Mobile Computing

1.History of mobile devices and mobile operating systems.

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Nowadays we can't imagine our life without mobile phones. Internet and mobile, these two things make our work to easy. So Yes, We are talking about mobile phone. Let's start with its history.

The first handheld cellular mobile phone was demonstrated by John F.Mitchell and Martin Cooper of Motorola in 1973, using a handset weighing 2 kilograms. The second generation(2G) digital cellular technology was launched in 1991 by Radiolinja in Finland. After ten years, the third generation(3G) was launched in Japan by NTT DoCoMo which was followed by 3.5G, 3G+ or turbo 3G enhancements based on the high-speed packet access. and now, it's the fourth generation, all people are using 4G smart phones. and the great news, Fifth generation(5g) is awaiting for us which will make internet speed too fast.

Mobile is not just a communication source, we can also access a lot of activities like notepad work, Microsoft power point etc. So Now categorizing the types of mobile phones according to research, it is of three types:-

1. The first one is "Smartphone" which is generally using by people. It is a class of multi-purpose mobile computing device which include the capabilities of a mobile phone, but are distinguished from feature phones by their stronger hardware capabilities and extensive mobile operating systems.
2. Second part is "Featured Phone" which typically provide voice calling, simple text messaging, and basic multimedia and internet capabilities.
3. Third one is "Kosher Phone". It's a phone with restricted features. featured with text message capability.

And hardware part of phone is also important. we should know that what hardware technologies are used in mobile phones. CPU (Processor of the phone), Battery (providing power source to the phone), Display (which echoes the user's typing, and displays text messages, contacts, and more), Speaker (for sound), SIM Cards, R-UIM Card.

The history of cell phones

The history of cell phones can be divided into four category of phones:

- **1G phones**
- **2G phones**
- **3G phones**
- **4G phones**

1G phones

1G phones were analogue mobiles and they presented a revolution in the field of communication. First telephone network was built in 1977 by the company named Bell. This network was based on 10 radio stations. After that we saw AMPS (American Advanced Mobile Phone System) that presented a great improvement over the first network and it used different frequencies that allowed easy communication between two people. Telephone network in Europe was first developed by NMT (Nordic Mobile Telephony). Their first network is known under the name NMT-450 and it used frequency of 450 MHz. Five years later, in 1986, they presented another network known as NMT-900 that used 890-960 MHz as its frequency. Since then, mobile networks and cell phones developed really fast and over 100,000 people just in UK were connected to mobile network. Phones were different than today and they were mainly used for receiving and giving phone calls. Until 1996 this first generation of cell phones developed a lot. Main improvements were smaller dimensions and longer battery time. Some of the best 1G phone models in that time were:

- **Nokia Mobira Talkman** – this phone was the first phone on the world that was easy to transport. It was released in 1984.

- **Motorola 8500X** – great Motorola phone of first generation of phones was released in 1987 and it was very popular phone all around the world. There

was a display that showed a telephone number and lots of other features that presented a real innovation back then.

- **Motorola FlipPhone 2** – this phone was a great hit among users because it offered innovative flip design and a place for 10 numbers to be stored. Signal strength was largely increased and dimensions were small for that time. It was launched in 1994.
- **Nokia RinGo –** this nice Nokia phone was released in 1997 and it was one of the last cell phones of first generation every launched. It included some basic features but its main advantage was simplicity.

revolution was started with this first generation of cell phones. They continued to develop and then got phones that used GSM networks and those are phones that go into 2G category.

2G phones

These phones are also called GSM mobiles and in this time countries used their own network systems. For example, UK used TACs and ETACs standards, countries in Scandinavia used NMT standards, Germany used C450 standards and France network was based on Radiocom 2000. GSM (Group Special Mobile) was a group made by CEPT and its goal was to make a standard system which will be used in all countries in Europe. GSM developed a lot and in 1991 a first GMS call was made by Finnish Minister and with Nokia phone. Finnish network also became the first GSM network. First GSM phone that was approved was Orbitel TPU900 but it wasn't very successful. In 1992 Motorola launched their own GSM phone called Motorola 3200 and later the same year Nokia also launched their own GSM phone called Nokia 1011. SIM card was used as an identity of GSM users and it became standard that is used today. There were lots of GSM cell phones that developed from 1992 to 2006, here are some of them that were the most successful:

- **Nokia 1011** – we start the list with one of the first GSM phones ever made. This phone maybe isn't exactly the first GSM phone, but it is the first phone that was mass produced.

- **Motorola Micro-TAC 5200** – micro-TAC version of analogue cell phone vas very successful so Motorola decided to make GSM version of the same phone. It was launched in 1994 and it presented an introduction of Motorola to GSM cell phones battle.

- **Nokia 3310** – this legendary phone was launched in 2000 and it was probably the most popular GSM phone ever made. Some sources say that Nokia 3310 was sold in over 126 million copies. It had lots of different innovative features, some games and it was pretty much indestructible.

- **Motorola MotoFone F3** – this was the last GSM phone made, released in 2006. IT was very cheap and it came with large battery but a pretty small number of features.

After that the revolution continued and we got smartphones.

3G phones

First 3G network was launched in Japan by NTT DoCoMo network provider. There was a need for faster services because of large number of new phones and larger internet needs of users. 3G network offered faster data transfer, better web browsing, a possibility of sending videos and large number of pictures over data network and much more. 3G network had speed of 2,000 kbps. With 3G networks we got a lots of new features and mobile phones. For example, Sony Ericsson T39 was the first phone with Bluetooth. In third generation of phones we also got iPhone, back in 2007.

After 3G networks we got 3G+. This network was pretty much the same as 3G, but also a little faster. In this generation of cell phones over 50% of people in Europe and America got their own phone. Some of the best phones we got during 3G and 3G+ phones generations are:

- **Motorola Droid 3** – this phone was released in 2011 and it had 1GHz dual-core processor with 8MP camera fast graphic processor.

- **Samsung Galaxy Nexus** – a Samsung phone from Galaxy series released in 2011 was the first phone to run on Android Ice Cream Sandwich OS. It came with 1.2GHz dual-core processor and HD Super AMOLED display.

- **Apple iPhone 4** – a new Apple iPhone released in the same year as Droid 3 and Galaxy Nexus presented a large improvement over its predecessors. It came with iOS 5 operating system, Siri voice assistant and a powerful dual-core A5 processor along with 8MP camera.

- **Sony Xperia P** – this phone was released in 2012 and it came with qHD display made with Sony WhiteMagic technology. It came with dual-core chipset, 8MP camera and 1GB of RAM.

- **HTC Nexus One** – Google phone released in 2010 was a great improvement over other smart phones on the market at the time. It had some powerful features, large battery and it could work with 3G networks of most European and Asian providers.

4G phones

And today we have 4G network and most powerful and fastest phones so far. This technology allows all users to download any content at a high speed and the term 4G refers to fourth generation of mobile network technology. In most large countries 4G was released back in 2012. Most smartphone users still use 3G networks but that should change in the next few years. The main advantage of 4G is, its speed. For example, 3G phone can reach the maximum speed on internet of 21Mbps and that speed with 4G phone can reach 300Mbps but that is the maximum number. Currently most of the providers offer speed between 40Mbps and 200Mbps. On the other hand, 4G phones and 4G contracts are lot more expensive than 3G but you get faster speed and lots of possibilities. All those "flagship" phones you see offer 4G but you can also find it on some other phones with lower price. Some of the best 4G phones you can buy currently are:

- **Samsung Galaxy S6 Edge** :- S6 Edge is probably the best phone we can have right now, unless you are Apple fan. This phone runs on octa-core Samsung chip and it comes with 3GB of RAM, 16MP back and 5MP front camera. You can also choose between 32GB, 64GB and 128GB of memory.

- **Apple iPhone 6 Plus :-** this model is the latest one from Apple and it is currently the best. You get 64-bit dual-core processor, 8MP camera, and full HD display with the resolution of 1080 x 1920.

- **LG G4 :-** this is maybe the most underrated phone currently. LG G4 is amazing, it comes with full HD display, 64-bit hexa-core Snapdragon processor and 16MP back camera. You also get 32GB of internal memory and 3GB of RAM memory.

- **HTC One M9 :-** HTC always produced great smartphones and One M9 is also great. It comes with great 20MP camera, powerful Snapdragon 810 chipset and 3GB of RAM. One M9 also comes with Dolby surround sound and BoomSound speakers.

- **Sony Xperia Z3+ :-** the last phone that deserved its place on this list is Sony Xperia Z3+. This phone looks like the Z3 model but it is more powerful because it comes with 64-bit Snapdragon 810 chipset, 3GB of RAM and Adreno 430 GPU. Back camera is 20.7MP and front is 5MP.

Mobile Operating System

Over the past decade, smart phones have taken the world by storm and recently, tablets have entered into the arena as well. These mobile devices are having a significant impact on our lives and are in fact redefining the way we access information and communicate with others. This is due to not only the hardware but the specialized software that these devices run and most importantly, their operating systems. In what follows, we will take an informative tour of modern mobile operating systems, their different types and usage across smartphone and tablet platforms.

just like a PC can run different operating systems (like Windows, Linux, BSD etc.) or different versions of the same operating system (like Windows XP, Windows Vista, Windows 7 etc.), most smart phones can also run different versions of the operating system they were made for and in exceptional cases, they might even be able to run operating systems they weren't made for. In general however, an Android phone will only run a version of Android while an iPhone will only run an iOS version.

A mobile operating system (or mobile OS) is an operating system for smart phones, tablets, or other mobile devices. While computers such as typical laptops are mobile, the operating systems usually used on them are not considered mobile ones, as they were originally designed for desktop computers that historically did not have or need specific mobile features. This distinction is becoming blurred in some newer operating systems that are hybrids made for both uses. The so-called mobile operating systems have majority use as of 2017 (measured by web use); with even only the smart phones running them (excluding tablets) more used than any other kind of device. Thus traditional desktop OS is now a minority used kind of OS; see usage share of operating systems. However, variations occur in popularity by regions, while desktop-minority also applies on some days in e.g., the US and UK.

Mobile operating systems combine features of a personal computer operating system with other features useful for mobile or handheld use; usually including, and most of the following considered essential in modern mobile systems; a touch screen, cellular, Bluetooth, Wi-Fi Protected Access, Wi-Fi, Global Positioning System (GPS) mobile navigation, camera, video camera, speech recognition, voice recorder, music player, near field communication, and infrared blaster. By the end of 2016, over 430 million smart phones were sold with 81.7 percent running Android, 17.9 percent running iOS, 0.3 percent running Windows Mobile and the other OSes cover 0.1 percent. Android alone is more popular than the popular desktop operating system Windows, and in general smartphone use (even without tablets) outnumber desktop use (desktop use, web use, overall is down to 44.9% in the first quarter of 2017).

Mobile devices with mobile communications abilities (e.g., smart phones) contain two mobile operating systems – the main user-facing software platform is supplemented by a second low-level proprietary real-time operating system which operates the radio and other hardware. Research has shown that these low-level systems may contain a range of security vulnerabilities permitting malicious base stations to gain high levels of control over the mobile device

Manufacturer-built Proprietary Operating Systems

Some device manufacturers use their own proprietary operating system for their phones and tablets. A good example is Apple, with iOS being the operating system developed by them for their iPod Touch, iPhone and iPad devices. Other examples include RIM who use their proprietary BlackBerry OS for all BlackBerry phones and tablets, and HP, using their proprietary Palm Web OS for their Palm series of smartphones and tablets. A characteristic of such operating systems is that they have a very consistent look and feel across all devices that they run on, the way Mac OS X appears and behaves the same way on a Macbook Pro as it does on an iMac or a Macbook Air.

Let's now take a look at some popular operating systems in this category.

– Apple iOS

iOS is the operating system used by Apple in all variants of iPod Touch, iPhone and iPad. While smartphones have been around since the 90's, it was Apple that successfully managed convincing masses to switch to them with the release of the first iPhone in 2007 running the first version of iOS. At the time of its release, iOS wasn't even capable of performing what most other smartphones operating systems had been doing for almost a decade – things such as true multitasking, data connection tethering, task switching, Bluetooth pairing, PC-like application installation using installer files, and dozens others – yet the first iPhone was received with immense enthusiasm by the masses, perhaps for not knowing any better.

The key to this success lay in an interface we would call 'idiot-friendly' that was targeted primarily at the least smart users to enable them to use a smartphone that was only a pseudo-smartphone back then. Other factors contributing to the success of iOS included smooth graphics, consistent user interface elements across apps, built-in iPod application, iTunes integration, an App Store for buying and installing apps and perhaps most importantly, a multi-touch finger-friendly capacitive touch screen that eliminated the use of a stylus while offering finger based gestures such as pinch-to-zoom, twist-to-rotate etc. These, coupled with the similarity with the hugely popular iPod Touch, resulted in the iPhone going viral and ended up in most people buying it as more of a status symbol of owning an iPhone, than for the utility of having a smartphone.

The introduction of the iPad in 2010 only added to the popularity of iOS. Much like the case of smartphones, tablets had been widely available for over a decade but it was again Apple that built upon the success of iPhone to bring them to the masses in form of the iPad, creating a modern tablet boom and leading to other competitors joining the market. With the iPad and the iPad 2, Apple still leads the tablet market share by a huge margin.

Due to its restricted nature, iOS limited users to only the features Apple decided appropriate. That's when the development community decided to intervene and came up with Jailbreaking. This allowed power users to install additional apps not available

in the official App Store and customize their iPhones beyond the standard features provided by Apple.

By now, iOS has improved a lot and as of the current version 4.3.3, it supports multi-tasking, audio and video playback to AirPlay devices, data tethering and several other enhancements, in addition to the above-mentioned features. Jail breaking continues to play an important role in iOS devices and enables users to take their iPhones beyond the often limitations set by Apple.

