M.Sc. (1st year, Sem- II)

MSCN Assignment **: Emerging Trends in Communication**

Group number - 19

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In the rapidly advancing frontiers of science, technology and globalisation, the core of distributed computing, industrial automation and manufacturing systems is essentially the reliable exchange of information i.e the art of effective communication. An important and necessary role is played by communication in every aspect of business and social welfare. Thus, the beneficiaries, IT experts, and the global market must ensure that it emulates with evolving technology and infrastructure. Doing so ensures that it can boost the myriad rewards that effective communication offers. So, the assignment talks about the recent emerging trends in communication along with the use cases, requirements and challenges. We begin with the recent advancement in the computing and communication world- ***Proliferation of cloud services, the fifth generation cellular mobile communications, the emergence of visible light communication, SD-WAN and LD-WAN along with a boost in autonomous and virtual world possible through AI, Augmented and Virtual reality.***

The detailed introduction to emerging trends of communication are described below-

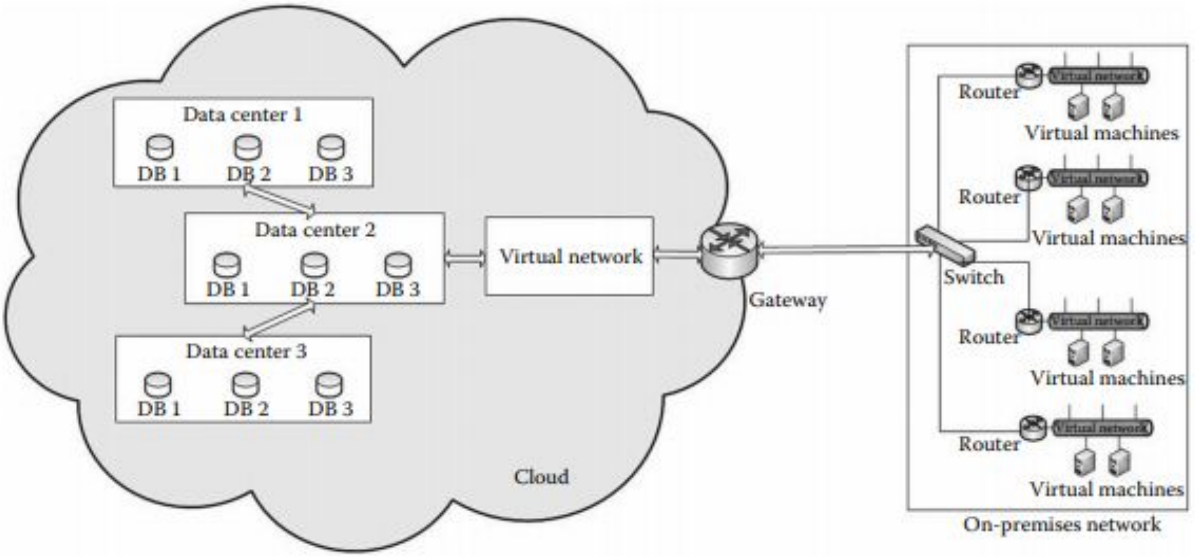
1) Cloud Communication services

The core concept of cloud computing has been into the news and discussions all around for a long time. The underlying hardware and software services need to be provided by the IT infrastructure and institutions to their employees for the completion of assigned tasks. The key component of the IT infrastructure is the network that connects servers, desktop computers, and mobile devices. But these services are high-cost and require a high-maintenance unit. It also requires expensive hardware and software and skilled IT service staff members to keep it running.

