The world’s first mobile phone call was made on 3 April 1973. Martin Cooper, a senior engineer at Motorola, called a rival telecommunications company from a phone that weighed a staggering 1.1kg and measured 228.6x127x44.4mm. This device took 10 hours to charge and the talk-time you got was only 30 minutes!

In India, the first mobile call was made on 31 July 1995, between Writer’s Building in Kolkata and Sanchar Bhavan in New Delhi when the then Union Telecom Minister Sukh Ram spoke to the then Chief Minister of West Bengal Jyoti Basu.

Just about 20 years back the mobile phone was a symbol of luxury in India. Most people had not even seen one, let alone own it. A new mobile phone was a pampered member of the family although it delivered just one service – allowing the user to call while on the go. Even the smallest of animations on the black and white display seemed amazing, and the monophonic ringtones were catchy enough for that time. Issues like heating up of the handset, application hanging, etc. were unheard of during those days, and the market for mobile phone accessories was yet in its infancy.

Today, however, mobiles are no more an exclusivity, they have become a necessity. They have transformed into an amalgamation of camera, calculator, ATM, map, photo album, jukebox, newspaper, television, discussion and chat forum, and so on, all in one place. They act as a professional camera, wallet, ATM, dictionary, home-theatre, navigator, computer, mirror, torch and much more. We are not just reading newspapers, ordering food, checking mails, making presentations on them, but also undertaking monetary transactions.

No wonder, the number of mobile devices has already exceeded the number of human beings on Earth. According to the latest statistics of GSMA Intelligence, as of today, GSMA’s real-time tracker puts the number of active mobile devices at almost 8.5 billion, while the US Census Bureau shows the world population at nearly 7.5 billion! Today, you can find a mobile network tower even in the remotest, harshest, and most hostile terrains on the Earth.

Mobile phones are fast becoming our virtual identity in the real world and losing one or falling into the wrong hands can be devastating. However, the benefits and merits still far outweigh the risks associated with them. Let us take a look at some of the state-of-the-art features of today’s revolutionary smartphones.

Privacy and Security

The mobile phone today is not just being used for communications, social relationships and entertainment but also to perform digital and online transactions leading to enormous growth of confidential data stored in and processed by the phone. Personal data security has become an issue of concern.

For years, the password was the only secured way of authentication but now passwords are much easier to hack and harder to remember. Smartphone companies are therefore replacing these traditional passwords with biometrics like fingerprint scanners, facial recognition, iris scanner, voice recognition, etc.

Voice Recognition Biometrics: Also called ‘speech recognition’, this is a technology that converts a speech signal captured by a microphone to a sequence of words. It is the identification of an individual identity using speech as the identifying characteristic.
The frequency spectrum of speech signal is encoded and stored in the internal system memory. The sound signal is digitised and then the digitised signal is compared to previously recorded samples held in a database to find the closest match. The result is a simple yes/no decision as to whether the speaker has been identified.

Both acoustic modeling and language modeling are important parts of modern speech recognition algorithms. Hidden Markov models, artificial neural networks, Dynamic Time Warping (DTW), Statistical models of spoken language, End-to-End automatic speech recognition are some of the tools used in voice recognition biometrics.

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Facial Recognition: In this, a user can unlock the smartphone just by looking at it. Many algorithms like colour segmentation, template matching, etc. for face detection and Eigen & Fisher face-for-face recognition are being used. The technology uses an infrared light that illuminates the face, and a projector projects an array of infrared dots at it. An IR camera snaps an image of these dots, which the phone uses to authenticate you against an already-stored image of your face. It builds a 3-D depth map of your entire face using a 30,000 point dot matrix. The system tracks a user’s face accurately even when the user is wearing glasses, a hat, in low-light conditions or with changes in beard.

Recently this technology has been launched by Apple by the name Face Id. The iPhone X, a new phone range of Apple has this face recognition technology called TrueDepth. The iPhone X has several sensors packed into the device, including an infrared camera, dot projector, proximity sensor and ambient light sensor.