– RIM BlackBerry OS

This is the operating system used in all BlackBerry devices. Despite having been popular in corporate sector, BlackBerry devices are losing market share to Android and iPhone. However, they still have a loyal following of users who are used to the signature hardware keyboard of BlackBerry devices and the convenience of the built-in corporate features of BlackBerry OS. RIM's attempts at entering the touch screen smartphone market haven't been too successful due to the limited number of quality apps available, though their recently released tablet called BlackBerry Playbook appears promising. Playbook is the first BlackBerry device to ship with their latest OS called QNX which is set to replace the older BlackBerry OS. Future phones by BlackBerry are also expected to ship with QNX.

A recent development that might change things for the better for RIM is the Android App Player that promises to bring support for running hundreds of thousands of Android apps on BlackBerry OS devices, as demoed at the recent BlackBerry World 2011 keynote.

– HP WebOS (Previously Palm WebOS)

Palm – despite being one of the initial players of the smartphone market – experienced declining market share and dropping revenues due to their old PalmOS devices not being able to keep up with iOS and Android. Palm tried to counter it by replacing its dying PalmOS with an entirely new operating system built from scratch – WebOS. Although WebOS was built by Palm as a pretty solid and feature-rich operating system having a killer interface to match, it wasn't enough to keep the company's lost reputation. Eventually, at the verge of bankruptcy, Palm ended up getting acquired by HP in 2010. The acquisition was followed by HP's announcement of continuing development of the Palm devices as well as WebOS under HP's brand name.

At its core, WebOS derives heavily from Linux and uses several open source components, maintained at the Palm Open Source website. HP is heavily promoting Palm OS and releasing several devices running it, including HP Veer & HP Pre 3 smartphones and HP TouchPad tablet. While WebOS doesn't have a prominent market share at the moment, things seem promising for this platform's future.

Third Party Proprietary Operating Systems

Another scenario is proprietary operating systems built by companies that do not manufacture devices, but license their operating system to manufacturers for running

it on theirs. The biggest examples are Windows Mobile and Windows Phone 7, built by Microsoft and found running on smartphones by HTC, Samsung, Dell and LG, amongst others. These operating systems also have usually a consistent appearance and behavior across all devices, just like Windows 7 appears and behaves the same regardless of what brand of computer you are running it on.

Let's take a look at these operating systems in detail.

– Microsoft Windows Mobile

You might be wondering what this now-obsolete operating system is doing in an article on modern mobile operating systems. However, no discussion on mobile operating systems can be complete without the mention of Windows Mobile. Back when PalmOS devices featured a grid of icons offering only the most basic built-in apps, BlackBerry OS and Symbian devices didn't even have touch screens. and iOS wasn't even around, Windows Mobile devices did almost all that modern smartphone operating systems do, and then some.

Windows Mobile devices were called Pocket PCs and were true to their name! The operating system had true multitasking, installation of apps using cab files, full file system access, registry access, options for replacing the entire user interface with another, integrated data tethering support, personal information synchronization and a complete office suite.

The platform enjoyed a loyal following amongst enthusiasts and lead to the creation of the famous XDA-Developers community where developers and power users from the whole world gathered to share their customizations and hacks for Windows Mobile devices. Later on, this community expanded to **Android devices** and is today the largest smartphone customization community online. Installing a heavily customized version of Windows Mobile to a device was as simple as connecting it to the computer via USB and running a standard software installation wizard on the computer, no ridiculous jail breaking/rooting/recovery/command line use required.

The primary reasons behind the fall of Windows Mobile were the inability of Microsoft to market it to the masses, little-to-no focus from Microsoft on developing an app ecosystem that would encourage developers to build apps for the platform, and the popularity gained by Apple's iPhone, which Windows Mobile couldn't compete against due to an interface that wasn't finger-friendly and required the use of a stylus.

In 2010, Microsoft decided to abandon Windows Mobile altogether in favor of Windows Phone 7. It's legacy however, remains. HTC Sense – hugely popular on Android – was initially made for Windows Mobile devices. Furthermore, Android's default interface involving multiple home screens, home screen previews and widgets on each screen derives heavily from the interface of SPB Mobile Shell – a third party Windows Mobile interface that innovatively introduced users to this concept.

– Microsoft Windows Phone 7

Windows Phone 7 was Microsoft's answer to the flourishing smartphone world. With Windows Mobile left abandoned, Microsoft built Windows Phone 7 from scratch, and presented users with an interface like no other. Given the name of Metro, this user interface takes a break from the conventional icon grids used by most competitors and brought the concept of live tiles on the home screen, focusing heavily on the presentation of information to users in a fluid, unobtrusive way. The result looked impressive, to say the least. However, many of the signature features of Windows Mobile such as true multitasking, app side loading etc. were dropped, drawing heavy criticism by loyal Windows Mobile users.

Although Windows Phone 7 hasn't gained a major market share by now, things look very promising as Microsoft has announced a major update for fall 2011, bringing true multitasking and several other important features to the platform in a few months. Developments on bringing app side loading are also under way. Apart from this, Microsoft is concentrating heavily on the app ecosystem in cooperating with developers and the Windows Live Marketplace has become the fastest growing app market today. Furthermore, Nokia has decided to switch from Symbian/MeeGo to Windows Phone 7 as its smartphone platform, and this alone promises to boost the market share of this operating system to a significant extent across the globe.

At present, there are over a dozen Windows Phone 7 devices available in the market, built by manufacturers such as HTC, Samsung, Dell and LG. Several other manufacturers including Nokia have also decided to join in, and many new Windows Phone 7 devices are expected to be released this year.

Free & Open Source Operating Systems

Last but not the least, there are open source operating systems built by a company, a group of companies or a community of developers and made available for everyone to modify them in any way they choose, and install them on their choice of devices.

Examples of these operating systems include Symbian, the upcoming MeeGo and most importantly, Android. Device manufacturers fine-tune such operating systems to best suit their devices and often add additional features or interfaces to set them apart from other versions of the same operating system, and this often becomes their selling point. HTC has had a history of customizing Android for its phones and including a graphically enhanced interface called HTC Sense in an effort to enhance user experience.

Furthermore, such operating systems have a lot more customizations available in form of installable software that changes their look, feel and behavior, providing different entirely user experiences. Being open source, these operating systems also offer independent developers the opportunity to modify them from scratch and run them on devices not supported officially, or to bring an entirely new user experience to officially supported devices.

Let's now individually examine major operating systems in this category.

– Android

When an operating system is open source, based on Linux, owned by Google, backed by all major mobile device manufacturers including HTC, Samsung, Motorola, Dell, Sony Ericsson, LG and countless more, and allows for endless customization, it is bound to make an impact. Initially developed by Android Inc. and purchased by Google in 2005, Android has become the leading smartphone OS in the world today, and is our smartphone platform of choice here at AddictiveTips. While it appeals more to the techies amongst us, Android has been received well by the non-techies as well, and with an app market boasting over 200,000 apps, there's plenty to do with it as well.

Android runs on literally hundreds of devices including smartphones and tablets. With multiple new releases each year, the operating system is continuously evolving. At present, the latest version for smartphones is 2.3.4 Gingerbread while that for tablets is 3.1 Honeycomb. The upcoming major release scheduled for Q3 or Q4 this year is called Ice Cream Sandwich and aims to bring both phone and tablet versions together.What truly rocks about Android is the level to which it can be customized. With different launchers and widgets, the entire way in which a user interacts with the device can be changed. If you are an Android user or plan on switching to it, you must check out our **Android customization series** to see how to personalize it beyond recognition!

Android has already beaten iOS to become the most widely used smartphone OS in the world, though its app Market still lags behind the Apple App Store in terms of the number of apps by roughly 100,000 apps, plus iOS apps in general tend to be more refined than Android apps, and this is the only reason we can see for any rational person to choose an iOS device over an Android device, but that's our personal opinion.

– MeeGo

A few years back, Nokia and Intel decided to merge their Linux-based Maemo and Moblin operating systems to form MeeGo, and several other high-profile companies also joined in to contribute to the open source project. Things seemed to be promising, smartphone and tablet enthusiasts – including us – were eagerly anticipating developments to bear fruit in form of another Android to bring competition to the market and provide a further incentive for innovation, when all of a sudden a key player i.e. Nokia decided to abandon it and switch over to Windows Phone 7 as its primary smartphone platform.

While Nokia has still announced to stick with its promise of releasing one MeeGo device this year before abandoning the project entirely, things aren't looking too well for the platform and unless Intel and the other companies involved really give it their level best, MeeGo might end up like one of those obscure Linux distributions that only the developers and their six friends use or worse, it could be entirely abandoned, though we hope that isn't the case.

– Symbian

There is a saying, "If you don't succeed at the first attempt, skydiving isn't for you!", and it applies too well in Symbian's case. Symbian – in its various forms – has

been the operating system of thousands of devices by dozens of manufacturers but despite its commercial success, it has failed to achieve any critical acclaim in the smartphone arena despite Nokia's repeated efforts of trying to get it right. We are including it here only due to the number of smartphones running Symbian globally, despite a negligible share in the United States. In all other aspects, it doesn't even come close to any of the other smartphone operating systems mentioned in this guide.

Nokia finally decided to let go of Symbian along with MeeGo to switch to Windows Phone 7 as its smartphone platform but without entirely abandoning it, as the company will continue to use it for its feature phones (phones that aren't smartphones).

The future of Symbian in the smartphone world is practically over. With Nokia's abandonment and more and more users switching to Android, iOS and Windows Phone 7 globally, it is safe to conclude that Symbian no longer has a place in the smartphone world.

Which Smartphone OS is the best?

Now that you are acquainted with all major smartphone operating systems out there, it's time for this important question. The answer is: whichever works best for you! Here at AddictiveTips, we are all for Android and I personally don't even like iOS one bit, yet I recommend iPhone to many people as it appears to suit them better. We would love to see MeeGo get released on a few high-end devices, HP WebOS gain more attention as well as apps and Windows Phone 7 become more open. Till then however, considering the development, the app ecosystem and the customization options, for most users, Android is currently the smartphone OS to go for.

Mobile Computing

Mobile Computing is a technology that allows transmission of data, voice and video via a computer or any other wireless enabled device without having to be connected to a fixed physical link. The main concept involves :-

- Mobile communication
- Mobile hardware
- Mobile software

- A technology that is capable of providing an environment which enables users to transmit data from one device to other device without the use of any physical link/cables is known as Mobile Computing.
- It means, data transmission is done wireless-ly with the help of wireless devices such as mobiles, laptops etc.
- Whenever any device is connected to a network without being connected physically over a link or cable, data transmission such as messages, voice recording, videos etc. can be done be done by using the concept of mobile computing.
- Mobile Computing technology helps users to access and transmit data from any remote locations without being present there physically.

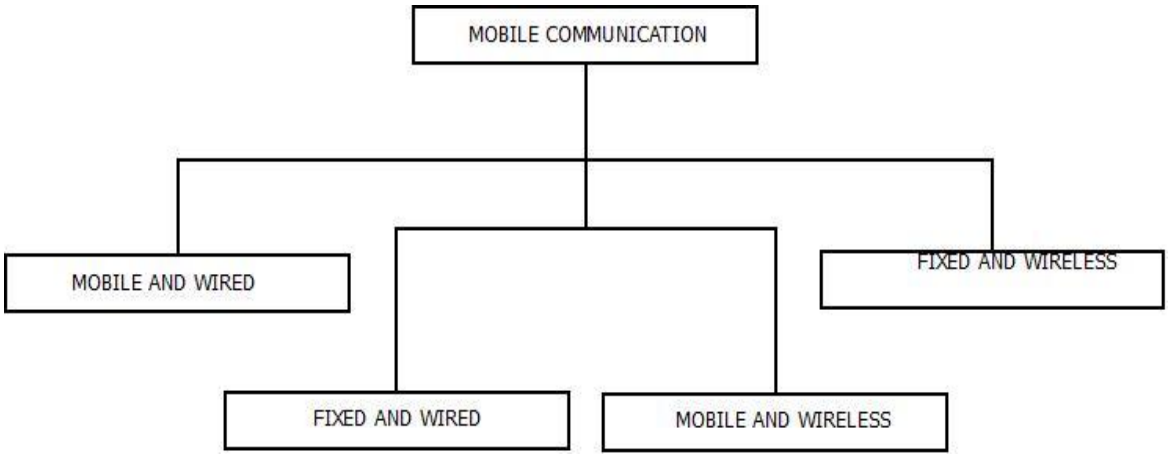
- Thus, having such a big coverage diameter, it is one of the fastest and most reliable sectors of computing technology field.

Mobile communication

The mobile communication in this case, refers to the infrastructure put in place to ensure that seamless and reliable communication goes on. These would include devices such as protocols, services, bandwidth, and portals necessary to facilitate and support the stated services. The data format is also defined at this stage. This ensures that there is no collision with other existing systems which offer the same service.

Since the media is unguided/unbounded, the overlaying infrastructure is basically radio wave-oriented. That is, the signals are carried over the air to intended devices that are capable of receiving and sending similar kinds of signals.

- Mobile Communication is the framework that is responsible behind the working of mobile computing technology.
- It ensures the consistency and reliability of communication process through this framework.
- Mobile communication framework includes communication devise such as mobiles, laptops, as rules of conduct, fitness etc. They are responsible for delivering of smooth communication process.
- Mobile communication can be of one of the following form as mentioned below.



1. **Mobile and Wired :** In this configuration, Some of the devices are wired and some are mobile in nature. For Example : Laptops.
2. **Fixed and Wired :** In this configuration, The devices are fixed at a position and are connected through a physical link for communication. For Example : Office/Desktop Computer.
3. **Mobile and Wireless :** In this configuration, devices can communicate(data transmission) with each other irrespective of their position and can connect to any network without the use of any wired device. For Example : WiFi Dongle.