A cloud system is managed by a central server. The front end consists of the client's computer or computer network. Also the application essential to access the cloud computing system. On the back end of the cloud system, there are various computers, servers and data storage systems that constitute it. A cloud-based network is an enterprise network that can be extended to the cloud. The cloud significantly simplifies the development of an enterprise network

system. In the cloud, the underlying network is constructed by a cloud provider. Cloud technology contributes as an emerging trend of communications providers as they host communication services through servers that they own and maintain. It provides a variety of communication resources. The need for cloud communications has resulted from the following trends in the technology world:

- Distributed and decentralized company operations in branch and home offices
- Increase in the number of communication and data devices accessing the enterprise networks
- Hosting and managing IT assets and applications



2) 5G Mobile Technology

A new global wireless standard after 1G, 2G, 3G, and 4G networks is the 5th generation of mobile communication, which is capable of providing higher multi-Gbps peak data speeds

Advantages of 5G-

- ultra low latency
- more reliability
- massive network capacity

- increased availability, and a more uniform user experience to more user
- Higher performance and improved efficiency

The previous generations of mobile networks are 1G, 2G, 3G, and 4G.

First generation - 1G 1980s: 1G delivered analog voice
Second generation - 2G - Early 1990s: 2G introduced digital voice (e.g. CDMA- Code Division Multiple Access).
Third generation - 3G - Early 2000s: 3G brought mobile data (e.g. CDMA2000).
Fourth generation - 4G LTE- 2010s: 4G LTE ushered in the era of mobile broadband.

5G Performance Parameters

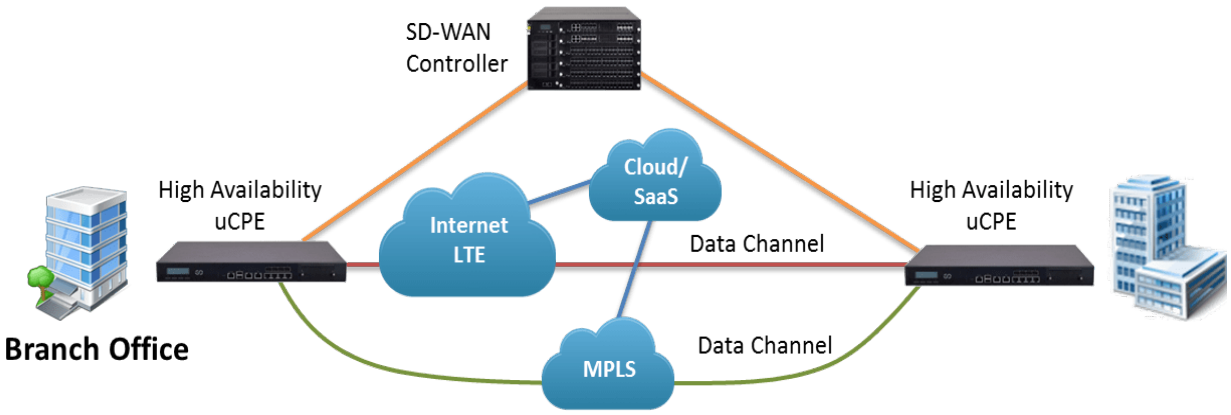
PARAMETERS	SUGGESTED PERFORMANCE
Peak data rate	At least 20Gbps downlink and 10Gbps uplink per mobile base station.
5G connection density	At least 1 million connected devices per square kilometre (to enable IoT support).
5G mobility	0km/h to "500km/h high speed vehicular" access.
5G energy efficiency	energy efficient but also drop into a low energy mode quickly when not in use.
5G spectral efficiency	30bits/Hz downlink and 15 bits/Hz uplink.
5G real-world data rate	per-user download speed of 100Mbps and upload speed of 50Mbps

3) SD-WAN

An SD-WAN is a software-defined wide area network, a software approach managing wide-area networks which uses a centralized control function to securely and intelligently direct traffic across the WAN. Its advantages are-

- Lower circuit costs by using broadband, DIA, LTE
- Increase network agility by simplifying control of the entire WAN
- Increased bandwidth capacity, and more efficient and higher per-site resiliency/availability
- Provide-reliable and secure Internet access to cloud and SaaS
- Deliver network circuit and carrier independence
- Centralize and unify the entire WAN to simplify management, deployment and change control

Need for SD-WAN :- As applications continue to migrate to the cloud, networking professionals are quickly realizing that traditional WANs were never architected for the cloud since they backhaul traffic. Thus, geographically distributed enterprises are embracing SD-WANs at an accelerating pace because they help businesses become more agile, enhance business productivity and dramatically lower costs.



