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NEWS LETTER




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"The computer was born to solve problems that did not exist before."

Metamaterials-based Antennas

INSP/T S N Singh

1. Introduction

The metamaterials have become a new promising paradigm in electromagnetic community. The unique electromagnetic properties of the meta-materials have significantly spurred the theoretical study of new physical concepts and phenomena with many scientific findings. The exciting scientific progress in metamaterials has yet created the expected impact on electromagnetic engineering so far due to the practical requirements such as low ohmic loss, wide operating bandwidth, simple structure, and so on. Therefore, more and more attention has paid to how to translate the scientific concepts of metamaterials to practical technologies. It will be exciting if we can apply the metamaterials-based technologies in enhancing the performance of antennas in terms of bandwidth increase, gain enhancement, radiation reconfiguration, and volume reduction.

2. Generalized metamaterial concept

A metamaterial (from the Greek word meta, meaning "beyond" and the Latin word materia, meaning "matter" or "material") is any material engineered to have a property that is not found in naturally occurring materials. They are made from assemblies of multiple elements fashioned from composite materials such as metals and plastics. The materials are usually arranged in repeating patterns, at scales that are smaller than the wavelengths of the phenomena they influence. Metamaterials derive their properties not from the properties of the base materials, but from their newly designed structures. Their precise shape, geometry, size, orientation, and arrangement gives them their smart properties capable of manipulating electromagnetic waves: by blocking, absorbing, enhancing, or bending waves, to achieve benefits that go beyond what is possible with conventional materials. Appropriately designed metamaterials can affect waves of electromagnetic radiation or sound in a manner not observed in bulk materials. Those that exhibit a negative index of refraction for particular wavelengths have been the focus of a large amount of research. These materials are known as negative-index metamaterials. Potential applications of metamaterials are diverse and include optical filters, medical devices, remote aerospace applications, sensor detection and infrastructure monitoring, smart solar power management, crowd control, high-frequency battlefield communication and lenses for high-gain antennas, improving ultrasonic sensors, and even shielding structures from earthquakes. Metamaterials offer the potential to create super lenses. Such a lens could allow imaging below the diffraction limit that is the minimum resolution that can be achieved by conventional glass lenses.

3. METAMATERIALS-BASED ANTENNAS

With the concept of metamaterials, many technologies can be developed to address a variety of engineering challenges. We have developed several technologies in enhancing performance and reducing volume of antennas in the past years.

A. Zero-Phase-Shift Loop Antennas

Near-field RFID technology at ultra-high frequency (UHF) bands is of increasingly interest because of its promising opportunities in item-level applications. The conventional single solid-line loop antenna is unable to generate strong and uniform magnetic field within an electrically

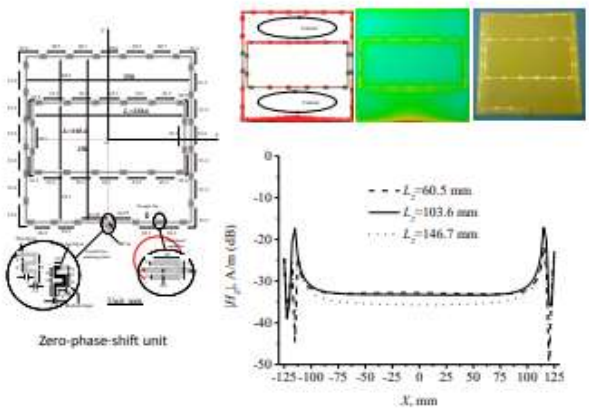


Figure 2 Loop antenna and magnetic field distribution

large interrogation zone at UHF bands. Segmented loop antennas can generate uniform and strong magnetic field in an electrically larger interrogation zone. The reported segmented loop antennas have been able to offer an interrogation zone with a perimeter of around two operating wavelengths. Using dual segmented loop configurations, the perimeters of the interrogation zone of the antennas can be larger than three operating wavelengths at UHF bands as shown in Figure 2.