Fingerprint Scanners: There are few different types of scanners used in this category all of which try to find ridges and valleys on fingers by different mechanisms. Optical scanners are the oldest method of capturing fingerprints. The technique involves capturing an optical image to detect unique patterns on the surface by analyzing the lightest and darkest areas of the image.

Capacitive scanners, on the other hand, use arrays of tiny capacitor circuits to collect data about the fingerprints. Ultrasonic scanners capture the 3-D scanned fingerprints. The technology uses ultrasonic transmitter and a receiver. An ultrasonic pulse is transmitted against the finger. Some of this pulse is absorbed and some of it is bounced back to the sensor, depending upon the ridges, pores and other details that are unique to each fingerprint.

ViVo has developed “in-display fingerprint scanning technology”, which is optical based and uses an ultra-sonic sensor. The OLED display panel of the phone emits light to illuminate the fingerprint and the lit-up fingerprint is then reflected into an in-display fingerprint sensor and authenticated. As the fingerprint scanner is built into the display there’s no need for a physical home key on the front of the phone.

Iris Scan: This is another biometric technology used in mobile phones. How much light reaches the retina on the back of the eyeball is a unique pattern that can be mathematically defined. Two systems are used to scan the retina: visible wavelengths and near infrared. The pattern has been recorded and translated into the data which is then compared against the stored data for the match. Biometrics on smartphones have increased data security, made payments secure and increased the pace of processes in various other applications. The technology is less time consuming and convenient too.
Sensors Used in Smartphones

Smartphones have gone through an incredible evolution in the last decade. They are becoming more like personal assistants, tracking our movements, monitoring our behavior and even anticipating our requirements. A large part of this evolution has been enabled by sensor technology.

Many operations in mobile phones are today done with the help of specific sensors, for instance, the display turns off when we put our phone on the ear while calling, the brightness sets automatically, compass positioning, etc. Different sensors are responsible for different functions.

**Proximity Sensor**: This is able to detect the nearby objects without any physical contact and is placed near the earpiece of the mobile. It consists of Infrared LED and IR light detector. The IR LED emits invisible light and when the light is reflected, the IR light detector detects the reflected light and the system will know that there is an object nearby.

**Ambient Light Sensor**: This sensor detects the amount of light and is used to set automatic brightness in the device. When the ambient light is more the display brightness increases and when it is dark display brightness decreases.

**GPS**: It is hard to imagine any smartphone without a GPS service. Global Positioning System in mobile phones is used to figure out where you are. The system navigates by means of a map with help from GPS satellites. GPS receivers in phones are passive devices and determine the position using data from at least three GPS satellites and the receiver through trilateration. The data is transmitted via radio signals. Trilateration uses the distance between the satellites and the receiver to create overlapping “spheres” that intersect in a circle. The intersection is your location on the ground.

**Barometer**: Higher-end phones have a built-in barometer – a sensor that can measure atmospheric pressure. It is used to determine how high the device is above sea level, which in turn results in improved GPS accuracy.

**Magnetometer**: This is the digital compass that shows the direction. With its ability to sense magnetic fields, it points the

**Accelerometer and Gyroscope**: Accelerometer determines the orientation of the device. Gyroscope does the same but with greater precision. An accelerometer measures linear acceleration of movement, while a gyro measures the angular rotational velocity. The data helps the phone’s software to determine in which direction the phone is and rotates the screen accordingly. These sensors are used for Virtual Reality (VR) applications, 360° videos, games and many other applications.
compass relative to the Earth’s magnetic north pole.

**Touchscreens:** They are the most commonly used input device in mobile phones today. They replaced the button system in phones. They are of four types – resistive, capacitive, surface acoustic wave and infrared touch.

1. **Resistive touchscreens:** It consists of two layers (one resistive and one conductive). An electric current is constantly sent through the layers. When the user touches the screen, the two layers make contact with each other and cause a change in the electric current. This change is measured and registers the location of the contact made.

2. **Capacitive touchscreens:** It consists of a single capacitive layer that stores a constant charge. When the user touches the screen the charge on the screen decreases and this change is measured.