4) Visible Light Communication- LIFI

Visible Light Communication technology- LiFi uses LEDs that operate under high-frequency voltage which is not visible to the human eye and does not penetrate walls, so their radius of action is rather small. Also, due to the use of light rays instead of radio waves, this communication technology, unlike WIFI, can be used in airplanes, medical centers and even at shallow depths underwater. LiFi is a wireless technology that holds the key to solving challenges faced by 5G. LiFi can transmit at multiple gigabits, is more reliable, virtually interference free and uniquely more secure than radio technology such as Wi-Fi or cellular.

Parameter	*Li-Fi*	*Wi-Fi*
Spectrum Used	Visible Light	RF
Standard	IEEE 802.15.7	IEEE 802.11
Range	Based on Light Intensity (< 10m)	Based on Radio propagation & interference (< 300 m)
*Data Transfer Rate**	Very high (~1 Gbps)	Low (100 Mbps-1 Gbps)
Power consumption	Low	High
Cost	Low	High
Bandwidth	Unlimited	Limited

Comparison of Wi-Fi and Li-Fi

Advantages of Li-Fi-

- *Efficiency:* Energy consumption can be minimised, very efficient in terms of costs as well as energy.
- *High speed:* Combination of low interference, high bandwidths and high-intensity output, help Li-Fi provide high data rates i.e. 1 Gbps or even beyond.
- *Availability:* Not an issue as there are abundant light sources
- *Cheaper:* Li-Fi not only requires fewer components for its working, but also uses only a negligible additional power for the data transmission.

- *Security:* Since light cannot pass through opaque structures, Li-Fi internet is available only to the users within a confined area and cannot be intercepted and misused, outside the area under operation.

Li-Fi technology has a great scope in future. The extensive growth in the use of LEDs for illumination indeed provides the opportunity to integrate the technology into a plethora of environments and applications.

5) LPWAN: low-power wide-area network

A low-power wide-area network (LPWAN) or low-power wide-area (LPWA) network or low-power network (LPN) is a type of wireless telecommunication wide area network designed to allow long-range communications at a low bit rate among things (connected objects), such as sensors operated on a battery. The low power, low bit rate and intended use distinguish this type of network from a wireless WAN that is designed to connect users or businesses, and carry more data, using more power. The LPWAN data rate ranges from 0.3 kbit/s to 50 kbit/s per channel.
A LPWAN may be used to create a private wireless sensor network, but may also be a service or infrastructure offered by a third party, allowing the owners of sensors to deploy them in the field without investing in gateway technology.
The potential of LPWAN is huge. As per analytics reports more than 20 billions of IoT devices will be available by 2020 and a large portion will be connected with LPWAN. There are several LPWAN technologies present on the market now. They differ from one another by frequency, bandwidth, RF modulation approach and spectrum utilization algorithms. And as a result, they have their key points to consider when choosing the right technology for the Internet of Things.

Technology attributes-

- *Long range:* varies from a few kilometers in urban areas to over 10 km in rural settings and also enables effective data communication in previously infeasible indoor and underground locations.

- *Low power requirements :* Optimized for power consumption, LPWAN transceivers can run on small, inexpensive batteries for up to 20 years
- *Minimised cost:* LPWAN's simplified, lightweight protocols reduce complexity in hardware design and lower device costs. Its long range combined with a star topology reduce expensive infrastructure requirements, and the use of license-free or licensed bands reduce network costs.