B. Zero-index Structure Loaded High-gain Tapered Slot Antennas

An antipodal tapered slot antenna prototype loaded with the zero-index metamaterial (ZIM) cells exhibits a gain enhancement of up to 6 dB in the frequency band of 7−13.5 GHz without any additional area or aperture. With use of the ZIM, the waveform at the aperture of the slot antenna is much more uniform (like a plane wave) so that the aperture efficiency increases for higher gain as shown in Figure 3.

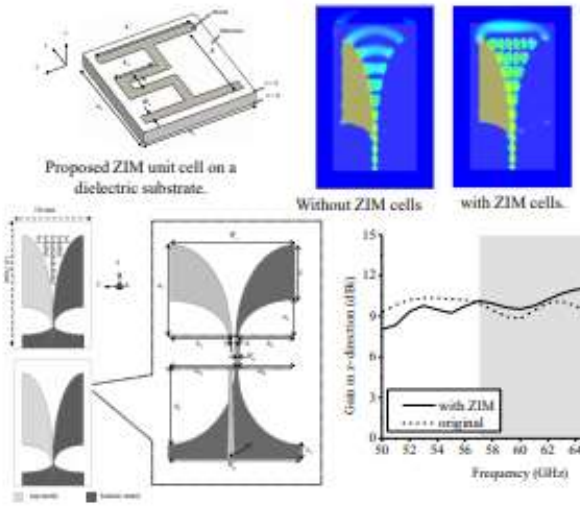


Figure 3. Tapered slot antenna at 60 GHz

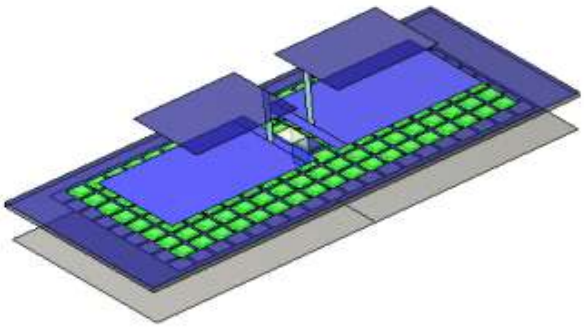


Figure 4

C. Broadband Low-profile Planar Antenna

A dipole antenna loaded with a high permittivity periodic structure (HPPS) was designed for broad operating bandwidth and high gain as shown in Figure 4. The antenna array comprises four planar dipoles, an HPPS and a finite-sized ground plane. The HPPS is two arrays of patches etched on the sides of a printed circuit board. The antenna achieved a wide impedance bandwidth of 44.4% (1.67-2.69 GHz), a maximum gain of 14.2 dBi with aperture efficiency up to 94%, and stable radiation patterns with low cross-polarization levels of -26dB across the bandwidth. With a ground plane size of 1.6 $\lambda_0 \times 1\ \lambda_0$ (λ_0 is the operating wavelength in free space), the 4-element linear array realized a 10-dB H-plane beam width of 40°.

4. Conclusion

There is an opportunity to research into the metamaterials by deeply exploring new physical phenomena. The applications of metamaterials are still quite challenging. We need much more effort to develop technology by translating the physical concepts to engineering design.

MIMO WIRELESS TECHNOLOGY

INSP/T S N SINGH

Multiple-input multiple-output, or MIMO, is a radio communications technology or RF technology that is being mentioned and used in many new technologies these days.

Wi-Fi, LTE; Long Term Evolution, and many other radio, wireless and RF technologies are using the new MIMO wireless technology to provide increased link capacity and spectral efficiency combined with improved link reliability using what were previously seen as interference paths.

Typical modern WiFi router using MIMO technology with multiple antennas.

Even now many there are many MIMO wireless routers on the market, and as this RF technology is becoming more widespread, more MIMO routers and other items of wireless MIMO equipment will be seen.

