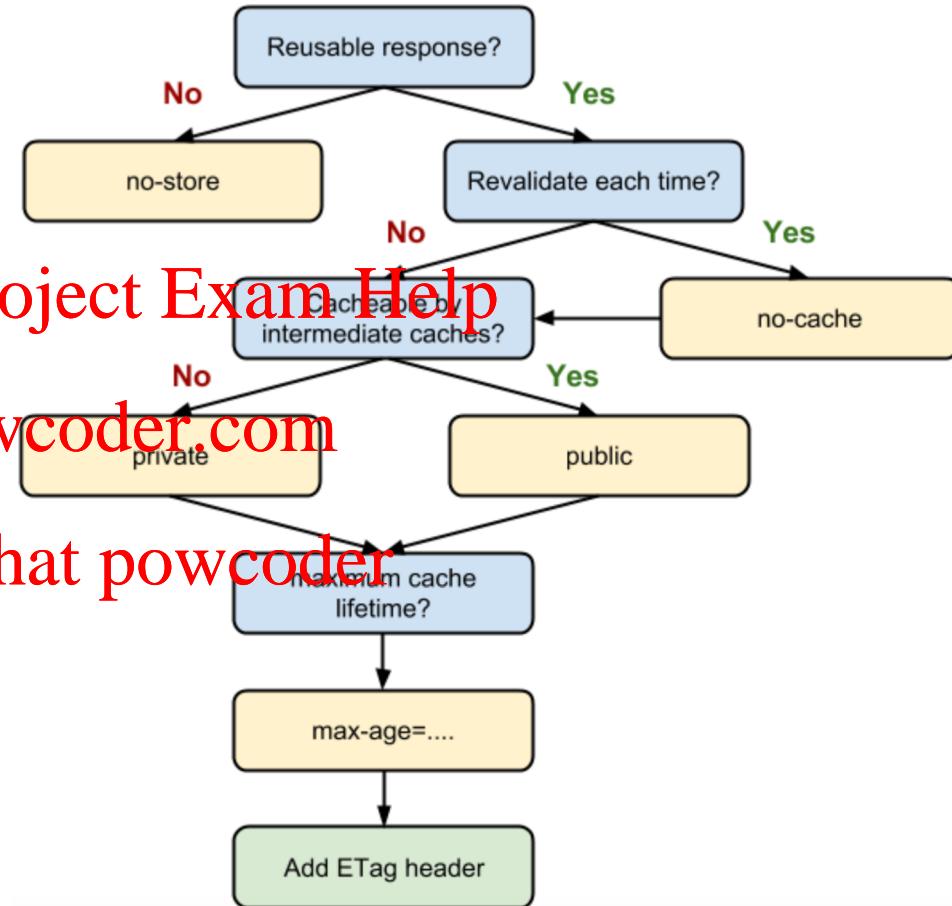
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- <https://developers.google.com/web/fundamentals/performance/optimizing-content-efficiency/http-caching>

## (4) Reuse Data - HTTP Caching

- HTTP Header cache-control directives:
  - **no-store**- can not cache the content
  - **no-cache**- can not use unless checking with the server
  - **public**- can be cached
  - **private**- can be cached for only one user
  - **max-age**- maximum time in seconds that the cached content can be used
  - **ETag** – use to check saved version at the client is still valid



## (4) Reuse Data - Cache Replacement Policies

- Storage is not unlimited, **not possible to cache everything...!**
- Memory cache vs Disk cache
- Use the most suitable cache replacement policy for the app.
  - FIFO - First In First Out
  - Largest Evict
  - **LRU - Least Recently Used**
  - **LFU - Least Frequently Used**
- Android Caching support
  - <https://developer.android.com/reference/android/net/http/HttpResponseCache>
  - <https://developer.android.com/reference/android/util/LruCache>
  - <https://developer.android.com/topic/performance/graphics/cache-bitmap>
- Image caching/loading libraries
  - Glide - <https://github.com/bumptech/glide>
  - Picasso - <http://square.github.io/picasso/>

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<https://powcoder.com>  
Tools For Network Debugging

