INSTITUTE OF BUSINESS MANAGEMENT
COLLEGE OF ENGINEERING & SCIENCES

Course: Communication System (M-14195)
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Instructor: Sir Dr Muhammad Imran Majid

Student name: Dildar Ali
ID:20202-27142

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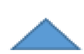
ASSIGNMENT#01

Q1: Demonstrate tessellation of polygon from n=3 to n=9 in the field of communication system. Report why hexagon is preferred and where is it applied (1 application from communication and 2 from other fields)?

Ans: A tessellation or tiling of a flat surface is the covering of a plan using one or more geometric shapes, called tiles, with no overlaps and no gaps. In mathematics, tessellations can be generalized to higher dimensions and a variety of geometrics. A periodic tiling has a repeating pattern.

Formula: $\boldsymbol{a} = \dfrac{\mathbf{180}(\boldsymbol{n}-\mathbf{2})}{\boldsymbol{n}}$

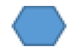
Applying the concept of tessellation to polygons from n=3 to n=9:

1. n=3 Triangle, $a = \frac{180(3-2)}{3}$ = 60, It is a factor of 360 degrees. 
   Here, if we add $\boldsymbol{a}$ six times or multiply it with 6, it makes 360. Therefore, a triangle will tessellate.

2. n=4 Square, $a = \frac{180(4-2)}{4}$ = 90, It is a factor of 360 degrees. 
   Here, if we add $\boldsymbol{a}$ four times or multiply it with 4, it makes 360. Therefore, a square will tessellate.

3.n=5 Pentagon, $a = \frac{180(5-2)}{5}$ = 108, It is a factor of 360 degrees. 
There is no way to make 360 with 108 since 108 + 108 + 108 = 324 and 324+108 = 432. Therefore, the

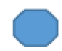
pentagon will not tessellate.

4. n=6 Hexagon, $a = \frac{180(6-2)}{6}$ =120, It is a factor of 360 degrees. 

Here, if we add $\boldsymbol{a}$ three times or multiply it with 3, it makes 360. Therefore, a Hexagon will tessellate.

5. n=7 Heptagon, $a = \frac{180(7-2)}{7}$ = 128.571, It is not a factor of 360 degrees. 

There is no way to make 360 with 128.571. Therefore, the Heptagon will not tessellate.

6. n=8 Octagon, $a = \frac{180(8-2)}{8}$ = 135, It is a factor of 360 degrees. 

There is no way to make 360 with 135. Therefore, the Octagon will not tessellate.

7. n=9 Nanagon, $a = \frac{180(9-2)}{9}$= 140, It is a factor of 360 degrees.

There is no way to make 360 with 140. Therefore, the Nanagon will not tessellate.

Here, only triangles, Squares and Hexagons makes a perfect tessellation shape. But mostly hexagons are preferred for tessellation. Because, the area of cell of hexagon is 83%. Which do not require by any square or triangle, that's why it commonly used for all the time and its being preferred shape for cellular communication system development.

Applications of hexagon:

- It is used for planning and analysis of cellular networks in communication system.
- Real life applications of hexagons are like a honeycomb and a screwing nut.
- Hexagonal floor tile, a clock.

Q2. Describe three pros and three cons of Bluetooth, 5G and Satellite Communications giving example of recent case study for each.

Ans: In the field of communication, wireless communications are mostly used. They can be used from minimum range to high range up to 36000 km.

Bluetooth is used for short range communication where the 5G is used for medium and for high range up to 36000km we use satellites.

Here are three pros and three cons of Bluetooth:

Pros	Cons
It avoids interference from other wireless devices.	It has relatively slow transmission of data relatively slow transmission of data
It is used for voice and data transfer.	It has a small range of communication
It has range better than Infrared communication.	It has a lengthy process for connection

Case Study: Smart-shepherd improves scalability for their smart farming IoT applications with Cassia's Bluetooth Gateways:

Founded in 2016, Smart-Shepherd is revolutionizing the way today's farmers are breeding their livestock and overcoming the challenges faced in the free-range livestock industry. Their first product is a non-invasive wearable smart collar used on various farm animals such as sheep, deer and goats to track and monitor the relationship between offspring and their mothers. The collar also identifies any poor performing breeding stock and farmers use this data to increase their livestock productivity while reducing carbon emission.