MIMO development and history

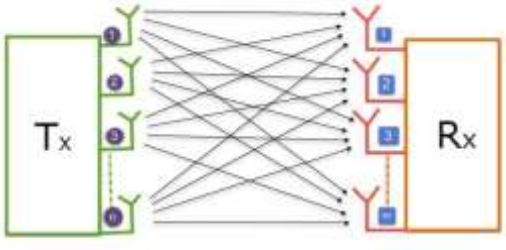
MIMO technology has been developed over many years. Not only did the basic MIMO concepts need to be formulated, but in addition to this, new technologies needed to be developed to enable MIMO to be fully implemented. New levels of processing were needed to allow some of the features of spatial multiplexing as well as to utilise some of the gains of spatial diversity.

Up until the 1990s, spatial diversity was often limited to systems that switched between two antennas or combined the signals to provide the best signal. Also various forms of beam switching were implemented, but in view of the levels of processing involved and the degrees of processing available, the systems were generally relatively limited.

How ever with the additional levels of processing power that started to become available, it was possible to utilise both spatial diversity and full spatial multiplexing.

The initial work on MIMO systems focussed on basic spatial diversity - here the MIMO system was used to limit the degradation caused by multipath propagation. How ever this was only the first step as system then started to utilise the multipath propagation to advantage, turning the additional signal paths into what might effectively be considered as additional channels to carry additional data.

MIMO -Multiple Input Multiple Output basics



Basic Structure of a MIMO System

Multiple-Input Multiple-Output abbreviated as MIMO, is a wireless technology that increases the data capacity of a RF radio by using multiple transmitting and receiving antennas.

In a MIMO system, same data is transmitted through multiple antennas over the same path in the same bandwidth. Because of this each signal reaches the receiving antenna through a different path, resulting in more reliable data. The data rate also increases by a factor determined by the number of transmit and receive antennas.

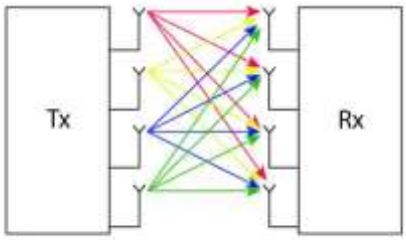
The receiver is designed to take into account the slight time difference between receptions of each signal as they travel through different paths, any additional noise or interference, and even lost signals.

Advantages of a MIMO system:

- A MIMO system provides better signal strength even without clear line-of-site as they utilize the bounced and reflected RF transmissions.
- The higher throughput allows better quality and quantity of video sent over the network.
- Multiple data streams reduces the number of lost data packets, which results in better video or audio quality.

Typical MIMO Configurations:

- 2x2 MIMO (two transmit antennas, two receive antennas)
- 3x3 MIMO (three transmit antennas, three receive antennas)
- 4x4 MIMO (four transmit antennas, four receive antennas)
- 8x8 MIMO (eight transmit antennas, eight receive antennas)



A 4x4 MIMO System

The two main formats for MIMO are given below:

- ***Spatial diversity:*** Spatial diversity used in this narrower sense often refers to transmit and receive diversity. These two methodologies are used to provide improvements in the signal to noise ratio and they are characterised by improving the reliability of the system with respect to the various forms of fading.
- ***Spatial multiplexing :*** This form of MIMO is used to provide additional data capacity by utilising the different paths to carry additional traffic, i.e. increasing the data throughput capability.

As a result of the use multiple antennas, MIMO wireless technology is able to considerably increase the capacity of a given channel while still obeying Shannon's law. By increasing the number of receive and transmit antennas it is possible to linearly increase the throughput of the channel with every pair of antennas added to the system. This makes MIMO wireless technology one of the most important wireless techniques to be employed in recent years. As spectral bandwidth is becoming an ever more valuable commodity for radio communications systems, techniques are needed to use the available bandwidth more effectively. MIMO wireless technology is one of these techniques.