6) Improved Communications through (AR and VR) augmented reality and analytics-

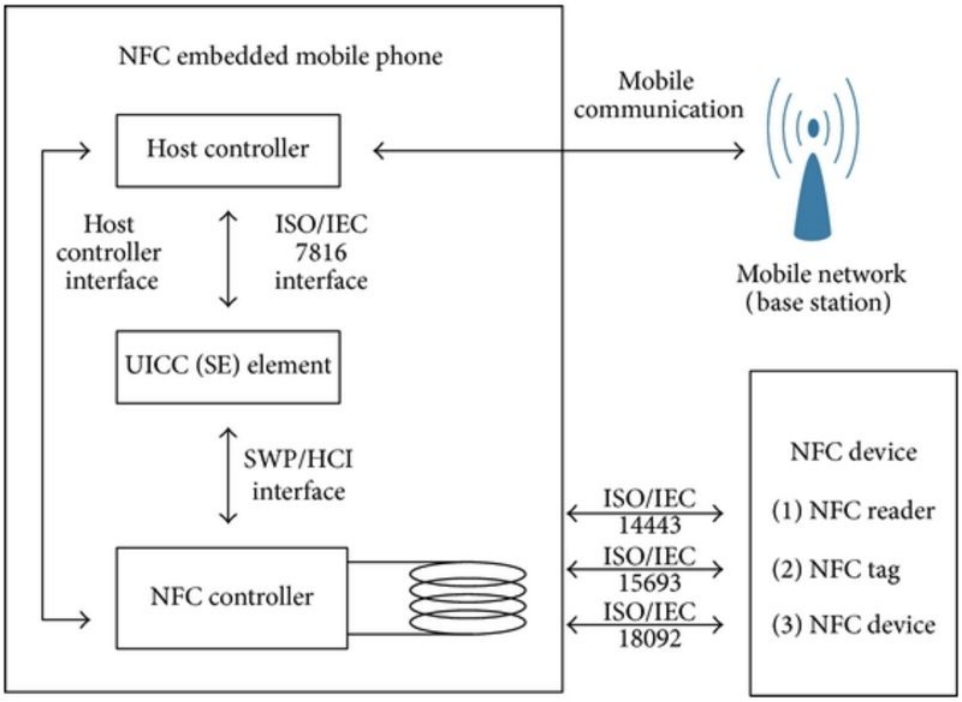
VR and AR are known to create immersive experiences that can beat any video call. It can be the final piece of the puzzle to create a truly digital workplace with happy and engaged employees. Augmented analytics is an approach that automates insights using machine learning and natural-language generation and marks the next wave of disruption in the data and analytics market.
Customer communication is evolving at a rapid rate. It has become conversational, rather than transactional. It takes place wherever the customer happens to be: WhatsApp, live video, SMS, voice, and more. AIs are beginning to supplement human agents and, in some cases, can handle simple queries from end to end. Yet as businesses do more to communicate effectively with customers, those same customers are showing an increasing preference for self-service. This is not the contradiction it might seem at first.

7) Near Field Communication

Near Field Communication (NFC) is a specification for contactless communication between two devices. It is limited to a distance between the two devices of up to 10 cm. NFC is intended to make it easier and more convenient to make transactions, exchange digital content, and connect electronic devices with a touch. NFC operates at 13.56 MHz and has been developed jointly between NXP Semiconductors (formerly Philips Semiconductors) and Sony Corporation.

Because NFC has the ability to read and write to devices, it is believed that they will have a wider use in the future than standard smart cards.