CHALLENGES: After launching their innovative smart collar solution for tracking and monitoring livestock, Smart-Shepherd soon discovered that the handheld devices being used to monitor the animals were limited by short-range, one-to-one connectivity. Furthermore, the company was not able to overcome the scalability issues and lack of critical data they needed to achieve full performance. Also, interpreting the data from the collars manually was very time-consuming and labor-intensive given the large number of animals in the field. With a growing number of users, it was clear that Smart-Shepherd needed a wireless solution that would deliver the reliability, long range, and multiple device connectivity needed to ensure consistent livestock tracking and monitoring to advance their operations and improve the speed at which data was being processed.

SOLUTION: Smart-Shepherd realized it needed a scalable and flexible wireless solution to meet their needs and to support their growing customer base. The company discovered an opportunity with Cassia Networks and decided that Cassia's X1000 Bluetooth gateways and IoT Access Controller (AC), a powerful network management solution, was the ideal solution to help overcome their challenges.

Case Study: Artificial Intelligence Driven Use Cases for 5G-IoT Networks

The higher data-rates possible in 5G-IoT makes it possible for the implementation of data-hungry and computation intensive Artificial Intelligence (AI) algorithms for various user applications. With high data transmission capacity of the network comes a possibility of the use of efficient deep learning algorithms such as virtual speech recognition and video classification over wireless 5G-IoT nodes. The combination of 5G, IoT and AI has a higher potential of changing the landscape of businesses by making intelligent decisions in real-time. With the availability of powerful hardware for IoT nodes, the inclusion of intelligence on IoT nodes or a fog node closer to end devices decreases latency, improves link capacity, and upgrades the network security.

Interestingly, AI based techniques could also be employed over 5G-IoT networks to further optimize its own performance at application, physical and network layers to further enhance data rates by predicting traffic patterns on the network, thus facilitating the provisioning of AI based user applications. For example, at the application layer, AI techniques could be utilized for studying network traffic and capacity trend analysis to make the network self-configurable, self-organized and self-adaptive. On physical and network layers, AI based optimization algorithms could facilitate dynamic spectrum management, structuring of huge data, integration of heterogeneous devices, ultra-densification of devices, IoT nodes interoperability, and improved battery life.