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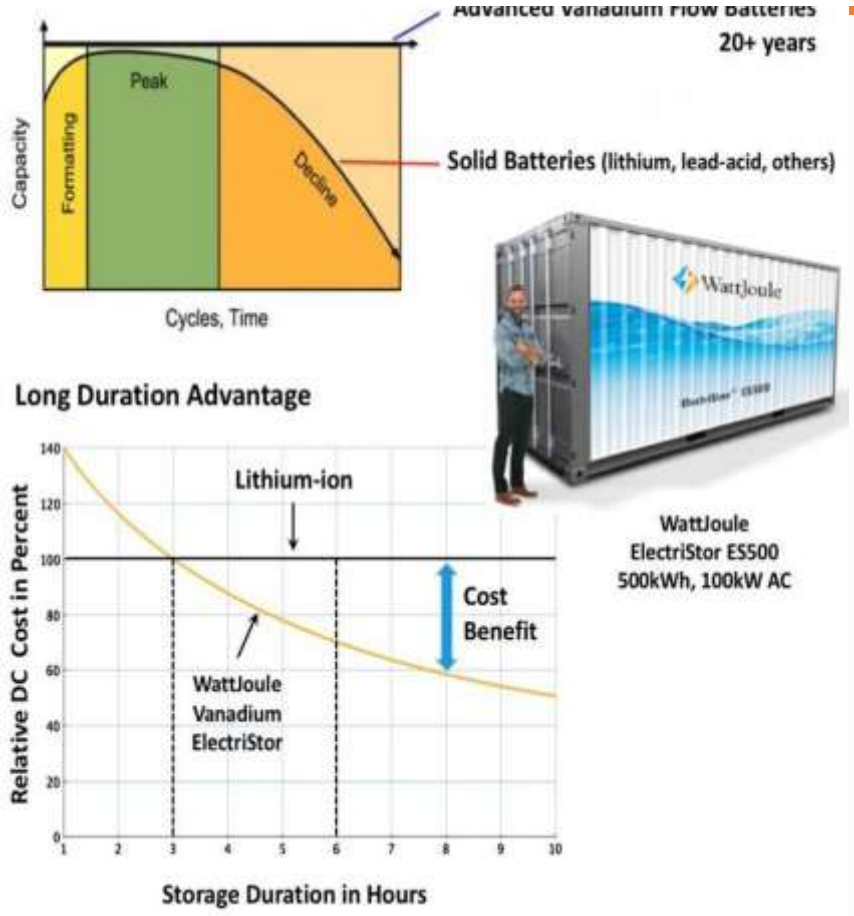
Energy's Future - Battery and Storage Technologies

ASI/T Jitender Singh

The efforts to lift our power generation and electrical grid into the 21st century is a multipronged effort. It needs a new generation mix of low-carbon sources that in-
clude hydro, renewables and nuclear, ways to capture carbon that don't cost a zillion dollars, and ways to make the grid smart.



Unlike solid batteries, like lithium-ion or lead-acid, that begin degrading after a couple of years.

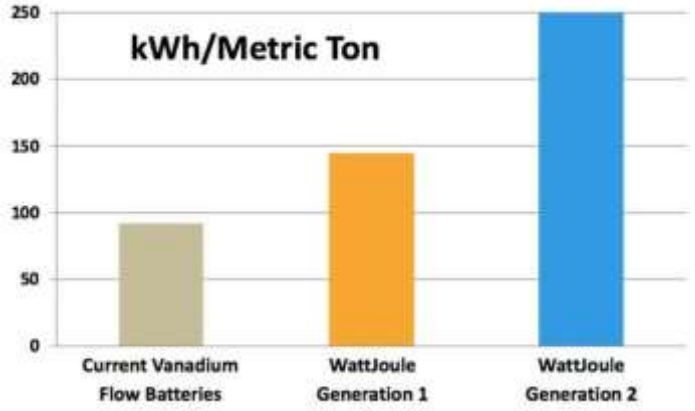
But battery and storage technologies have had a hard time keeping up. And they are critical for any success in a carbon-constrained world that uses intermittent sources like solar and wind, or that worries about resilience in the face of natural disasters and malicious attempts at sabotage.

This was pressed home this week by the Department of Energy's decision to build a multimillion dollar electric grid research complex at the Pacific Northwest National Laboratory. And better, larger batteries are a main component of this research.