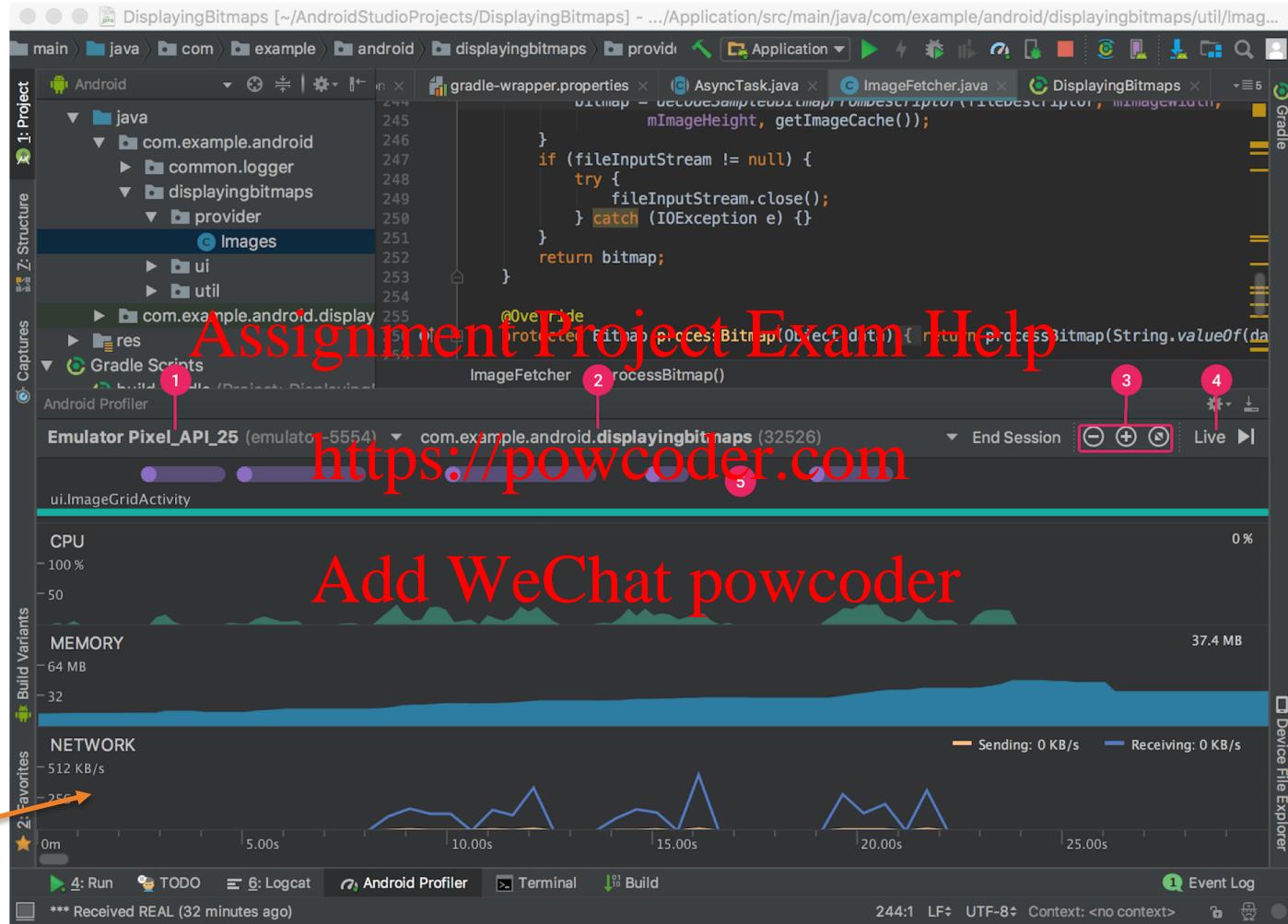
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# Android Profiler

- Available from Android Studio 3.0
  - **View > Tool Windows > Android Profiler**
- Great tool to ensure efficient/in-efficient usage of resources of your app **Assignment Project Exam Help**
  - CPU Profiler
  - Memory Profiler <https://powcoder.com>
  - **Network Profiler**
- Enable Advanced Profiling
  - **Run > Edit Configurations > Profiling > Enable advanced profiling**