Mobile Hardware

Mobile hardware includes mobile devices or device components that receive or access the service of mobility. They would range from portable laptops, smartphones, tablet Pc's, Personal Digital Assistants.

These devices will have a receptor medium that is capable of sensing and receiving signals. These devices are configured to operate in full- duplex, whereby they are capable of sending and receiving signals at the same time. They don't have to wait until one device has finished communicating for the other device to initiate communications.
Above mentioned devices use an existing and established network to operate on. In most cases, it would be a wireless network.

Mobile software

Mobile software is the actual program that runs on the mobile hardware. It deals with the characteristics and requirements of mobile applications. This is the engine of the mobile device. In other terms, it is the operating system of the appliance. It's the essential component that operates the mobile device.

Since portability is the main factor, this type of computing ensures that users are not tied or pinned to a single physical location, but are able to operate from anywhere. It incorporates all aspects of wireless communications.

Applications : Mobile Computing

- Some of the major field in which mobile computing can be applied are:
  - Web or Internet access.
  - Global Position System(GPS).
  - Emergency services.
  - Entertainment services
  - Educational services.

Advantage of Mobile Computing :

1. Increasing productivity — Mobile devices can be used in the field of various instruments, so reducing time and cost for customers and themselves.
2. Entertainment — For entertainment purposes, mobile devices can be used for both people and customers for personal and even presentations.
3. Portability — The main advantages of this, you are not bound to one Zone . It help to access any wireless devices without place boundation.
4. Cloud Computing — This service is available to save documents on online servers and whenever you make a connection to the Internet, they are able to
access them at anytime and anywhere and these files can be used for many mobile devices or even That can also access on PC.

Disadvantage of Mobile Computing :

- Battery consumption hindrance
- Interference is persisted in shielding.
- Inefficient bandwidth in transmission.
- Connection losses over entire network.
- Network stability.
- Interoperability problem.
- Protection constraints.

Limitations of Mobile Computing

- Resource constraints: Battery
- Interference: Radio transmission cannot be protected against interference using shielding and result in higher loss rates for transmitted data or higher bit error rates respectively
- Bandwidth: Although they are continuously increasing, transmission rates are still very low for wireless devices compared to desktop systems. Researchers look for more efficient communication protocols with low overhead.

- Dynamic changes in communication environment: variations in signal power within a region, thus link delays and connection losses
- Network Issues: discovery of the connection-service to destination and connection stability
- Interoperability issues: the varying protocol standards
- Security constraints: Not only can portable devices be stolen more easily, but the radio interface is also prone to the dangers of eavesdropping. Wireless access must always include encryption, authentication, and other security mechanisms that must be efficient and simple to use.

What is a Mobile Computing System

Mobile Computing System is a distributed system, which is connected via a wireless network for communication. The clients or the nodes possess mobility and the ability to provide computing at anytime, anywhere.

Main Components of a Mobile Computing System

A mobile computing system consists of the following components.

Mobile Hardware

Mobile Hardware is a small and portable computing device with the ability to retrieve and process data. Smartphones, handheld and wearable devices fall under mobile hardware. These devices typically have an Operating System (OS) embedded in them and able to run application software on top of it. These devices are equipped with sensors, full-duplex data transmission and have the ability to operate on wireless networks such as IR, WiFi, and Bluetooth.

Mobile Software

Mobile Software is the software program which is developed specifically to be run on mobile hardware. This is usually the operating system in mobile devices. These operating systems provide features such as touchscreen, cellular connectivity, Bluetooth, Wi-Fi, GPS mobile navigation, camera, video camera, speech recognition, voice recorder, music player, near field communication and sensors. The device sensors and other hardware components can be accessed via the OS.

Mobile Communication

Mobile Communication refers to the exchange of data and voice using existing wireless networks. The data being transferred are the applications including File Transfer (FT), the interconnection between Wide-Area-Networks (WAN), facsimile (fax), electronic mail, access to the internet and the World Wide Web. The wireless networks utilized in communication are IR, Bluetooth, W-LANs, Cellular, W-Packet Data networks and satellite communication system. It is the mobile communication infrastructure which takes care of seamless and reliable communication between mobile devices.

Principles of Mobile Computing

The following factors have been identified as the Principles of Mobile Computing.

Portability

Devices/nodes connected within the mobile computing system should facilitate mobility. These devices may have limited device capabilities and limited power supply, but should have a sufficient processing capability and physical portability to operate in a movable environment.

Connectivity

This defines the Quality of Service (QoS) of the network connectivity. In a mobile computing system, the network availability is expected to be maintained at a high level with the minimal amount of lag/downtime without being affected by the mobility of the connected nodes.

Interactivity

The nodes belonging to a mobile computing system are connected with one another to communicate and collaborate through active transactions of data.

Individuality

A portable device or a mobile node connected to a mobile network often denote an individual; a mobile computing system should be able to adopt the technology to cater the individual needs and also to obtain contextual information of each node.

Fixed Vs. Wireless Networks : The Difference

- The difference between Fixed Vs. Wireless networks can be seen as, wireless networks does not require any sort of cables to get the devices connect physically. It is a shared medium that can be accessed easily.
- While in case of fixed networks, physical configuration of devices is required in order to perform data transmission process. Every new device needs to be connected separately and physically to the network. Let’s have a look at their comparisons.

Wireless Networks	Fixed Networks
1) No physical configuration is required.	1) Physical configuration is required.
2) Data loss rate is high.	2) Since a perfect link is established, data loss rate is very low.
3) Low data transmission rate which results in less speed.	3) High rate of data transmission ad hence high speed.
4) More delays.	4) Less delays.
5) Low on security.	5) Highly secured.

Fixed Vs. Wireless Networks : Issues in Mobile Computing

- Mobile computing technology has a number of advantages- from mobility to portability and from cloud to productivity. But, there are certain issues which do pops out while using the mobile computing technology. These are:

1. **Wireless Medium**
   - Since the mobile computing technology mainly focuses on wireless infrastructure, issues like cost, efficiency, delays and security needs to be considered too.
2. **Device Mobility**
   - The device mobility is certainly a major advantage of mobile computing technology. But, it is one of its major issue too.
   - The mobility feature of mobile computing technology needs to be of highest standards. It means, this configuration needs to structure the environment, every time the mobile device changes it's environment.
   - Device mobility feature needs to work and configure itself according to the location, environment and surroundings of a mobile device on regular basis.
3. **Security Issues**
   - It is one of the most discussed issue with mobile computing technology, as it arises due to the shared medium ability.
   - The major security issues includes:
     - Data Security à Physical Security.
     - System Security à Network Security.
   - Some of the most common tactics used to get rid of these issue are:
     - Use of VPN technology.
     - Use of Cryptography & Network Security.
     - Use of Firewall technology.

Advantages : Mobile Computing Technology

- Device Mobility.
- Simple Framework/Infrastructure.
- Portability
- Better Productivity.
- Use of cloud technology.

Disadvantages : Mobile Computing Technology

- Less Secured.
- Low data transmission rates.
- High data losses.
- High on power consumption.
- Frequent network issues.

Mobile Computing vs. wireless Networking

The terms "mobile" and "wireless" are often used interchangeably but in reality, they are two very different concepts applied to modern computing and technology.

Mobile is a word that is commonly used to describe portable devices. Wireless, on the other hand, does not mean mobile.

A mobile device is one that is made to be taken anywhere. Therefore, it needs an internal battery for power, and must be connected to a modern mobile network that can help it to send and receive data without attaching to a hardware infrastructure.

Wireless, on the other hand, does not mean mobile. Traditional computers or other non-mobile devices can access wireless networks. One very common example is the use of a localized browser product in a local area network (LAN), where the router takes what used to be a cabled interaction and makes it wireless. Other kinds of wireless networks called wide area networks (WAN) can even use components of 3G or 4G wireless systems made specifically for mobile devices, but that doesn't mean that the devices on these networks are mobile. They may still be plugged in or require proximity to a router or network node.

Mobile and wireless systems really accomplish two very different things. While a wireless system provides a fixed or portable endpoint with access to a distributed network, a mobile system offers all of the resources of that distributed network to something that can go anywhere, barring any issues with local reception or technical area coverage.

For another example of the difference between mobile and wireless, think of businesses that offer Wi-Fi hotspots. A Wi-Fi hotspot is typically a resource for someone who has a relatively fixed device, such as a laptop computer that doesn't have its own internal Internet access built in. By contrast, mobile devices already have inherent access to the Internet or other wireless systems through those cell tower networks that ISPs and telecom companies built specifically for them. So mobile devices don't need Wi-Fi - they already have their connections.

To some who are used to using both wireless and mobile networks, this distinction may seem very simple. However, the difference between providing mobile and wireless is likely to be something that gets explored more as new technologies continue to develop, and companies continue to offer more different kinds of interfaces to consumers.

Wireless vs. Mobile Computing

As you know that wireless refers to the method of transferring the information between a computing device without any physical connection.

And you also know that now all the wireless communications technologies are mobile.

Mobile simply describes a computing device that is not restricted to a desktop. A mobile device may be a PDA (Personal Data Assistant), a Smart cell phone, a laptop computer, or any one of numerous other devices that allows the users to complete computing tasks without being tethered or connected to a network.

Mobile computing does not necessarily require wireless communication. In fact, it may not require communication between the devices at all.

As already told that wireless communication is a data communication without any use of landlines. This may involve cellular telephone, two-way radio, fixed wireless, laser, or satellite communications. Here the computing device is continuously connected to the base network.

Mobile or untethered computing means that the computing device is not continuously connected to the base or central network.

Mobile devices includes PDAs, laptop computers, and many of today's cell phones also called as smart phones. These products may communicate with a base location with or without a wireless connection.

Here is a table that gives you an idea about different computing devices, which can be either wireless or mobile or both:

Example	Wireless	vs.	Mobile
Stationary computer	No		No
Notebook in a hotel	No		Yes
Wireless LANs in historic buildings	Yes		No
PDA	Yes		Yes
Smart phones, pagers	Yes		Yes

Wireless/Mobile Computing Technologies

Here are the list of some important technologies and interfaces used for wireless and mobile computing that you will learn in separate tutorials:

- GSM
- CDMA
- WLL
- GPRS
- 1G, 2G, 3G, and 4G Networks
- 3G and EDGE
- 4G and LTE
- SMS
- Chat
- Video Conferencing
- Voice over Internet Protocol (VoIP)
- Wi-Fi
- Wi-Fi Hotspots
- WiMax

From my point of view, wireless communication refers to the technology being used, i.e., communication "over the air", without wires. It does NOT state anything about the behavior of the devices (with respect to mobility). In contrast, mobile communication states technology agnostic that devices are mobile, i.e., can/will/should move around the scene. This typically implies a wireless communication paradigm, i.e., communication in a mobile scenario is (nearly) always wireless, but you can also use wireless communication in a completely static (with respect to the mobility of the devices) environment.

Mobile is subgroup from wireless. We have wireless systems that are not mobile and we have technologies which are wireless but not mobile in sense of technologies deployed in mobile operators networks. We have fixed wireless (e.g. fixed WiMAX) and e.g. TETRA which is not technology deployed in mobile (operators) networks.

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Wireless communication is the technology used to achieve mobility in mobile communication

Mobile is subgroup from wireless. We have wireless systems that are not mobile and we have technologies which are wireless but not mobile in sense of technologies deployed in mobile operators networks. We have fixed wireless (e.g. fixed WiMAX) and e.g. TETRA which is not technology deployed in mobile (operators) networks.

Mobile Computing Applications

1. Traffic:

During traveling in traffic if we require to know road situation, latest news and when if feel more stress in driving then can play music and other important broadcast data are received through digital audio broadcasting(DAB). If we forget the road then we can know our exact location with the help of **global positioning system** (GPS).In case if got accident then can to inform police and ambulance via an emergency call to the service provider, which help to improve organization and save time & money.

2. Emergencies Situation:

To play a vital role in the medical sector can hire an ambulance with great quality wireless connection and help of this can carry significant information about injured persons. The useful step can prepare for a particular accident and doctor can be consulted for diagnosis. Only Wireless networks work of communication in nature disaster 2 such as earthquakes, tsunami, flood, and fire. In worst conditions only decentralized, wireless ad-hoc networks survive. Means that can handle Emergencies situation by mobile computing easily.

3. Use in Business:

As per business point of view CEO help of this computing system can represent the presentation at the front of their clients while can access hot news of the market. Help of video conference could be discuss at the topic without hindrance any time.

Another side if traveling salesman wants to access the company database as per requirement then can be retrieved data on his wireless device and maintain the consistency company's database. Cause of these every employee are updated up to date.

4. Credit Card Verification:

Credit card verification using this computing most secure. In respect of Sale terminals(POS) when customer buy items in malls and other small shops when and pay bill in the form of swap credit card for transactions then need to establish network in between POS terminal and bank central computer then over protected cellular network verify the credential information of card fastly, if match it then proceed further otherwise denied get boost up speed of transaction process and relieve the burden at the POS network.

5. Replacement of Fixed Networks:

Wired network has been replaced in wireless network e.g. trade shows, remote sensors and historical buildings. in wired networks, weather forecasting, earthquake detection and to get environmental data are impossible. This is possible only in adapting the replacement of fixed networks in this computing.

6. Infotainment:

Wireless networks are capable to deliver the latest information at any suitable regions and can download knowledge about concert at morning through wireless network that concert is conducting in any region as well as Another growing field of wireless network applications lies in entertainment and games to enable, e.g., ad-hoc gaming networks as soon as people meet to play together. So Infotainment by wireless computing is more easy.