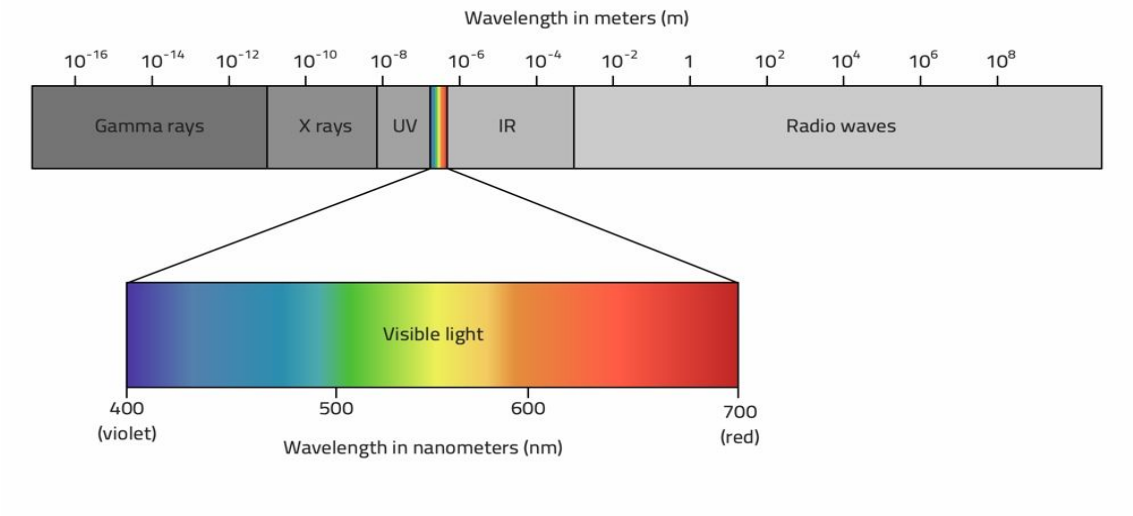
NFC involves an initiator and a target. The initiator, as follows from the name, initiates and actively generates an RF signal and controls the exchange of data (a payment device) where the request is answered by a passive target (a Smartphone). The NFC protocol also distinguishes between two modes of communication: active and passive. Active is where both the initiator and target both communicate by generating their own electric fields. They do this in half duplex; deactivating their RF field until no other device is transmitting. In this mode both devices will typically have power supplies. Passive mode will be the more common application in which the initiator is the only device that generates an RF signal, the target device answers that call by modulating the existing field which the initiator device listens out for, and then processes therefore transferring data. The data rates currently supported are 106, 212, 424 or 848 Kbit/s.



NFC is a very short range protocol which is backward compatible with the RFID infrastructure, because of its very short range it is inherently secured from most types of remote attacks. The procedure of establishing communication is very familiar to human's natural way of doing things, you want something to communicate, touch it together. This makes it much more user friendly than the older data transfer methods of searching then establishing a connection. This makes it much less daunting and much more accessible for novice users. The whole process feels like devices recognize each other by touch.

8) Infrared Transmission

Infrared light transmissions have existed for many years. However, they now are assuming a position of some, if still limited, importance.
The transmission of data or voice information over infrared (IR) light. Infrared data transmission is often used to connect laptops or Personal Digital Assistants (PDAs) to peripherals (such as printers) or to desktop computers for synchronizing work files.



Electromagnetic Spectrum

IR is light that is beyond the red end of the visible spectrum. Wavelengths in the range of 770 to 1400 nanometers are called the near infrared region of the

electromagnetic spectrum, while longer wavelengths are called the far infrared. An IR transducer consists of a driver and an IR emitter that can both transmit and receive infrared transmissions. The transducer is connected to an encoder/decoder that interfaces with the computer or peripheral's universal asynchronous receiver-transmitter (UART) for asynchronous serial transmission between the devices.

IrDA devices that use the IrDA Data protocol suite initiate a connection using the discovery functions of the Infrared Link Management Protocol (IrLMP) and establish the primary and secondary stations using the Infrared Link Access Protocol (IrLAP). The secondary station then adjusts its data speed to match the primary station and establishes a serial communication link.

Advantages of infrared-

- The main advantage of infrared technology is its simple and extremely cheap senders and receivers which are integrated into nearly all mobile devices available today.
- No licenses are required for infrared and shielding is very simple.
- PDAs, laptops, notebooks, mobile phones etc. have an infrared data association (IrDA) interface.
- Electrical devices cannot interfere with infrared transmission.

Disadvantages of Infrared-

- Disadvantages of infrared transmission are its low bandwidth compared to other LAN technologies.
- Limited transfer rates to 115 Kbit/s and we know that even 4 Mbit/s is not a particular high data rate.
- Their main disadvantage is that infrared is quite easily shielded.
- Infrared transmission cannot penetrate walls or other obstacles.
- Typically, for good transmission quality and high data rates a LOS (Line of site), i.e. direct connection is needed.