3. **Surface Acoustic Wave:** It does not have any layer instead uses a transducer placed along the edge of the glass that sends an ultrasonic wave across the glass. A receiver on the other end receives the waves. The two transducers are placed along the X and Y axis of the screen. When the user touches the screen, it disturbs the waves and position of the disturbance computed to register the location of the input.

4. **Infrared touchscreens:** This technology consists of photo detectors and infrared LED which are aligned vertically and horizontally. When the user touches the screen, the infrared rays will be disturbed and the photo detectors register the location of the disturbance.

**Integrated Camera**

In recent years, the cell phones have shifted from being used merely for verbal communication to a multimedia device, replacing other gadgets such as cameras and video cameras. In fact, with smartphones increasingly becoming similar in design, performance and utility, the camera is often used by many as the primary differentiator when buying a new smartphone.

The first cameras introduced on phones were considered to be just an extra feature providing low quality images. But today many consumers have completely discarded their cameras using just their cell phones instead. All the way from the very first phone camera to the first 12MP camera, and till the present dual-lens technology that even a DSLR can’t offer, we have come down to some major milestones in camera phone technology.

**VGA camera:** VGA stands for Video Graphics Array that typically has a visual graphic size of 640 x 480 pixels (equivalent to about 0.3 MP). These are the most basic flashless cameras that take bluish overexposed images. It is the standard resolution for camera sensors, displays, photos and videos. With the advent of high-megapixel cameras, VGA is now an outdated visual technology.

**MP Cameras:** MP or Megapixel (one million pixels) is the measurement of the imaging sensing capacity of a camera. Pixel
standing for Picture Element is the basic unit of programmable colour on an electronic display. The higher the number of pixels, the better is the resolution of the image. For example, a 3 MP camera covers an area nine times as large as covered by a one VGA camera. 1.3 MP camera has a scanning area of 1280 x 960 pixels.

**LED Flash:** Camera phones are now expected to take quality pictures in low-light conditions too. There is therefore a need for an illumination source that does not rapidly drain the cell phone’s battery. This gave birth to phones with a basic flash.

**Dual Lens Cameras:** Dual cameras made their debut in 2011. Dual cameras capture 3D images. Depending on the type of the secondary camera used, a dual camera can help you get a sharper image with more details, enable an ultra-wide angle mode or simply help you take photos with a shallow depth of field to make the subject stand out. It can also help you add 1x or 2x optical zoom to the phone.

**Liquid Crystal Display:** LCD, short for Liquid Crystal Display, is the technology behind most of the screens today. Liquid crystals have an ordered crystalline structure with elongated molecules oriented in specific directions that can flow like a liquid. LCD works on the principle of blocking light rather than emitting it.

The thin, flat panel consists of a layer of liquid-crystal matrix, electrodes and polarizing filters which enables specific filters to pass from a backlight source to the screen. Each pixel in the pixel matrix has three colour sites with colour filter for red, green or blue. The most commonly used liquid crystal structure is twisted nematic. In the absence of electric field, a nematic field shifts the polarization of light to 90 degrees and the screen appears black. When the voltage is applied, the orientation of liquid crystals is twisted due to the electric field produced and the polarization shift is reduced displaying the colours on the screen.

Earlier LCD screens used to have a passive matrix, known to appear blurry when images moved quickly on the screens. Modern phones have an active matrix variety which contain Thin-Film Transistors (TFTs) and are cheaper.

**TFT-LCDs:** These are the most common type of display units used across mobile phones with one transistor at each pixel making it more responsive to change. It offers better image quality and higher resolution compared to earlier generation LCD displays but is limited to narrow viewing angles and poor visibility when exposed to direct light or sunlight. The technology being cheaper is used to manufacture budget phones and lower-end smartphones. Large TFT displays consume more power and hence are not battery friendly.