Characteristics of Mobile computing

1. **Portability** - The Ability to move a device within a learning environment or to different environments with ease.
2. **Social Interactivity** - The ability to share data and collaboration between users.
3. **Context Sensitivity** - The ability to gather and respond to real or simulated data unique to a current location, environment, or time.
4. **Connectivity** - The ability to be digitally connected for the purpose of communication of data in any environment.
5. **Individual** - The ability to use the technology to provide scaffolding on difficult activities and lesson customization for individual learners.
6. **Small Size -** Mobile devices are also known as handhelds, palmtops and smart phones due to their roughly phone-like dimensions. A typical mobile device will fit in the average adult's hand or pocket. Some mobile devices may fold or slide from a compact, portable mode to a slightly larger size, revealing built-in keyboards or larger screens. Mobile devices make use of touch screens and small keypads to receive input, maintaining their small size and independence from external interface devices. The standard form of a mobile device allows the user to operate it with one hand, holding the device in the palm or fingers while executing its functions with the thumb.

Netbooks and small tablet computers are sometimes mistaken for true mobile devices, based on their similarity in form and function, but if the device's size prohibits one-handed operation or hinders portability, then it cannot be considered a true mobile device.

7. **Wireless Communication** - Mobile devices are typically capable of communication with other similar devices, with stationary computers and systems, with networks and portable phones. Base mobile devices are capable of accessing the Internet through Bluetooth or Wi-Fi networks, and many models are equipped to access cell phone and wireless data networks as well. Email and texting are standard ways of communicating with mobile devices, although many are also capable of telephony, and some specialized mobile devices, such as RFID and barcode.

Limitations of Mobile Computing

1. Deficient Bandwidth: Mobile web access is usually slower than direct cable connections, victimization technologies like GPRS and EDGE, and additional recently 3G networks. These networks are typically accessible at intervals vary of economic mobile phone towers. Higher speed wireless LANs are cheap however have terribly restricted vary.

2. Security Standards: once operating mobile, one relies on public networks, requiring careful use of Virtual personal Network (VPN). Security could be a major concern whereas regarding the mobile computing standards on the fleet. One will simply attack the VPN through an enormous variety of networks interconnected through the road.

3. Power consumption: once an influence outlet or moveable generator is not accessible, mobile computers should swear entirely on battery power. Combined with the compact size of the many mobile devices, this typically means that uncover priced batteries should be accustomed get the required battery life. Mobile computing should additionally look at Greener IT, in such the simplest way that it saves the ability or will increase the battery life.

4. Transmission interferences: Weather, terrain, and also differ from the closest signal purpose will all interfere with signal response. Reception in tunnels, some structures, and rural areas is usually poor.

5. Potential health hazards: those that use mobile devices whereas driving are usually distracted from driving are so assumed additional probably to be concerned in traffic accidents. Cell phones could interfere with sensitive medical devices. There are allegations that mobile phone signals could cause health issues.

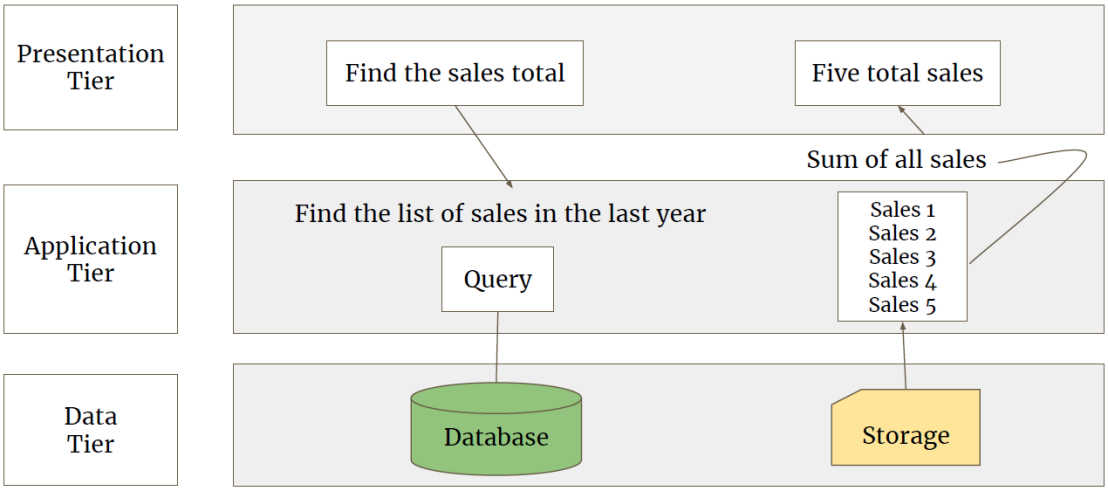
6. Human interface with mechanism: Screens and keyboards are likely to be little, which can create them exhausting to use. Alternate input strategies like speech or handwriting recognition need coaching.

Structure of Mobile Computing Application

- It is structured based on the functionality implementations
- Most of them are 3 tier architecture.

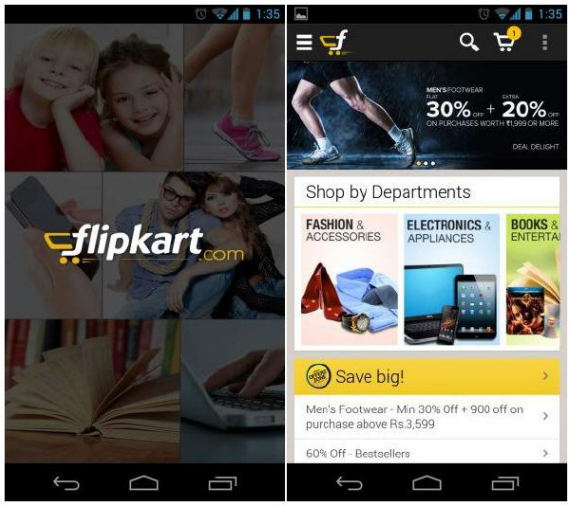
Presentation (Tier - 1)
Applications (Tier - 2)
Data (Tier - 3)

Elaborated View (Sales System)



Presentation Tier

- Top most level of mobile computing application.
- Good user interface that is responsible to produces the results in a meaningful manner.
- Runs on client side.
- Compatible with browsers and customized client applications.
- E.g. : Flip kart Interface



Application Tier

- Vital responsibility of this layer is making **logical decisions** and **performing calculations.**

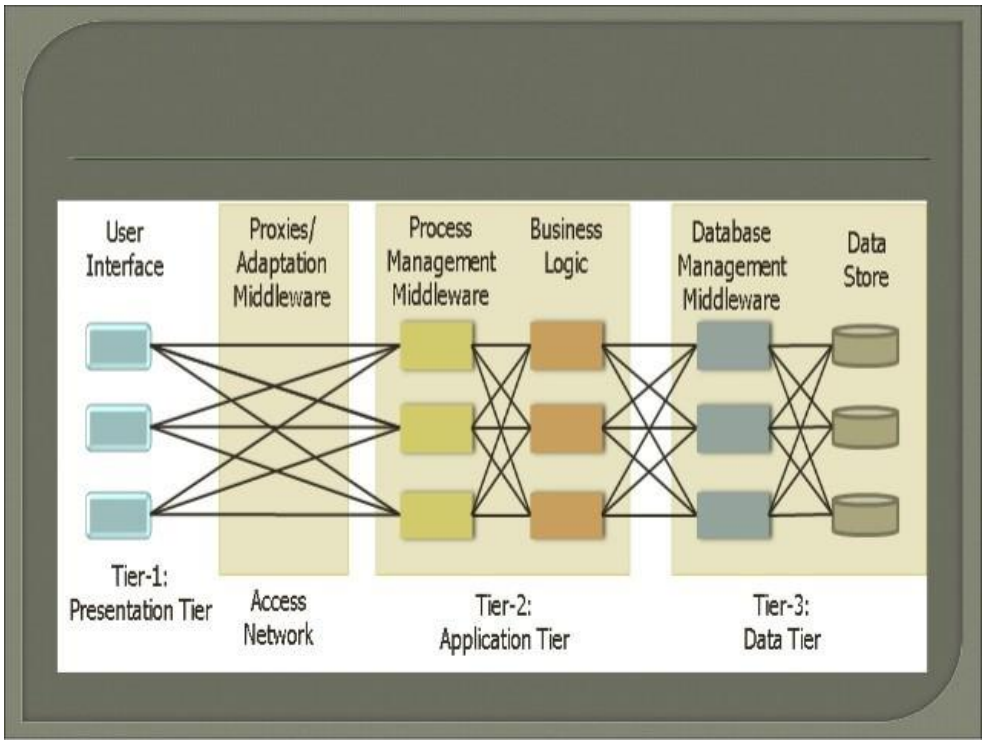
- It moves and process the data between presentation and data tiers.
- It is also considered **engine** of the application.
- It gets the user input information and process with the logic and makes the decisions.
- It is implemented using the technology like Java, .NET services.

Data Tier

- It provides the basic facilities of data.
  - ➢Storage.
  - ➢Access.
  - ➢Manipulations.
- This layer contains databases and Query processors.
- This layer implemented in the fixed server.

A 3-tier architecture is an application program that is organized into three major parts, comprising of:

- *The data access layer tier at the bottom,*
- *The application tier (business logic) in the middle and*
- *The client tier (presentation) at the top.*



Each tier is distributed to a different place or places in a network. These tiers do not necessarily correspond to physical locations on various computers on a network, but rather to logical layers of the application.

1. Presentation Layer (UI):

- This layer presents data to the user and optionally permits data manipulation and data entry, also this layer requests the data form Business layer.
- This layer accomplished through use of Dynamic HTML and client-side data sources and data cursors.

2. Business Logic Layer:

- The business logic acts as the server for client requests from workstations. It acts according Business rules fetch or insert data through the Data Layer.
- In turn, it determines what data is needed (and where it is located) and acts as a client in relation to a third tier of programming that might be located on a local or mainframe computer.
- Because these middle-tier components are not tied to a specific client, they can be used by all applications and can be moved to different locations, as response time and other rules require.

3. Data Access Layer:

- The third tier of the 3-tier system is made up of the DBMS that provides all the data for the above two layers.
- This is the actual DBMS access layer.
- Avoiding dependencies on the storage mechanisms allows for updates or changes without the application tier clients being affected by or even aware of the change.

Mobile Device Operating Systems

A **mobile operating system** (or **mobile OS**) is an operating system for phones, tablets, smartwatches, or other mobile devices.

computers such as typical laptops are 'mobile', the operating systems usually used on them are not considered mobile ones, as they were originally designed for desktop computers that historically did not have or need specific *mobile* features. This distinction is becoming blurred in some newer operating systems that are hybrids made for both uses.

- The mobile operating system is a set of data and programs that runs on a mobile device. It manages the hardware and makes it possible for smartphones, tablets, and wearables to run apps.
- A mobile OS also manages mobile multimedia functions, mobile and internet connectivity, the touch screen, Bluetooth connectivity, GPS navigation, cameras, speech recognition, and more in a mobile device.
- Most operating systems are not interchangeable among devices. If you have an Apple iOS phone, you can't load the Android OS on it and vice versa.

- Mobile operating systems combine features of a personal computer operating system with other features useful for mobile or handheld use; usually including, (modern mobile systems):-
    - Wireless inbuilt modem

- SIM tray for telephony and data connection.
- Touchscreen.
- Cellular, Bluetooth.
- Wi-Fi Protected Access.
- Wi-Fi, Global Positioning System (GPS) mobile navigation.
- Video- and single-frame picture cameras.
- Speech recognition.
- Voice recorder.
- Music player.
- Near field communication.
- Infrared blaster.

There are three **kinds** of Windows **Mobile operating system**, namely, Windows **Mobile** Standard, Windows **Mobile** Professional,Windows **Mobile** Classic.

Commercial Mobile Operating Systems

9 Popular Mobile Operating Systems

- Android OS (Google Inc.) ...
- Bada (Samsung Electronics) ...
- BlackBerry OS (Research In Motion) ...
- iPhone OS / iOS (Apple) ...
- MeeGo OS (Nokia and Intel) ...
- Palm OS (Garnet OS) ...
- Symbian OS (Nokia) ...
- webOS (Palm/HP)

- **Apple's iOS:** Incredibly popular operating system from Apple, running devices such as the iPhone, iPad, iPod Touch, and Apple TV.
- **Google's Android:** Google's mobile device operating system, powering devices from several device manufacturers.
- **Microsoft's Windows Phone:** A newer operating system from Microsoft that ships on devices from a variety of vendors. Windows Phone 7 represents a complete redesign of Microsoft's previous operating system, Windows Mobile 6.5.
- **Research In Motion's Blackberry:** A long-standing favorite in the enterprise due to security and manageability features. The iOS and Android platforms have increased in popularity in recent years and have become alternatives to Blackberry in many enterprises.
- **Nokia's Symbian:** Open-source operating system managed by Nokia. In 2011, Nokia announced that it would begin building devices based on the Microsoft Windows Phone operating system, rendering the future of Symbian questionable.

Software Development Kit: iOS, Android

The **iOS SDK (Software Development Kit)** (formerly **iPhone SDK**) is a software development kit developed by Apple Inc. The kit allows for the development of mobile apps on Apple's iOS operating system.

the iOS SDK helps developers write iOS apps using officially supported programming languages, including Swift and Objective-C. Other companies have also created tools that allow for the development of native iOS apps using their respective programming languages.

What are Mobile Development Tools?

Mobile Development Tools are software designed to assist in the creation of mobile applications. This can be accomplished in multiple ways, for example, there are ***native mobile development tools***, but also ***cross-platform mobile development tools***.