9) Bluetooth

A number of different wireless technologies have been developed for very short distances. These are referred to as 'short-range wireless communication.' Signals travel from a few centimeters to several meters.

In contrast, signals in medium-range wireless communication travel up to 100 meters or so, while signals in wide-area wireless communication can travel from several kilometers to several thousand kilometers.

Bluetooth is a type of wireless communication used to transmit voice and data at high speeds using radio waves. It is a standard protocol for short-range radio communications between many different types of devices, including mobile phones, computers, entertainment systems and other electronics. Devices need to be within approximately 10 meters of each other, and the typical data transfer rate is around 2 megabits per second (Mbps).

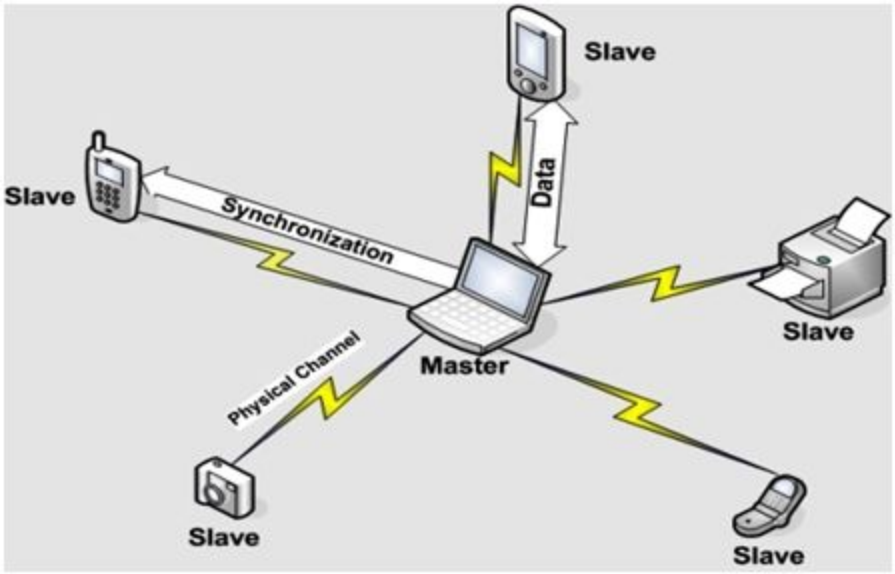
Bluetooth uses a spread-spectrum frequency-hopping technology. This means it uses multiple frequencies at the same time to limit interference when using multiple devices. While Bluetooth does not need a direct line of sight, the signals do not carry very far, and the devices need to be within approximately 10 meters. This works great to make phone calls using the audio system in your car or to play music through a wireless speaker, but it does not work well to connect multiple computers in an office building.

Bluetooth is widely used in mobile phones and is used to establish a wireless connection between a computer and various peripheral devices, including a mouse, keyboard, printer, digital camera, etc.

How Bluetooth Works?

Bluetooth Network consists of a Personal Area Network or a piconet which contains a minimum of 2 to maximum of 8 bluetooth peer devices- Usually a single master and upto 7 slaves. A master is the device which initiates communication with other devices. The master device governs the communications link and traffic between itself and the slave devices associated with it. A slave device is the device that responds to the master device. Slave devices are required to synchronize their transmit/receive timing with that of the

masters. In addition, transmissions by slave devices are governed by the master device (i.e., the master device dictates when a slave device may transmit). Specifically, a slave may only begin its transmissions in a time slot immediately following the time slot in which it was addressed by the master, or in a time slot explicitly reserved for use by the slave device.



Many modern electronic devices have Bluetooth built in, such as remote controls for video games. It is also used for regular desktop and laptop computers but is not nearly as common as a WiFi card. However, if your computer does not have Bluetooth, you can use a Bluetooth USB dongle instead.