**IPS-LCD:** IPS stands for In-Place Switching in which liquid crystals are aligned in a plane parallel to the glass substrates. This is another LCD technology that improves on TFT-LCDs. It highlights two transistors for each pixel. IPS-LCDs have wider viewing angles and better colour reproduction. Lower power consumption leads to a much improved battery life. IPS-LCDs are costlier than normal TFT-LCD and hence are found in mid-range to higher-end smartphones.

**OLED:** Organic Light Emitting Diode (OLED) is a newer display technology for mobiles and monitors. It consists of an organic layer sandwiched between two conducting sheets (an anode and a cathode) with a glass plate at the top (seal) and
bottom (substrate). The carbon-based organic material emits electro-luminescent light when electricity is applied across the two conducting sheets. The panel is much thinner as it does not require backlight and filters. OLEDs are superior to LCDs in their exceptional colour reproduction, blazing fast response times, wider viewing angles, higher brightness and extremely light weight designs.

**AMOLED:** Abbreviated for Active-Matrix Organic Light-Emitting Diode, AMOLED displays are a type of OLED displays for mobiles. AMOLED screens have all the attributes of an OLED display like brilliant colour reproduction, light weight, better battery life, higher brightness and sharpness. AMOLED displays are now getting into the mainstream and most of the latest higher-end smartphones are now coming with AMOLED displays.

**Super AMOLED:** An even advanced version of AMOLED displays is Super AMOLED. It is built with touch sensors on the display itself, in contrast to a separate touch sensitive layer (as in capacitive touchscreen), which makes it the thinnest display technology on the market. Super AMOLED Advanced are brighter S-AMOLED screens with higher resolution and for resolutions above 720x1280 pixels HD Super AMOLED displays are there.

**Retina Display:** Retina Display got its name from Apple which claims that its pixels cannot be individually distinguished by the human eye, thus making the display super sharp with brilliant picture quality. The Retina Display is a 640 x 960 pixel version of IPS LCD used in Apple iPhone 4.

**Gorilla Glass:** For added protection and reliability of smartphones, the manufacturers now use gorilla glass on gadget displays. It is a scratch- and impact-resistant durable glass shield that helps protect mobile screens from scratches, drops, and bumps of everyday use. It is made up of alkali-aluminosilicate, formed by bonding aluminium, silicon and oxygen together.

**Smart Storage**

Back in the infancy of the mobile phone era, internal storage was considered as a ‘futuristic’ optional feature. A few Megabytes (MB) then is equivalent to a few Gigabytes (GB) now. But not that it wasn’t enough, because we were still using CDs and Floppy Disks having storage nowhere near a GB. Moreover, normal file formats had not evolved so much in terms of quality; therefore the average file size was not too large.

Interestingly, the internal storage capacity of mobiles started expanding much after the micro SD card became a common accessory. Inevitably, with the development of the Internet and electronic media, the demand for storage capacity also increased. There are various types of memory storage in a mobile, but the two main memory types are RAM and ROM. Random Access Memory (RAM) is a memory which is accessible quickly to the processor but is temporary. RAM in mobile phones speeds up their functioning, and the more the RAM the faster the phone applications will execute.

The concept of cloud storage has also gained much popularity – this does away with the necessity to stock up a number of pen drives. The idea is to link your phone’s memory storage to your online account and upload the contents with the help of the Internet. So even if you lose your mobile, your important data like contacts, photos, documents, etc. stay safe and accessible through your online ID.

**The Bottomline**

Today, the smartphone is not only the most effective survival tool in the global world, it is also the most influential gadget to make the global world local. The beauty of its functionality lies in its sheer simplicity. You don’t need to be a tech-savvy teen or a gizmo geek to use its features. Thanks to the space-age software and operating systems in mobiles, you don’t even need a computer anymore to make presentations, check e-mails, and edit documents.

‘Being connected’ is no more the purpose of keeping a smartphone, when there is a myriad of things to do whether for learning or leisure. Whether to learn from and utilize this pocket gadget, or to get caught in the cobwebs of time-killing applications, is however entirely up to you. The smartphones will continue to become smarter even if we don’t, and the least we can do as users is to be aware of their features as well as their flaws!

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