- **Native development tools**
- **Cross-platform development tools (including Coding Platforms, Low-Coding Platforms and No-Coding Platforms).**

Native Mobile Development Tools

A **native development tool** is a software which allows developers to create applications for use in a single particular system family, platform or device, like Android, iOS, or Windows (note: support for Windows Mobile ends in December 2019). A native app is specially made and coded for a specific mobile platform in its native programming language, these being:

- iOS (Objective-C or Swift)
- Android (Java or Kotlin)
- Windows Phone (C#)

There are different guidelines for each of these platforms and developers need to stick to them as they differ in typography, graphic styles, gestures, visual effects, data entry and more.

native mobile development tool:

1. Xcode
2. Android Studio
3. AppCode

Cross-Platform Mobile Development Tools

With **cross-platform mobile development**, programmers on one platform can develop apps for one or more other platforms or mobile operating systems simultaneously. This can also enable developers to essentially use the same code base for different platforms. Meaning that such generic apps can be published and used on both an Android Phone and an iPhone. This greatly reduces the time and costs needed for creating an application, however; there are also down sides. Due to it being one and the same code base, these generic apps tend to have more platform-specific issues and a lower quality (user-interface, performance) than a native application. This of course varies per application, system and platform used.

The reason cross-platform mobile development tools are so handy is because there are so many different types of devices out there. If you want to release your app on as many app stores as possible so that lots of phones and tablets can use it, you'll need the app to support multiple platforms.

Furthermore, this category has also been split into three platforms:

- **Coding Platforms**
- **Low-Coding Platforms**
- **No-Coding Platforms**

Coding Platforms

Coding platforms provide you with full control over your entire development process. The downside is that it requires knowledge over your chosen coding language. But this trade-off is undoubtedly worth it if you can streamline your app to perfection and have perfect control over your application.

1. **Appcelerator**
2. **Xamarin**
3. **Adobe PhoneGap**
4. **Ionic**
5. **React Native**
6. **MobiLoud**
7. **Ninox**

Low-Coding Platforms

Want to make the process less time consuming? Then these low-coding platforms might be what you're looking for. These platforms are able to efficiently streamline your development process, by limiting the amount of coding that is required. Instead the platform itself will assist you with specialized building programs, yet still allowing customization with coding.

1. **OutSystems**
2. **Fliplet**
3. **TrackVIA**

No-Coding Platforms

Even if you have no prior knowledge of coding whatsoever, these days, you can still create an app that's perfectly suited for your company. This is made possible through the use of no-coding platforms, they provide you with services, such as, a drag-and-drop interface, allowing you to create an application without typing a line of code. The downside is that because it's made to be simple and efficient, it removes a large chunk of customisation and flexibility that comes with coding.

1. **AppSheet**
2. **Quick Base**
3. **Alpha anywhere**
4. **BuildFire**

Best Mobile App Development Tools For 2019

There are plenty of mobile app development tools and frameworks that can help you create app for single or multiple platforms. If you are willing to build an app from scratch, the following are the best app development tools for 2019.

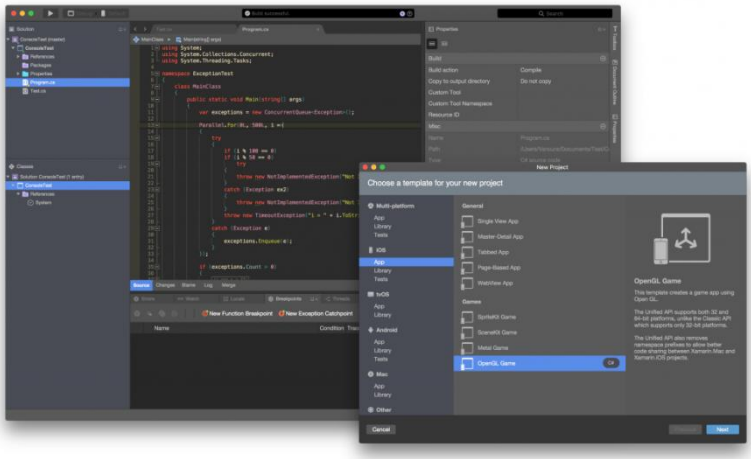
1. Android Studio

Android presents unrepressed amount of opportunities for Android developers, with density of users owning Android smartphones hitting the peak.
Android studio is without a doubt a best Android app development tool in 2019 and is likely to stay like that in coming years. Android studio presents you with incredible resources, handy tools and other important features.

2. Xcode

Xcode is considered as the best iPhone app development tool for 2019 as it is wholeheartedly dedicated to helping iOS developers build impeccable, slick and highly engaging apps for Apple's iOS platform.
Xcode comes with professional polished editor that lets you write flawless codes with advanced code completer, syntax highlighting and code folding.
It contains message bubble as well to give you warning of errors and code-related information so that you can correct or improve it in time. You can design and test the app UI and use its graphic debugger for more refined results.

3. Xamarin



Xamarin is compatible cross-platform framework based on C# that app developers can leverage. The best trait about the tool is that it allows users to work with native IDEs, APIs or languages.

This quality makes Xamarin a preferred choice of tool for building native applications. This wonderful tool enables data access across multiple platforms and reuses business logic layers.

This attribute of Xamarin gives developers a handsome advantage while implementing specific functions such as local data, offline capability, image recognition and more.
The framework is quite useful for creating apps for popular mobile platforms: Android, iOS and Windows.

MAC Protocols

Media access control (**MAC**) is a sublayer of the data link **layer** (DLL) in the seven-**layer** OSI network reference model. **MAC** is responsible for the transmission of data packets to and from the network-interface card, and to and from another remotely shared channel.

What is the use of MAC protocol?

In telecommunication **protocols**, **MAC** addresses are used by the Media Access Control sub-**layer** of the Data Link Control (DLC) **layer**, which is the **protocol layer** of a program that handles the flow of data moving in and out over physical links in the network.

What is the role of MAC address?

The purpose of **MAC addresses** is to provide a unique hardware **address** or physical **address** for every node on a local area network (LAN) or other network. A node is a point at which a computer or other device (e.g., a printer or router) is connected to the network.

Wireless MAC Issues

The media access control (**MAC**) is a data communication protocol and it is a sub-layer of the data link layer. It allows several nodes in the network to share the medium using the channel access control mechanisms. Collision in **MAC** layer is the major issue in **wireless** transmissions.

Wireless MAC protocols

- **Fixed Assignment Protocols (Reservation Based Schemes)**
- **Demand assignment Protocols**
- **Random Assignment Protocols**

Fixed Assignment Protocol

- In fixed-assignment strategies, each node is allocated a predetermined fixed amount of the channel resources. Each node uses its allocated resources exclusively without competing with other nodes. reserve some resources (time, frequency, etc) for each node so that no collisions can occur.
- No loss of capacity due to collision.
- But we waste resources when reservations are not fully utilized.
- Called as Circuit Switched Schemes
- Resources are assigned for the entire call duration while making call
- Typical protocols that belong in this category include
  - frequency-division multiple access (**FDMA**)

- time-division multiple access (**TDMA**)
- code-division multiple access (**CDMA**)

FDMA

Frequency Division Multiple Access (FDMA) is one of the most common analogue multiple access methods. The frequency band is divided into channels of equal bandwidth so that each conversation is carried on a different frequency.

FDMA is the process of dividing one channel or bandwidth into multiple individual bands, each for use by a single user. Each individual band or channel is wide enough to accommodate the signal spectra of the transmissions to be propagated. The data to be transmitted is modulated on to each subcarrier, and all of them are linearly mixed together.

A specific frequency band is given to one person, and it will received by identifying each of the frequency on the receiving end. It is often used in the first generation of analog mobile phone.

Advantages of FDMA

As FDMA systems use low bit rates (large symbol time) compared to average delay spread, it offers the following advantages −

- Reduces the bit rate information and the use of efficient numerical codes increases the capacity.
- It reduces the cost and lowers the inter symbol interference (ISI)
- Equalization is not necessary.
- An FDMA system can be easily implemented. A system can be configured so that the improvements in terms of speech encoder and bit rate reduction may be easily incorporated.
- Since the transmission is continuous, less number of bits are required for synchronization and framing.

Disadvantages of FDMA

Although FDMA offers several advantages, it has a few drawbacks as well, which are listed below −

- It does not differ significantly from analog systems; improving the capacity depends on the signal-to-interference reduction, or a signal-to-noise ratio (SNR).
- The maximum flow rate per channel is fixed and small.
- Guard bands lead to a waste of capacity.
- Hardware implies narrowband filters, which cannot be realized in VLSI and therefore increases the cost.

TDMA

- TDMA is digital transmission technology that allows a number of communicating nodes to access a single radio-frequency channel without interference. Each user transmits data on a time slot (a channel) on multiple frequencies.

- This is achieved by dividing the radio frequency into time slots and then allocating unique time slots to each communicating node. A user sends data at an accelerated rate (by using many frequencies) when its time slot begins
  Data is stored at receiver and played back at original slow rate
- It is worth noting, however, that *only one node is actually using the channel at any given time for the duration of a time slot.*

Advantages of TDMA

Here is a list of few notable advantages of TDMA −

- Permits flexible rates (i.e. several slots can be assigned to a user, for example, each time interval translates 32Kbps, a user is assigned two 64 Kbps slots per frame).
- Can withstand gusty or variable bit rate traffic. Number of slots allocated to a user can be changed frame by frame (for example, two slots in the frame 1, three slots in the frame 2, one slot in the frame 3, frame 0 of the notches 4, etc.).
- No guard band required for the wideband system.
- No narrowband filter required for the wideband system.

Disadvantages of TDMA

The disadvantages of TDMA are as follow :

- High data rates of broadband systems require complex equalization.
- Due to the burst mode, a large number of additional bits are required for synchronization and supervision.
- Call time is needed in each slot to accommodate time to inaccuracies (due to clock instability).
- Electronics operating at high bit rates increase energy consumption.
- Complex signal processing is required to synchronize within short slots.

CDMA

• CDMA is a spread spectrum (SS)–based scheme that allows multiple communicating nodes to transmit simultaneously. Spread spectrum is a radiofrequency modulation technique in which the radio energy is spread over a much wider bandwidth than that needed for the data rate.

Advantages of CDMA

- One of the main advantages of CDMA is that dropouts occur only when the phone is at least twice as far from the base station. Thus, it is used in the rural areas where GSM cannot cover.

- Another advantage is its capacity; it has a very high spectral capacity that it can accommodate more users per MHz of bandwidth.

Disadvantages of CDMA

- Channel pollution, where signals from too many cell sites are present in the subscriber. s phone but none of them is dominant. When this situation arises, the quality of the audio degrades.
- When compared to GSM is the lack of international roaming capabilities.

- The ability to upgrade or change to another handset is not easy with this technology because the network service information for the phone is put in the actual phone unlike GSM which uses SIM card for this.

- Limited variety of the handset, because at present the major mobile companies use GSM technology.

Demand Assignment protocol

- The main objective of demand assignment protocols is to improve channel utilization by allocating the capacity of the channel to contending nodes in an optimum fashion.
- Demand assignment protocols ignore idle nodes and consider only nodes that are ready to transmit.
- The channel is allocated to the node selected for a specified amount of time, which may vary from a fixed-time slot to the time it takes to transmit a data packet.

- Demand assignment protocols may be further classified as:
  - centralized
  - distributed.
- *Polling* schemes are representative of centralized control.
    - whereas *token- and reservation-based* schemes use distributed control.

Random Assignment Protocols

- Random assignment strategies attempt to reduce problem occur in fixed assignment strategy by eliminating pre allocation of bandwidth to communicating nodes.
- Random assignment strategies do not exercise any control to determine which communicating node can access the medium next. Furthermore, these strategies do not assign any predictable or scheduled time for any node to transmit.
- All backlogged nodes must contend to access the transmission medium. Collision occurs when more than one node attempts to transmit simultaneously. To deal with collisions, the protocol must include a mechanism to detect collisions and a scheme to schedule colliding packets for subsequent retransmissions.

Modern mobile operating systems and their architecture

What is meant by Mobile Operating System?

A mobile operating system, also called a mobile OS, is software that is specifically designed to run on mobile devices such as mobile phones, smartphones, PDAs, tablet computers and other handheld devices. Much like the Linux or Windows operating system controls your desktop or laptop computer, a mobile operating system is the software platform on top of which other programs can run on mobile devices. which controls mobile devices is responsible for determining the functions and features available on mobile devices .

Symbian OS, Window CE, Mac OS are the operating systems used in Mobile computing applications. It offers the user to run an application without considering the hardware specifications and functionalities. It provides functions which are used for scheduling the multiple tasks in a system.

It provides the functions required for the synchronization of multiple tasks in the system. It uses multiple threads synchronization and priority allocation. Management functions (such as creation, activation, deletion, suspension, and delay) are used for tasks and memory. It provides Interfaces for communication between software components at the application layer, middleware layers, and hardware devices.

It facilitates the execution of software components on diversified hardware. It provides Configurable libraries for the GUI (graphic user interface) in the device. It provides User application‘s GUIs, VUI (voice user interface) components, and phone API. It provides the device drivers for the keyboard, display, USB, and other devices.

- Offers the user to run an application without considering the hardware specifications and functionalities.
- Provides functions which are used for scheduling the multiple tasks in a system**.**
- Provides the functions required for the synchronization of multiple tasks in the system.
- Multiple threads synchronization and priority allocation.
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- Facilitates execution of software components on diversified hardware.
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- Provides the device drivers for the keyboard, display, USB, and other devices**.**

List out the features of Mobile Operating Systems.

1. Multitasking
2. Scheduling
3. Memory Allocation

4. File System Interface
5. Keypad Interface
6. I/O Interface
7. Protection and Security
8. Multimedia features

Architecture of Mobile OS.