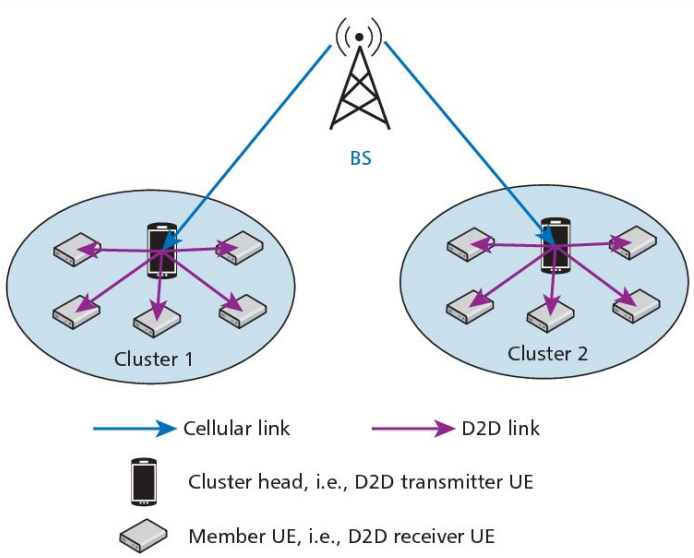
While Bluetooth and WiFi have some similar applications, there are some key differences. WiFi is typically used as a replacement for high speed cabling in local area networks and makes it possible for a mobile device to establish an Internet connection. Bluetooth is more commonly used as a replacement for cables between different electronic devices to communicate with each other, establishing a personal area network. Bluetooth is not widely used for an Internet connection.

WiFi also allows for higher speeds and connections over greater distances. On the other hand, Bluetooth is often much simpler to operate and may only require a single button press, such as in remote controls and headsets.

10) Device-to-device communication

Device-to-Device (D2D) communication in cellular networks is defined as direct communication between two mobile users without traversing the Base Station (BS) or core network. D2D communication is generally non-transparent to the cellular network and it can occur on the cellular frequencies (i.e., inband) or unlicensed spectrum (i.e., outband).

Communication through BS suits conventional low data rate mobile services such as voice call and text messaging in which users are seldom close enough for direct communication. However, mobile users in today's cellular networks use high data rate services (e.g., video sharing, gaming, proximity-aware social networking) in which they could potentially be in range for direct communications (i.e., D2D). Hence, D2D communications in such scenarios can greatly increase the spectral efficiency of the network. The advantages of D2D communications go beyond spectral efficiency; they can potentially improve throughput, energy efficiency, delay, and fairness.



Existing data delivery protocols in D2D communications mainly assume that mobile nodes willingly participate in data delivery, share their resources with

each other, and follow the rules of underlying networking protocols. Nevertheless, rational nodes in real-world scenarios have strategic interactions and may act selfishly for various reasons (such as resource limitations, the lack of interest in data, or social preferences).

For example, if a node has limited battery resources or the cost of the network bandwidth delivered by mobile network operators is high, it would not willingly relay data for others until appropriate incentives are provided. Meanwhile, malicious nodes may attack the network in different ways to disturb the normal operation of the data transmission process. An adversary, for example, may drop received messages but produce forged routing metrics or false information with the aim of attracting more messages or decreasing its detection probability. This issue becomes more challenging when colluding attackers boost their metrics to deceive the attack detection systems. Dealing with non-cooperative mobile nodes is very challenging because of the distributed network model and intermittent access of nodes to central authorities.

D2D Applications:

- *Local Services:* In local service, user data is directly transmitted between the terminals and doesn't involve the network side, e.g. social media apps, which are based on proximity service.
- *Emergency communications:* In case of natural disasters like hurricanes, earthquakes etc., the traditional communication network may not work due to the damage caused. Ad-hoc networks can be established via D2D which could be used for such communication in such situations.
- *IoT Enhancement:* By combining D2D with the Internet of things (IoT), a truly interconnected wireless network will be created. Example of D2D-based IoT enhancement is vehicle-to-vehicle (V2V) communication in the Internet of Vehicles (IoV). When running at high speeds, a vehicle can warn nearby vehicles in D2D mode before it changes lanes or slows down.

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