At present, the most widely used storage method is pumped hydro storage, which uses surplus electricity to pump water up to a reservoir behind a dam. Later, when demand for energy is high, the stored water is released through turbines in the dam to generate electricity.

Pumped hydro is used in 99% of grid storage today, but there are geologic and environmental constraints on where pumped hydro can be deployed.

It is looked at other gravity-based energy storage systems, like Advanced Rail Energy Storage, that uses surplus wind and solar energy to move millions of pounds of rock uphill in special electric rail cars that roll back downhill, converting this gravitational potential energy to electricity that goes out onto the grid.



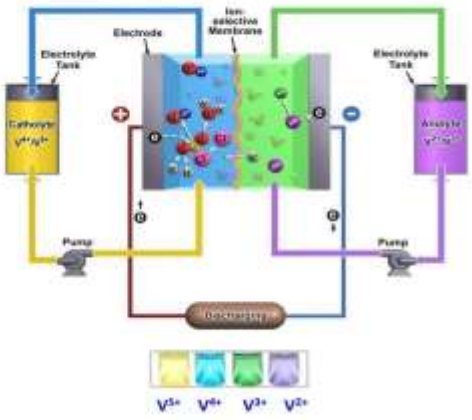
But we really need utility-scale chemical battery storage to deal with rapid intermittency in both generation (renewables) and demand (rapid changes in use throughout the commercial day). These need to be very large but very stable and long-lasting.

Lithium ion batteries are what we know now. They can pack a lot of energy storage in a small, light battery, making them the battery of choice in small electronics such as laptops and cell phones.

But Li-ion batteries have too short an operating life and have issues such as rapid heat generation. For the near-future, they will dominate the small-volume niche such as personal devices and electric vehicles, but for the utility-scale commercial battery market, we need bigger systems that last longer.

The latest technology to emerge is the vanadium redox battery, also known as the vanadium-flow battery. And the best one seems to be from WattJoule, especially because their cost is so much lower than other V-flow batteries.

V-flow batteries are fully containerized, nonflammable, compact, reusable over semi-infinite cycles, discharge 100% of the stored energy and do not degrade for more than 20 years. The Earth's crust has much more vanadium than lithium, and we produce twice as much V as Li each year.



V-flow batteries are fully containerized, nonflammable, reusable batteries, using 100% of the energy.

Most batteries use two chemicals that change valence (or charge or redox state) in response to electron flow that converts chemical energy to electrical energy, and vice versa. V-flow batteries use the multiple valence states of just vanadium to store and release charges in a water-based electrolyte containing vanadium salts.

V can exist as several ions of different charges in solution, V(2+,3+,4+,5+), each having different numbers of electrons around the nucleus (see figure). Fewer electrons gives a higher positive charge. Energy is stored by providing electrons making V(2+,3+), and energy is released by losing electrons to form V(4+,5+).

Flow batteries consist of two tanks of liquid, which simply sit there until needed. When pumped into a chemical reactor, the two solutions flow adjacent to each other past a membrane, and generate a charge by moving electrons back and forth during charging and discharging.

This type of battery can offer almost unlimited energy capacity simply by using larger electrolyte storage tanks. It can be left completely discharged for long periods with no ill effects, making maintenance simpler than other batteries.

Commercialization of vanadium flow battery systems has suffered from the high cost of the V. So you have to either store more electricity in the same amount of V through improved chemistry, and improved cell and stack designs. Or lower the cost of V.

Extracting multiple metals from the vanadium rich input source, either fresh ore dug out of the ground or slag, used catalyst or oily fly ash - what are considered industrial waste products – provides additional revenue. The non-vanadium metals, such as iron, titanium, and nickel, are then sold at market prices which subsidizes the vanadium extraction.

There is a lot of oily fly ash and coal waste to be had. This subsidy has been found to substantially offset the vanadium cost, and in some cases it can reduce the cost to zero.

Contrast that with today's sale of vanadium into the highly competitive, cost driven commodity metallurgical market today which is a one-off transaction.