A mobile OS is a software platform on top of which other programs called application programs, can run on mobile devices such as PDA, cellular phones, smartphone and etc.

Applications
OS Libraries
Device Operating System Base, Kernel
Low-Level Hardware, Manufacturer Device Drivers

Examples of Mobile OS

There are many mobile operating systems. The followings demonstrate the most important ones:

- Java ME Platform
- Palm OS
- Symbian OS
- Linux OS
- Windows Mobile OS
- BlackBerry OS
- Android OS
- iPhone OS
- Google Android Platform
- Windows Phone

Mobile platforms and middleware

Structure Of Mobile Computing Application

- Programming languages are used for mobile system software. Operating system functions to run the software components onto the hardware.
- Middleware components deployment. Layered structure arrangement of mobile computing components is used. Protocols and layers are used for transmission and reception.
- Layered structure arrangement of mobile computing components.
- Protocols and layers used for transmission and reception.

Programming Languages

The following are the programming languages used for Mobile Computing applications are:

- Java - J2SE.
- J2ME (Java2 Micro edition)
- JavaCard (Java for smart card)
- The Java enterprise edition (J2EE) used for web and enterprise server based applications of mobile services
- C and C++
- Visual C++
- Visual Basic

Middleware

- Software components that link the application components with the network-distributed components.
- It is used to discover the nearby device such as Bluetooth.
- It is used to discover the nearby hot spot for achieving device synchronization with the server or an enterprise server.
- It is used for retrieving data (which may be in Oracle or DB2) from a network database.
- It is used for service discovery at network.
- It is used for adaptation of the application to the platform and service availability.

Architecture of Mobile Computing Applications

Client/server architecture (and its variants) is often adopted for this kind of applications. However we have to take into consideration some specific aspects related to the mobile devices (clients), and their connectivity with servers.

Clients

There are many mobile device types, including RIM devices, cellular telephones, PDAs, Tablet, PCs, and Laptop PCs. These mobile devices can typically operate as thin clients or fat clients, or they can be developed so that they can host web pages.

Thin Clients

Thin clients have no custom application code and completely rely on the server for their functionality. They do not depend as heavily on the mobile device‘s operating system or the mobile device type as fat clients. Thin clients typically use widely available web and Wireless Application Protocol (WAP) browsers to display the application content pages.

Fat Clients

Fat clients typically have one to three layers of application code on them and can operate independently from a server for some period of time. Typically, fat clients

are most useful in situations where communication between a client and server cannot be guaranteed.

For example, a fat client application may be able to accept user input and store data in a local database until connectivity with the server is re-established and the data can be moved to the server.

This allows a user to continue working even if he/she is out of contact with the server. Fat clients depend heavily on the operating system and mobile device type and the code can be difficult to release and distribute. Fat clients can be implemented using one, two, or three layers of application code. However, if you only use one layer it is extremely difficult to isolate the individual areas of functionality and reuse and distribute the code over multiple device types.

Mobile Computing System Layers

1. Physical for sending and receiving signals (for example, TDMAor CDMAcoding).
2. Data-link (for example, multiplexing).
3. Networking (for linking to the destination).
4. Wireless transport layer security (for establishing end-to-end connectivity).
5. Wireless transaction protocol.
6. Wireless session protocol.
7. Wireless application environment (for running a web application, for example, mobile e-business).

Android SDK.

- Android is a **software platform** and **Operating System** for mobile devices.
- Android is an operating system based on the Linux kernel, and designed primarily for touchscreen mobile devices such as smartphones and tablet computers.
- The Android SDK provides API libraries and developer tools necessary to build, test, and debug apps for Android.
- Android SDK is a software development kit that enables developers to create applications for the Android platform.
- The Android SDK includes sample projects with source code, development
- tools, an emulator, and required libraries to build Android applications.
- Android is open source and Google releases the source code under the Apache License.
- The Android SDK (software development kit) is a set of development tools used to develop applications for Android platform.
- The Android SDK includes the following:

    - Required libraries

- Debugger
- An emulator
- Relevant documentation for the Android application program interfaces (APIs)
- Sample source code
- Tutorials for the Android OS

Advantages and Disadvantages of Android Mobile OS

Advantages	Disadvantages
Large number of devices using Android**.**	Some device manufacturers add alternative UI front-ends which reduces OS consistency.
Frequent Enhancement**.**	Updates are controlled by device manufacturers and may be slow or nonexistent**.**
Larger number of applications availability.	Applications are not validated**.**
Excellent UI.	
Multi-tasking.	
Free developer tools.	
No restrictions on applications.	
Phones are available from every service provider.	
Many devices can be unlocked with third-party applications.	

iOS platforms

- Apple **iOS** is a proprietary mobile operating system that runs on the **iPhone**, iPad and iPod Touch.
- Apple **iOS** is based on the Mac OS X operating system for desktop and laptop computers.
- The **iOS** developer kit provides tools that allow for **iOS** app development.

Advantages And Disadvantages Of Apple IOS

Advantages	Disadvantages
Excellent UI**.**	Closed Architecture**.**
Larger number of applications Availability**.**	Limited number of devices to choose from – all from apple**.**
Apple validates applications**.**	No multi-tasking for applications
Consistent UI across devices**.**	Applications must be approved by Apple before being made available via the Marketplace**.**
Frequent free OS updates.	Can’t be unlocked

Mobile Internet Protocol And Transport Layer

Overview of Mobile IP

Mobile IP is a communication protocol (created by extending Internet Protocol, IP) that allows the users to move from one network to another with the same IP address. It ensures that the communication will continue without user's sessions or connections being dropped. Mobile IP provides network layer mobility. Provides seamless roaming ''Extends'' the home network over the entire Internet

Mobile IP solves the following problems:

- if a node moves without changing its IP address it will be unable to receive its packets.
- if a node changes its IP address it will have to terminate and restart its ongoing connections every time it moves to a new network area (new network prefix).
- Mobile IP is a routing protocol with a very specific purpose.
- Mobile IP is a network layer solution to node mobility in the Internet.
- Mobile IP is not a complete solution to mobility, changes to the transport protocols need to be made for a better solution (i.e., the transport layers are unaware of the mobile node's point of attachment and it might be useful if, e.g., TCP knew that a wireless link was being used!).

Terminologies:

- **Mobile Node (MN):**
  It is the hand-held communication device that the user caries e.g. Cell phone.
- **Home Network:**
  It is a network to which the mobile node originally belongs to as per its assigned IP address (home address).(is the network within which the device receives its identifying IP address (home address).)
- **Home Agent (HA):**
  It is a router in home network to which the mobile node was originally connected
- **Home Address:**
  The home address of a mobile device is the IP address assigned to the device within its home network.
- **Foreign Network:**
  It is the current network to which the mobile node is visiting (away from its home network).
- **Foreign Agent (FA):**
  It is a router in foreign network to which mobile node is currently connected. The packets from the home agent are sent to the foreign agent which delivers it to the mobile node.
- **Correspondent Node (CN):**
  It is a device on the internet communicating to the mobile node.
- **Care of Address (COA):**
  It is the temporary address used by a mobile node while it is moving away from its home network.
- **Binding**

A binding is the association of the home address with a care-of address.

Working:

Correspondent node sends the data to the mobile node. Data packets contains correspondent node's address (Source) and home address (Destination). Packets reaches to the home agent. But now mobile mode is not in the home network, it has moved into the foreign network. Foreign agent sends the care-of-address to the home agent to which all the packets should be sent. Now, a tunnel will be established between the home agent and the foreign agent by the process of tunneling.

Tunneling establishes a virtual pipe for the packets available between a tunnel entry and an endpoint. It is the process of sending a packet via a tunnel and it is achieved by a mechanism called encapsulation.

Now, home agent encapsulates the data packets into new packets in which the source address is the home address and destination is the care-of-address and sends it through the tunnel to the foreign agent. Foreign agent, on other side of the tunnel receives the data packets, decapsulates them and sends them to the mobile node. Mobile node in response to the data packets received, sends a reply in response to foreign agent. Foreign agent directly sends the reply to the correspondent node.

Key Mechanisms in Mobile IP:

1. **Agent Discovery:**
   Agents advertise their presence by periodically broadcasting their agent advertisement messages. The mobile node receiving the agent advertisement messages observes whether the message is from its own home agent and determines whether it is in the home network or foreign network.
2. **Agent Registration:**
   Mobile node after discovering the foreign agent, sends registration request (RREQ) to the foreign agent. Foreign agent in turn, sends the registration request to the home agent with the care-of-address. Home agent sends registration reply (RREP) to the foreign agent. Then it forwards the registration reply to the mobile node and completes the process of registration.
3. **Tunneling:**
   It establishes a virtual pipe for the packets available between a tunnel entry and an endpoint. It is the process of sending a packet via a tunnel and it is achieved by a mechanism called encapsulation. It takes place to forward an IP datagram from the home agent to the care-of-address. Whenever home agent receives a packet from correspondent node, it encapsulates the packet with source address as home address and destination as care-of-address.

Route Optimization in Mobile IP:

The route optimization adds a conceptual data structure, the binding cache, to the correspondent node. The binding cache contains bindings for mobile node's home address and its current care-of-address. Every time the home agent receives a IP datagram that is destined to a mobile node currently away from the home network, it sends a binding update to the correspondent node to update the information in the correspondent node's binding cache. After this the correspondent node can directly tunnel packets to the mobile node.

Cellular Networks And Wireless LANs Provide

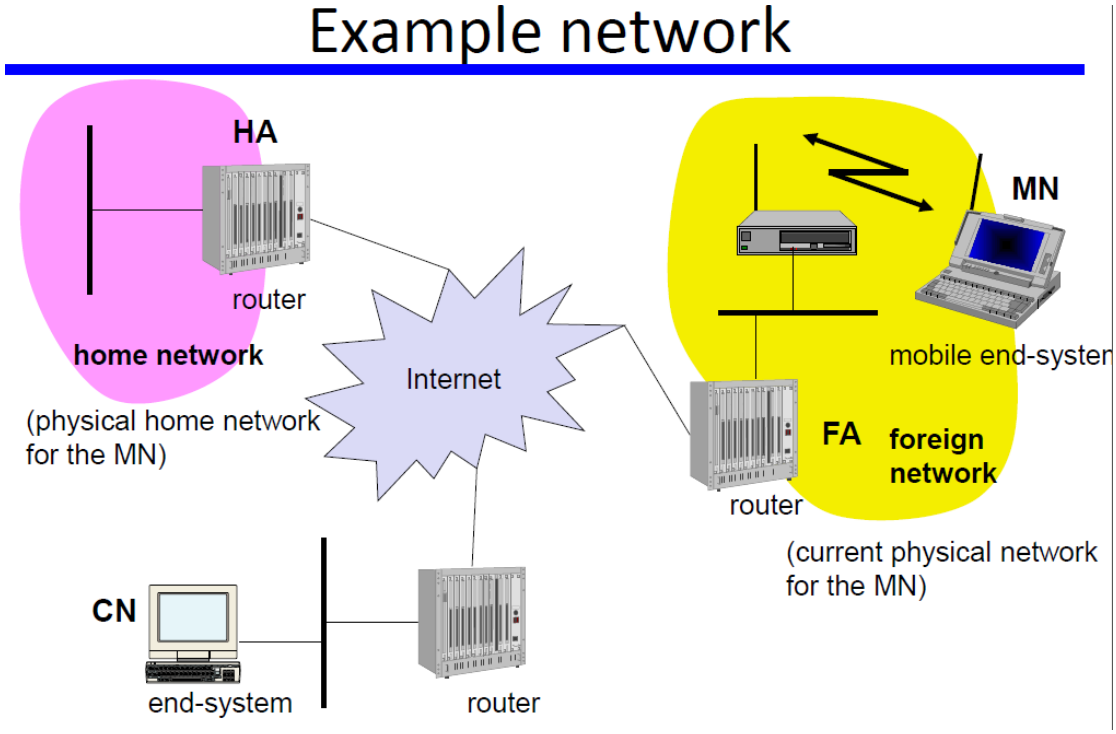
- Wireless connectivity
- Mobility at the data link layer

Dynamic Host Configuration Protocol (DHCP)?

- It provides local IP addresses for mobile hosts.
- Is not secure.
- Does not maintain network connectivity when moving around.

Features of Mobile IP

- Allows a host to be reachable at the same address, even as it changes its location.
- makes it seem as one network extends over the entire Internet.
- continuous connectivity, seamless roaming even while network applications are running.
- fully transparent to the user.