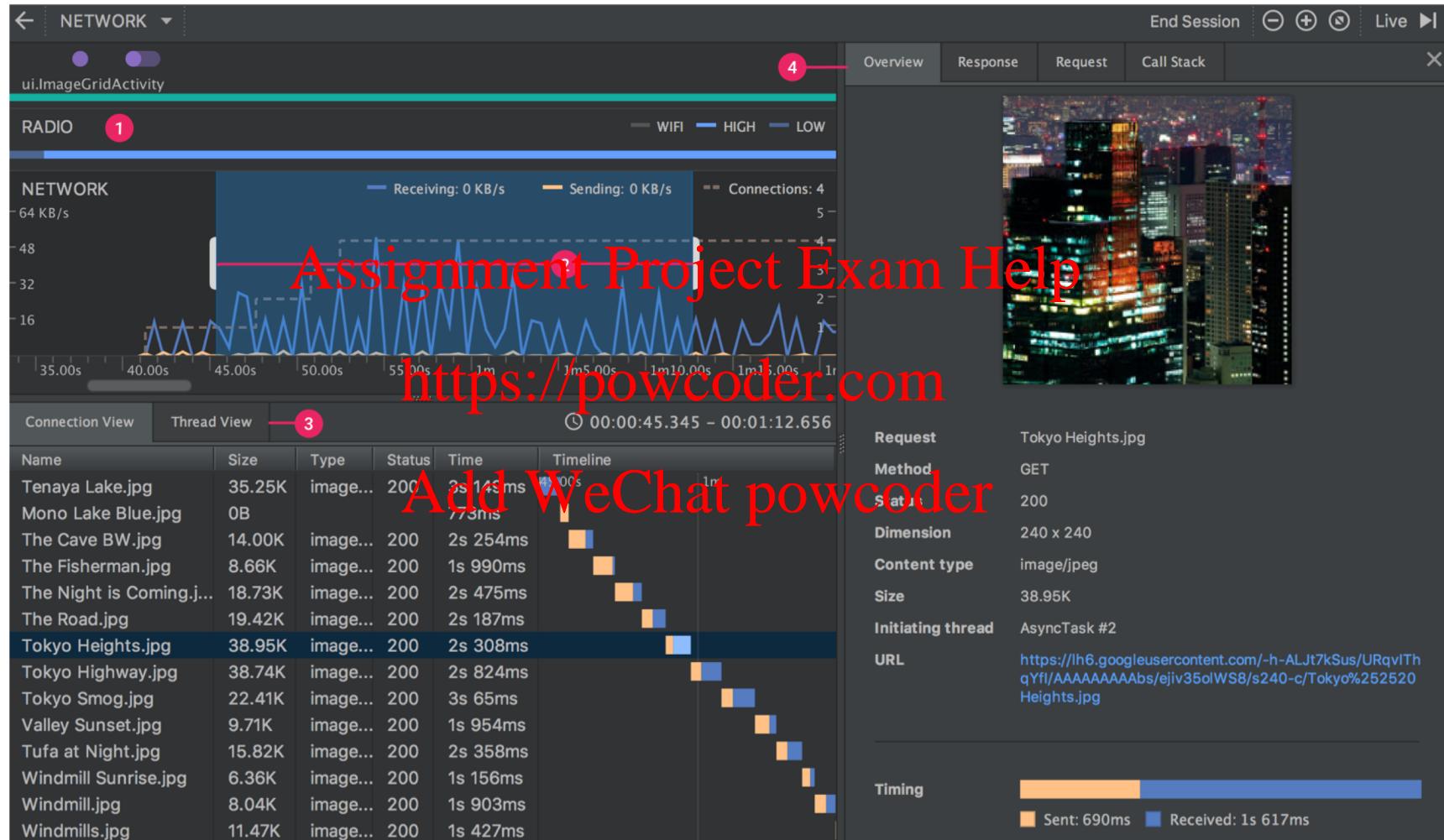
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# Android Profiler