These V-flow batteries can be quite large and best suited to industrial and utility scale applications. They could never fit in an electric car, so the Tesla battery is safe for now. But the V-flow battery outcompetes Li-ion, and any other solid battery, for utility-scale applications. They’re just safer, more scalable, longer-lasting and cheaper - less than half the cost per kWh.

Storing energy for the future is becoming more important as power generation evolves and we need to be more creative, and less costly, than we’ve been so far. We have the tools - batteries, pumped storage, thermal - we just have to deploy them fast.

How to Check for Malware on Android

HC/RO Biswarup Chatopadhyay

As you know many Android devices are vulnerable to malware (malicious software). If you are one of the Android users that is using an older device with an outdated version of Android, there is an increased risk of hackers stealing your personal data (such as your bank details). Here's how to check if you have malware on your Android device, and how to prevent your device from getting infected.

Signs that Your Android Device is infected

While you can't always tell if your Android device has been infected with malware, here are some of the signs that you should keep an eye out for:

- You see an increase in data usage
- Your phone bill has increased charges
- Your phone and apps keep crashing
- You see pop-up ads
- There are unfamiliar apps on your phone
- Your phone is overheating

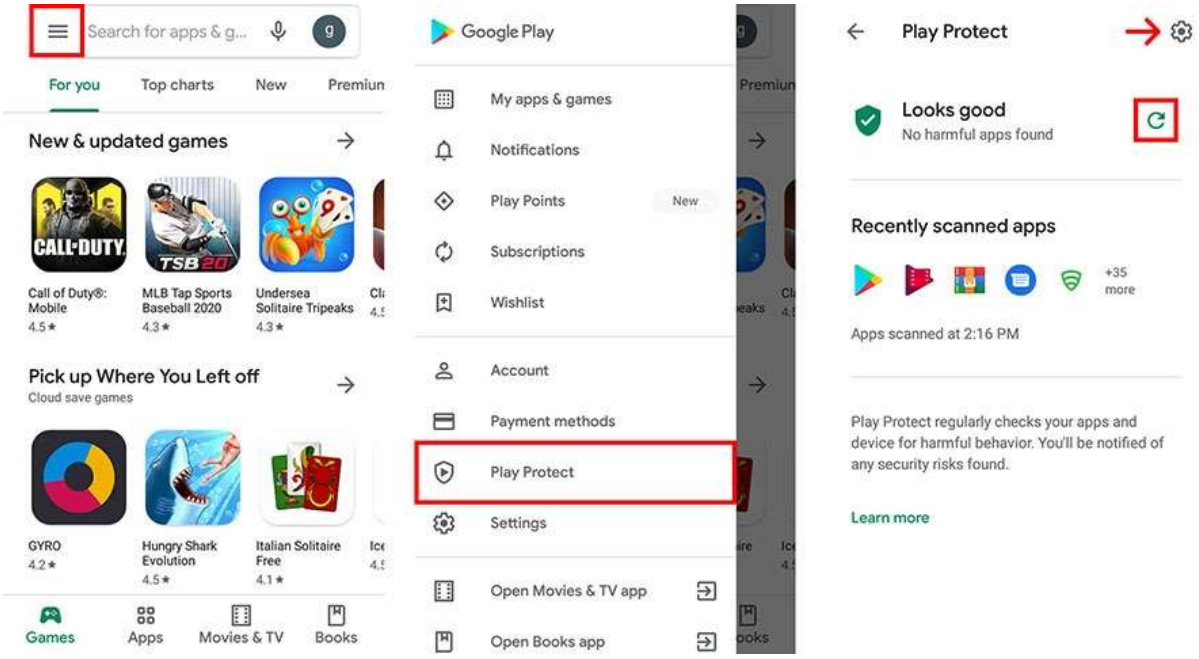
If you have experienced any of these symptoms, or you are using an Android device that's more than two years old, you might want to check for malware on your Android device.

How to Check for Malware on Android

To check for malware on your Android device, go to the Google Play Store app and click the three-line icon in the top-left left corner of your screen. Then *Google Play Protect* and tap the scan button.