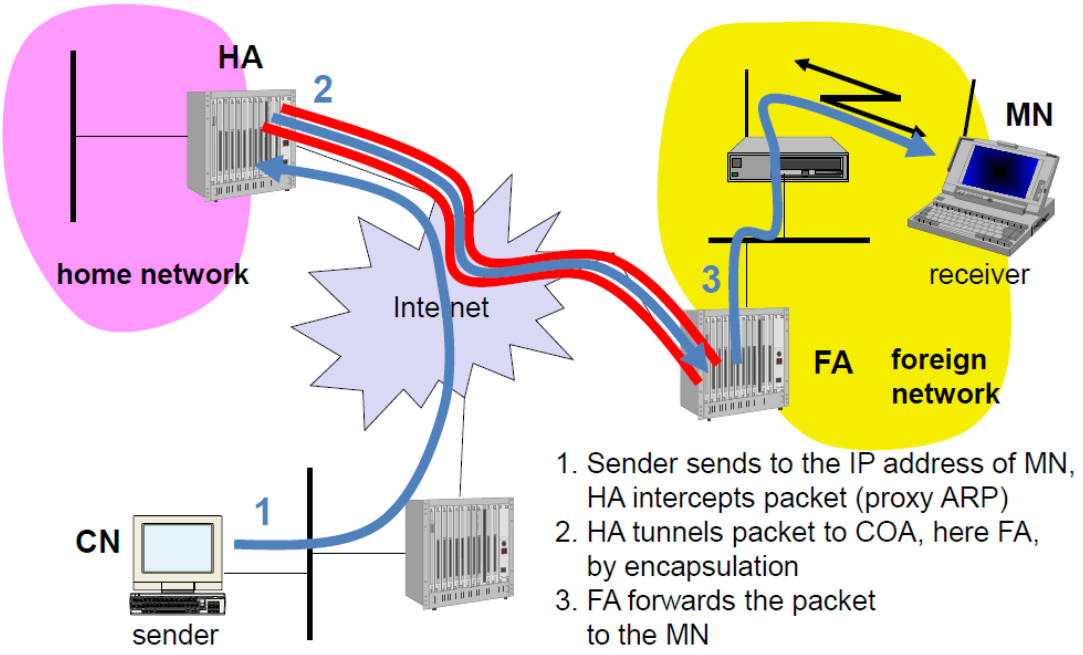


Key Mechanism in Mobile IP

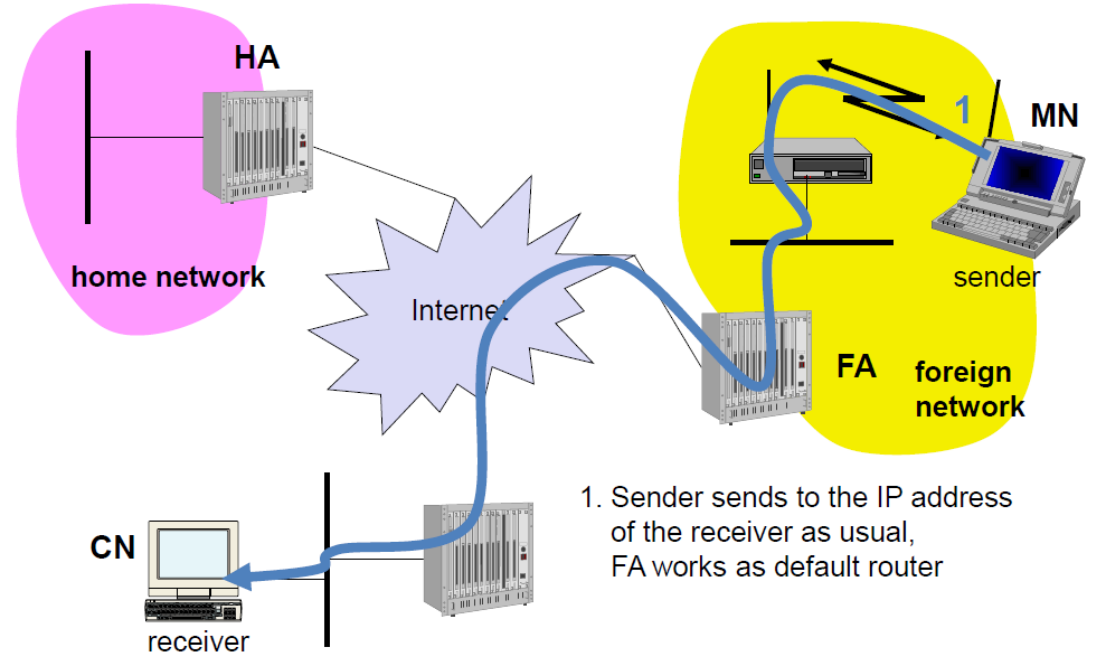
- Home Agents and Foreign Agents advertise their presence on any attached links by periodically multicasting or broadcasting special Mobile IP messages called *Agent Advertisements* .
- Mobile Nodes listen to these *Agent Advertisements* and examine their contents to determine whether they are connected to their *home link* or a *foreign link.*

- A Mobile Node connected to a *foreign link* acquires a *care-of address*. A *foreign agent care-of address* can be read from one of the fields within the foreign agent's *Agent Advertisement*. A *collocated care-of address* must be acquired by some assignment procedure, such as *Dynamic Host Configuration Protocol (DHCP)*, the *Point-to-Point Protocol's IP Control Protocol (IPCP),* or manual configuration.

Data transfer to the mobile system



Data transfer from the mobile system



- The mobile IP Registers the care-of address acquired previously with its home agent, using a message-exchange defined by Mobile IP. It asks for service from a Foreign Agent, if one is present on the link. In order to prevent Denial-of-Service attacks, the registration messages are required to be authenticated.
- The Home Agent or some other router on the *home link* advertises reachability to the network-prefix of the Mobile Node's *home address*, thus attracting packets that are destined to the Mobile Node's *home address*. The Home Agent intercepts these packets, and *tunnels* them to the care-of address that the mobile node registered previously.
- At the *care-of address* – at either the Foreign Agent or one of the interfaces of the mobile node itself – the original packet is extracted from the *tunnel* and then delivered to the Mobile Node.
- In the reverse direction, packets sent by the Mobile Node are routed directly to their destination, without any need for *tunneling*. The Foreign Agent serves as a *default router* for all packets generated by visiting node .

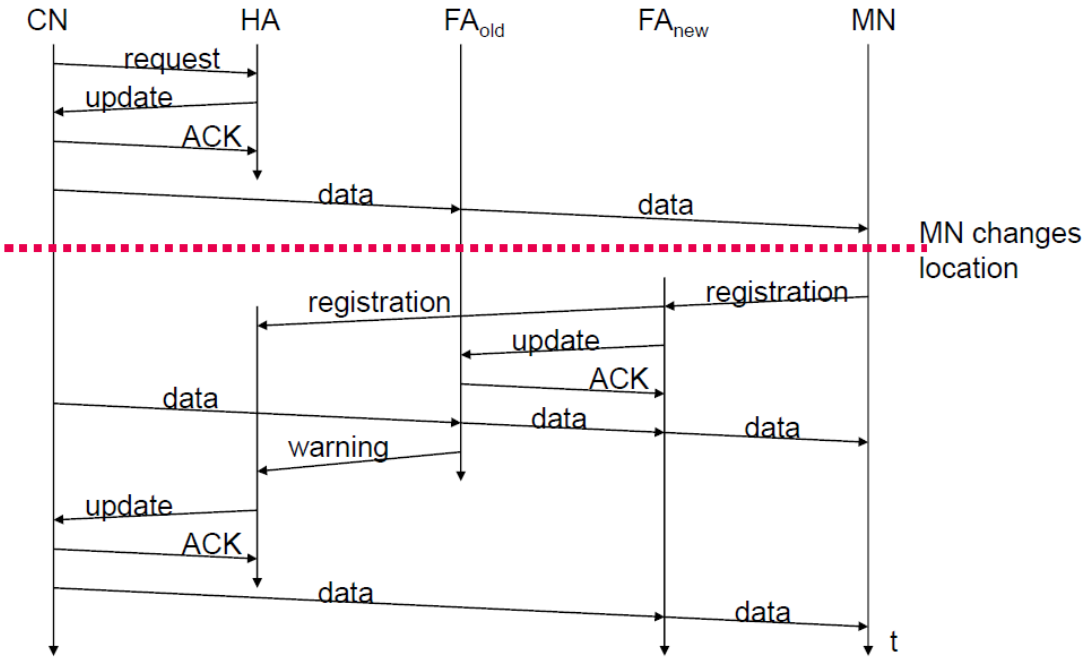
Route Optimization

- Triangle Routing: tunneling in its simplest form has all packets go to home network (HA) and then sent to MN via a tunnel.
    - This involves two IP routes that need to be set-up, one original and the second the tunnel route.
    - Causes unnecessary network overhead and adds to the latency.
- Route optimization: allows the correspondent node to learn the current location of the MN and tunnel its own packets directly. Problems arise with
    - mobility: correspondent node has to update/maintain its cache.
    - authentication: HA has to communicate with the correspondent node to do authentication, i.e., security association is with HA not with MN.

Optimization of Packet Forwarding

- Change of FA
    - packets on-the-fly during the change can be lost.
    - new FA informs old FA to avoid packet loss, old FA now forwards remaining packets to new FA.
    - this information also enables the old FA to release resources for the MN.

Change of foreign agent



Overview of TCP/IP

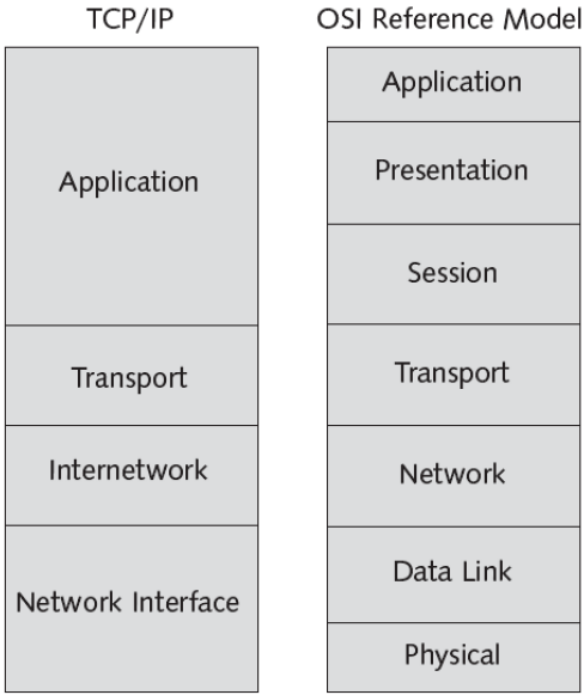
TCP (Transmission Control Protocol) and IP (Internet Protocol) are two different networking protocols but are mostly used together. **TCP/IP** became the standard terminology to refer this protocol suite which was invented before wireless communications emerged and was used primarily for **wired network communications** where TCP transfers data across an IP network. TCP is a connection-oriented protocol that establishes virtual connections between the networking devices using request-reply messages across the physical network.

- TCP divides the file or the message into packets, transmits them over the internet and reassembles them at the destination.
- IP provides the addressing for the packets to deliver them to their correct destination.

- Reliable, *full-duplex*, *connection-oriented*, *stream* delivery.
  - Interface presented to the application doesn't require data in individual packets.
  - Data is guaranteed to arrive, and in the correct order without duplications
    - Or the connection will be dropped.
  - Imposes significant overheads.

- The TCP/IP model explains how the protocol suite works to provide communications

- Four layers: Application, Transport, Internetwork, and Network Interface



Protocol architecture comparison

Layers of TCP/IP Protocol Suite

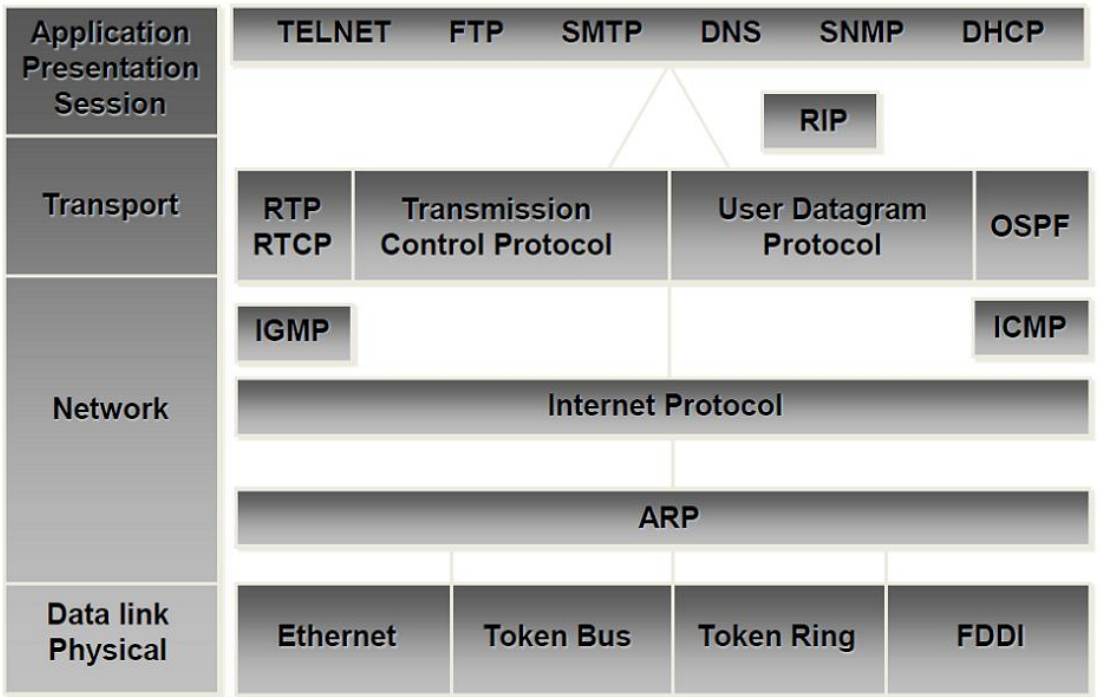
There are four layers of the TCP/IP protocol suite:

- **Datalink Layer:** It consists of protocols and methods which operate on links connecting hosts or nodes in a network. The common protocols of this layer are ARP (Address Resolution Protocol) and Ethernet.
- **Internet (Network) Layer:** It connects various independent networks for transporting data packets across various network boundaries. The important protocols of the internet layer are ICMP and IP.
- **Transport Layer:** It is responsible for communication between computer systems. This layer handles reliability, multiplexing and flow control. Protocols of this layer are UDP (User Datagram protocol) and TCP.
- **Application Layer:** It handles data exchanges between various applications. Important protocols of this layer are FTP, HTTP, POP (Post office Protocol) and SMTP (Simple Mail Transfer Protocol).