Clicking here opens Network Profiler

# Network Profiler

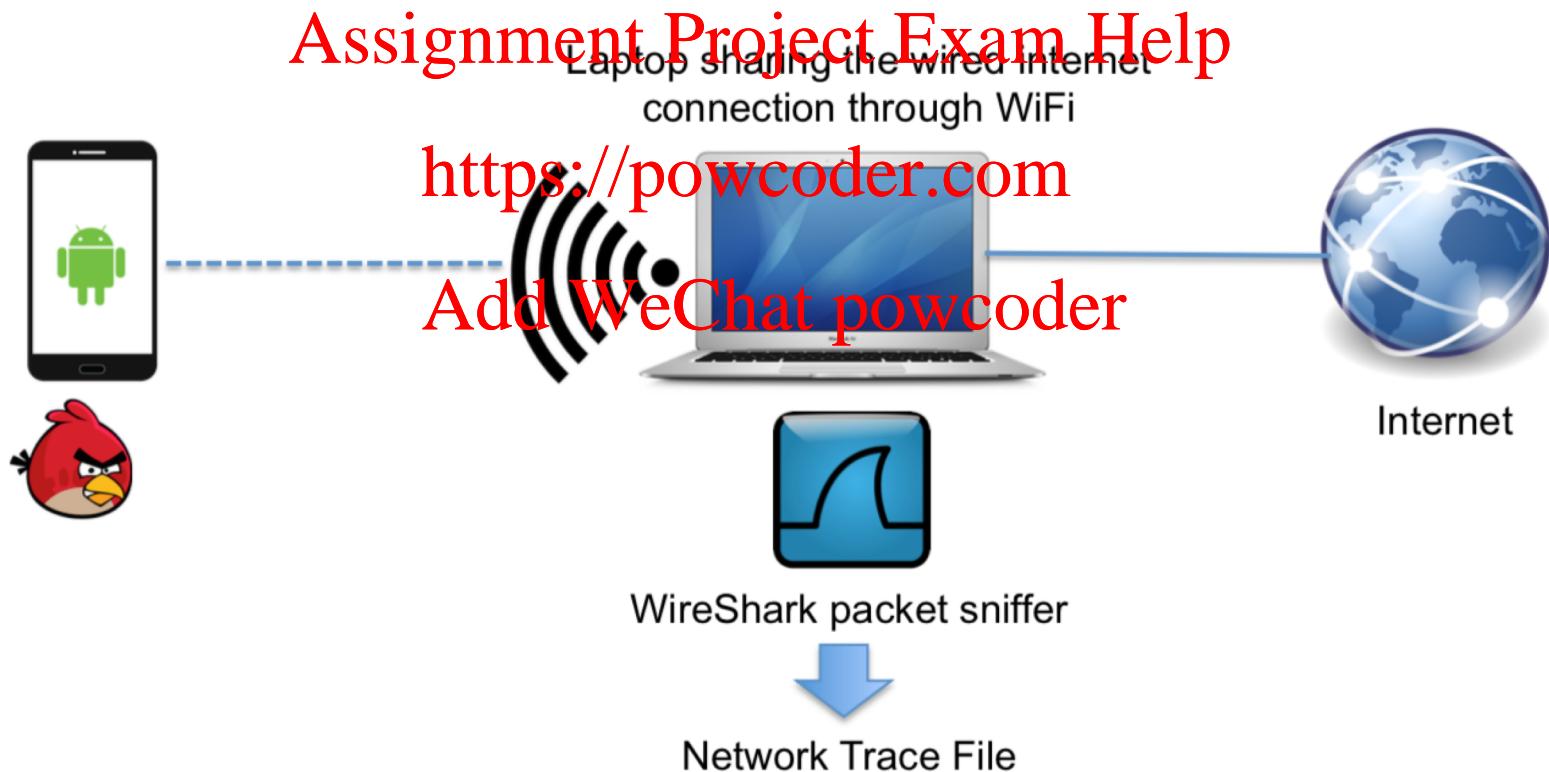


# Network Profiler

- Click on the network timeline to open Network Profiler
- **Connection view**
  - List both sent and received files including the size, type, status, etc.
- **Thread view**
  - Display activities of each thread
- Currently supports ~~HttpURLConnection and OkHttp~~ libraries
  - Add WeChat powcoder
- Can not profile other application traffic to answer questions like;
  - What happened to all of my data?
  - Why my battery drains so fast?
  - Is my data safe?

# Wireshark for passive network measurements

- Wireshark Packet Sniffer
  - Download - <https://www.wireshark.org>



# Resources

- Android Developer Documentation
  - <https://developer.android.com/guide/topics/connectivity/>
- Computer Network Fundamentals **Assignment Project Exam Help**
  - **Computer Networking: A Top Down Approach, 7<sup>th</sup> Edition, Jim Kurose, Keith Ross** <https://powcoder.com>
- Mobile networking best practices **Add WeChat powcoder**
  - **AT&T Video Optimizer Best Practices**
  - <https://developer.att.com/video-optimizer/docs/best-practices>

## What's Next?

- Assignment 2 released today.
- Media access tutorial today, which provides the basis for Assignment Project Exam Help
- Project Proposal due next week.  
<https://powcoder.com>
- Submit a PDF via Canvas by the deadline  
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- Next week
  - Mobile Privacy and Security