Google Play Protect is an in-built service that automatically scans all the apps on your device to check for malware on your Android. Google Play Protect warns you about any detected potentially harmful apps that it finds, and it removes known harmful apps on your device.

1. **On your Android device, go to the Google Play Store app**. You can find this app by tapping the Apps icon at the bottom of your home screen.
2. **Then tap the menu button.** This is the three-line icon in the top-left corner of your screen.
3. **Next, tap on *Google Play Protect***. This will show you the status of your device and the results of the latest scan.
4. **Tap the scan button to force your Android device to check for malware.**
5. **If you see any harmful apps on your device, you will see an option to remove it**.



Once you have manually scanned for malicious software, you should also make sure that your device is set to scan your apps automatically. You can do this by tapping the gear icon in the top-right corner of your screen and making sure that both sliders are green.

Technical Quiz

R&D Team

1. Which of the following stores all the user-related data that is relevant for the GSM system in mobile computing?

   a) Sim
   b) HLR
   c) ELR
   d) VLR

2. Which of the following stores Mobile Subscriber ISDN number – MSISDN?

   a) Home location register
   b) Visitor location register
   c) Entity equipment register
   d) None of the above

3. In which of the following Codes with specific characteristics can be applied to the transmission?

   a) GSM
   b) GPRS
   c) CDMA
   d) None of the above

4. Which of the following allow the use of entire bandwidth simultaneously?

   a) TDMA
   b) FDMA
   c) CDMA
   d) None of the above

5. The base station covers a specific area that is called a ——

   a) Cell
   b) Tessellate
   c) Mobile station
   d) None of the above

6. In a cellular system, the shape of the cell depends on ——
   a) Environmental conditions
   b) Social conditions
   c) Political conditions
   d) None of the above

8. Cellular System or having small cells needs ———

   a. Handover
   b. Infrastructure
   c. Frequency planning
   d. All of the above

9. In a cellular system, the same frequency is used for other users using the technique ———-

   a) Frequency planning
   b) Frequency hopping
   c) Frequency reuse
   d) None of the above

9. Which of the following provides packet mode data transfer service over the cellular network system?

   a) GSM
   b) GPRS
   c) TCP
   d) None of the above

10. Which of the following services/ services are defined by the GSM?

   a) Bearer
   b) Supplementary
   c) Tele
   d) All of the above

Technical Terms

R&D Team

Authenticator

A method of how a user can prove his/her identity to a system. It can be a password, a fingerprint, a face scan.

Blacklist

A list of emails or other service providers that spread spam messages. Blacklists help users and companies to prevent the flood of unwanted messages.

Closed Source

A proprietary technology whose copyright hides its source code and forbids its distribution or modification. The examples of closed source commercial software are Skype, Java, Opera.

Data Loss Prevention (DLP)

The complex of security measures, related to detecting and preventing data loss and cyberattacks. DLP is included in the organization policy, but individuals must also use this strategy to keep all data safe during ransomware or malware attack.

Incident response plan

A complex of measures to be taken in case of a cyberattack to reduce damages from the attack.

Patch

A regular system update that is designed to cover security blunders that have been discovered.

Spyware

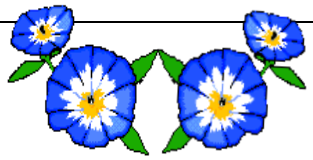
malware that spies on the computer to collect the information about a product, a company, a person. The goals can be different – to sell this information to those who may benefit from it, like the advertisers, competitors, data companies; to obtain the banking information and passwords, and so on. The most widespread spyware are keyloggers and trojans.

Brute force attack

A method for cracking an account password, when a hacker uses a cracking machine which can try multiple passwords until it gets the right one.

Acknowledgement

We are highly thankful for reading out this compilation and hope it will be useful for you in our day to day professional and personal life. We would like to hear your interest areas, suggestions from you to make this newsletter more informative and interesting. Your views will definitely help us to create this newsletter as an effective medium to reach you with latest development in the fields of communication and technology.



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Answers to the Quiz

1	2	3	4	5	6	7	8	9	10
A	A	C	C	A	A	D	C	B	D