TCP/IP Layer Overview

TCP/IP Layers (OSI model*)	Tasks	Protocol Examples
Application (7)	Application specific	Telnet, rlogin, FTP, SMTP, SNMP, HTTP, ...
Transport (4)	End-to-end flow of data between application processes	TCP, UDP
Network (3)	Routing of packets between hosts	IP, ICMP
Link (2)	Hardware interface Packet transfer between network nodes	PPP, Ethernet, IEEE 802.x, ARP

TCP/IP Architecture



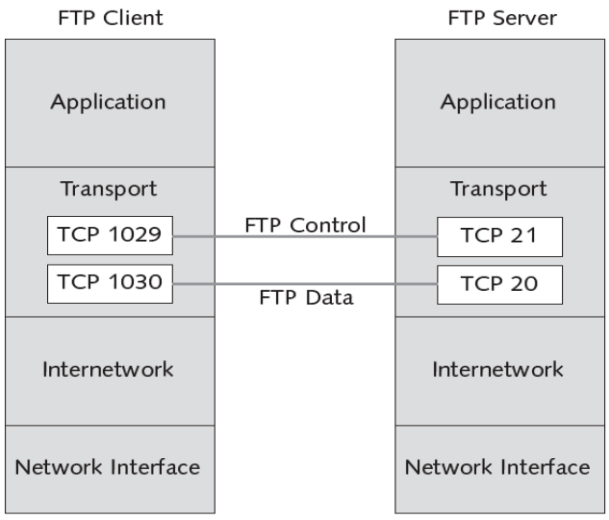
Application Layer

Protocols at the TCP/IP Application layer include:

- File Transfer Protocol (**FTP**)
- Trivial File Transfer Protocol (**TFTP**)
- Network File System (**NFS**)
- Simple Mail Transfer Protocol (**SMTP**)
- Terminal emulation protocol (**telnet**)
- Remote login application (**rlogin**)
- Simple Network Management Protocol (**SNMP**)
- Domain Name System (**DNS**)
- Hypertext Transfer Protocol (**HTTP**)

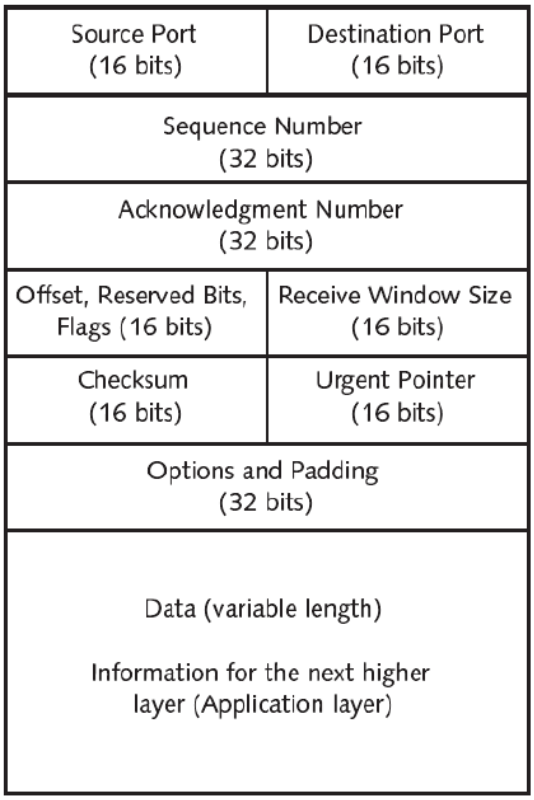
Transport Layer

- Performs end-to-end packet delivery, reliability, and flow control
- Protocols:
  - **TCP** provides reliable, connection-oriented communications between two hosts.
    - Requires more network overhead.
  - **UDP** provides connectionless datagram services between two hosts
    - Faster but less reliable.
    - Reliability is left to the Application layer.
- TCP and UDP use port numbers for communications between hosts
  - Port numbers are divided into three ranges:
    - Well Known Ports are those from 1 through 1,023.
    - Registered Ports are those from 1,024 through 49,151.
    - Dynamic/Private Ports are those from 49,152 through 65,535.

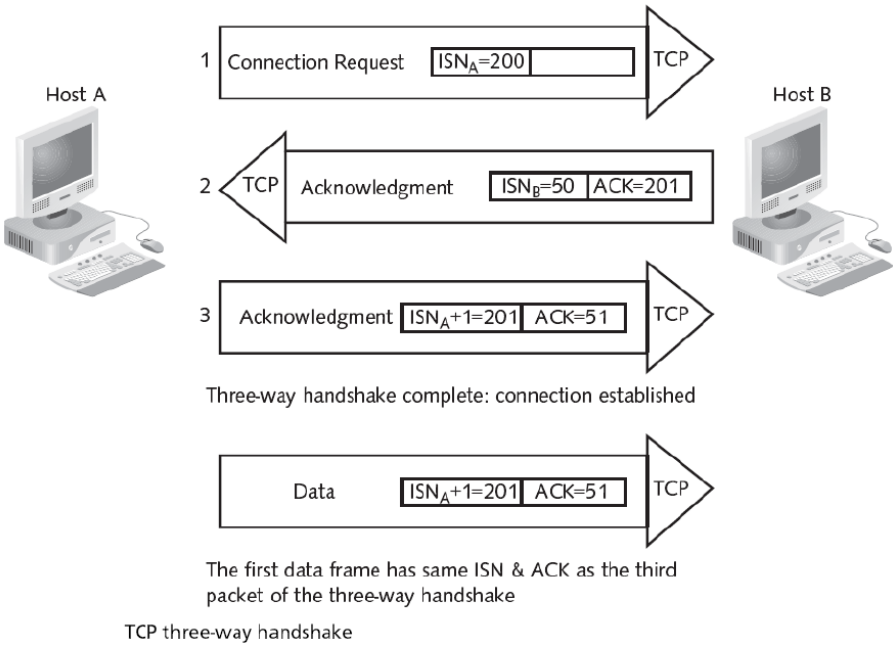


TCP port usage in FTP communications

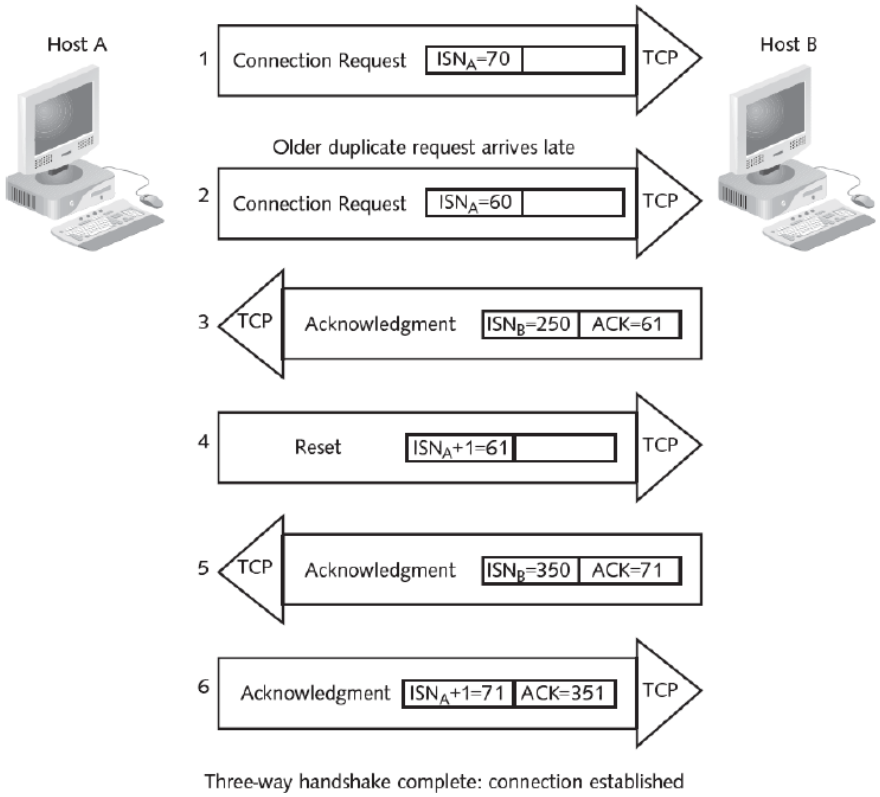
- TCP three-way handshake
  - Establishes a reliable connection between two points.
  - TCP transmits three packets before the actual data transfer occurs.
  - Before two computers can communicate over TCP, they must synchronize their **initial sequence numbers (ISN).**
  - A **reset packet (RST)** indicates that a TCP connection is to be terminated without further interaction.



TCP packet header



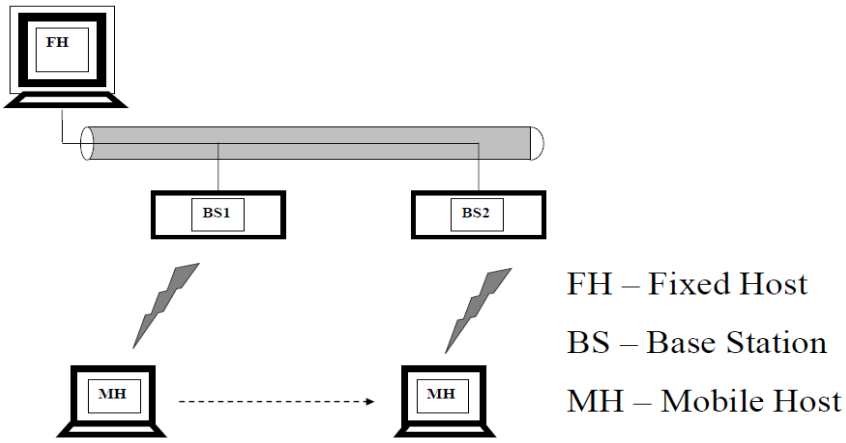
TCP three-way handshake



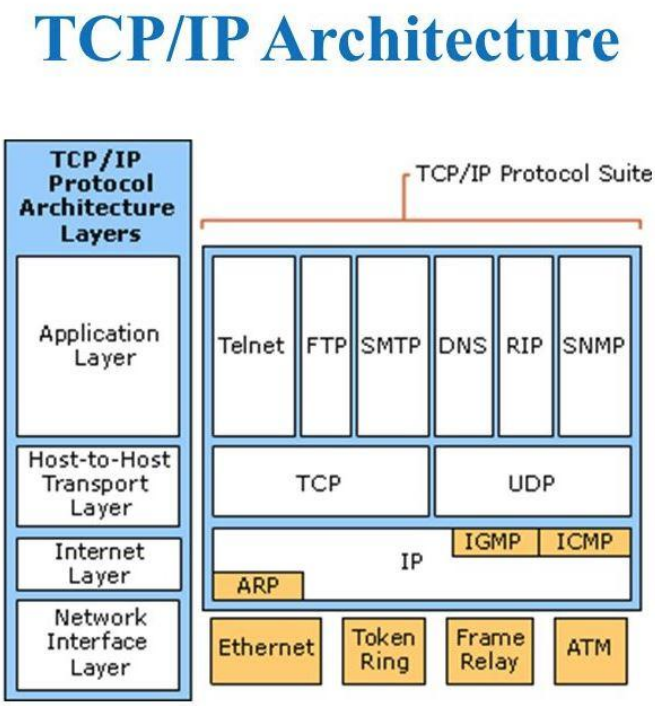
Adaption of TCP Window

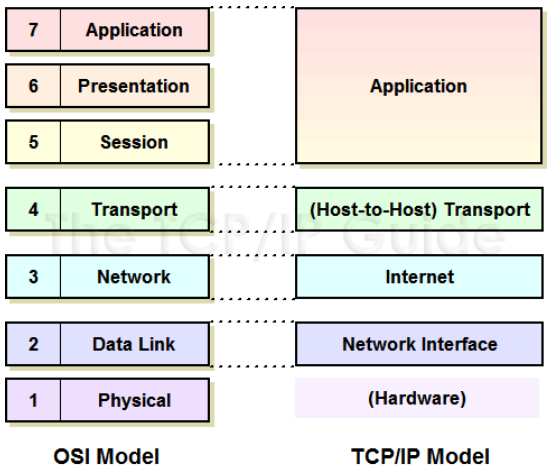
- TCP **sliding windows.**
  - Control the flow and efficiency of communication.
  - Also known as windowing.
    - A method of controlling packet flow between hosts.
    - Allows multiple packets to be sent and affirmed with a single acknowledgment packet.
  - The size of the TCP window determines the number of acknowledgments sent for a given data transfer.
  - Networks that perform large data transfers should use large window sizes.

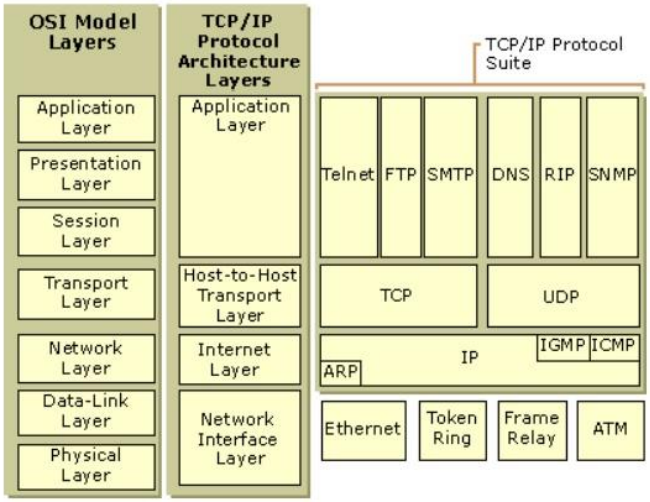
Mobile Networks Topology



Architecture of TCP/IP







TCP/IP PROTOCOL