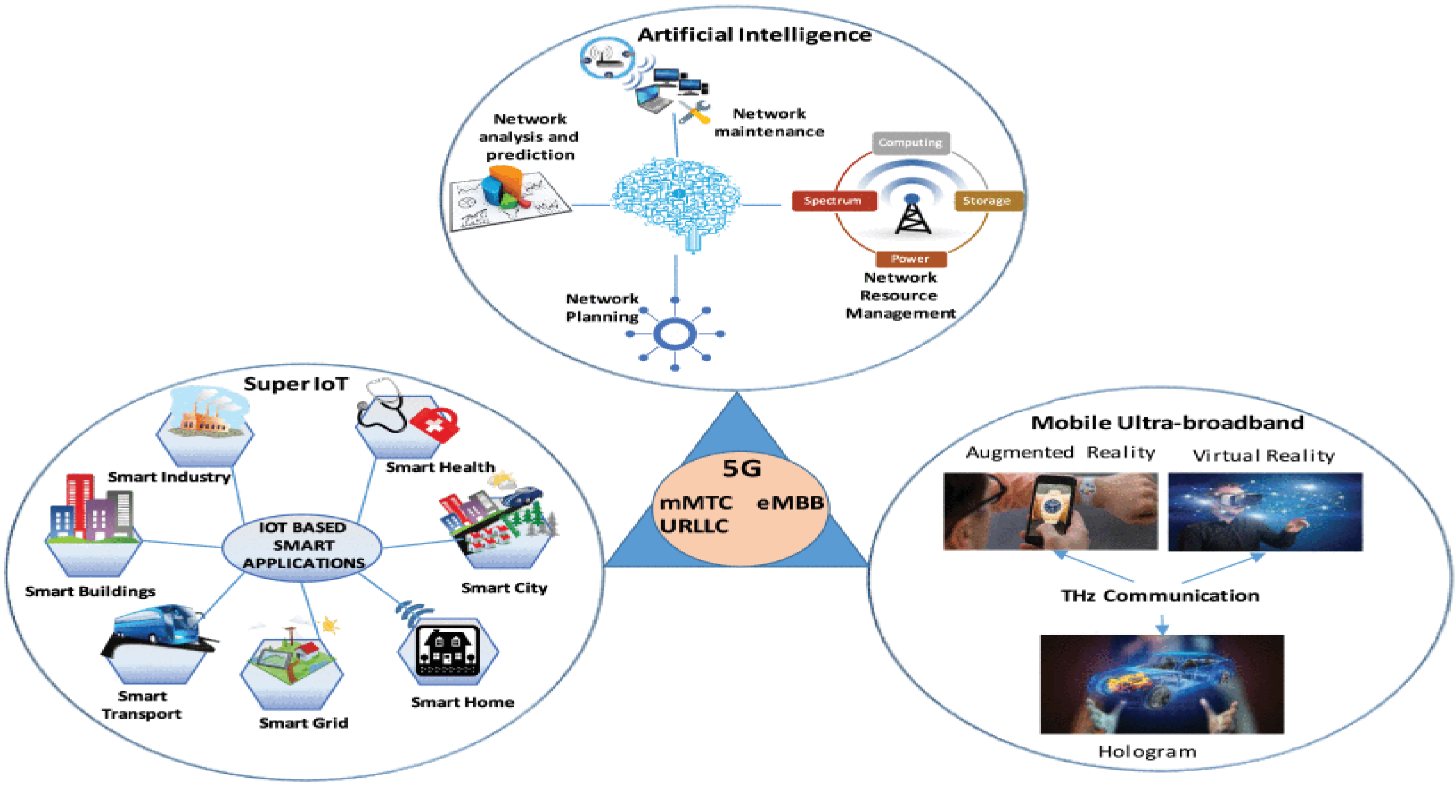


FIG:
Architectural scenario where 5G meets artificial intelligence.

THE TELEDESIC SATELLITE SYSTEM: The teledesic Network uses a constellation of low-Earth orbit (LEO) Ka-band satellites to provide a variety of services including multimedia conferencing, video conferencing, video telephony, distance learning, and voice. The satellite uplinks operate in the 30 GHz band and the downlinks operate in the 20 GHz band. The constellation consists of 924 satellites at 700 Km altitude in 21 orbital planes inclined at 98.2”. The orbital planes are spaced 9.5” apart. The teledesic Network provides low-cost worldwide untethered low-delay bandwidth-on-demand to geographically diverse users in addition to wideband trucking capability between a limited number of sites worldwide. A family of subscriber terminals provide on demand data rates from 16 Kbps up to 2.048 Mbps (El), and for special applications from 155.52 Mbps (OC-3) up to 1.24416 Gbps (OC-24). This allows a flexible, efficient match between system resources and subscriber requirements.

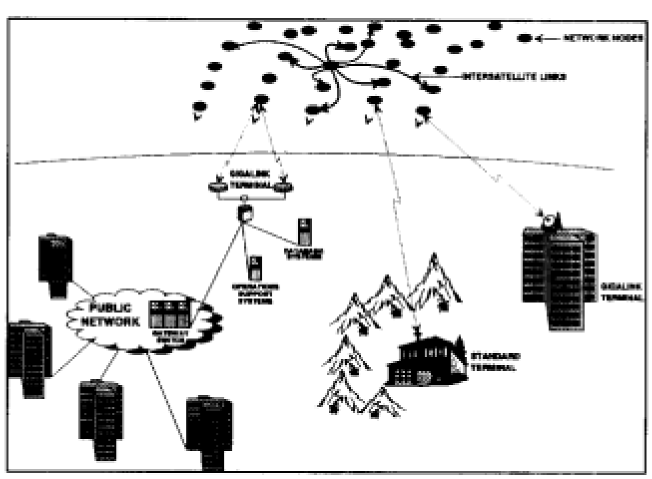


Fig: The Teledasic Network

Q3: Show that the Parsevl's theorem has implications for society?
Ans: Parseval's theorem states that the energy of a signal in the time domain equals the energy of the transformed signal in the frequency domain. In mathematics, Parseval's theorem usually refers to the result that the Fourier transform is unitary; loosely, that the sum (or integral) of the square of a function is equal to the sum (or integral) of the square of its transform. Parseval's theorem is also known as Rayleigh's energy theorem, or Rayleigh's identity.

Formula of Parseval's theorem:

$$\mathbf{P}_{x(t)} = \sum_{n=-\infty}^{+\infty} |\mathbf{Cn}|\mathbf{2}$$

Applications Parseval's theorem:
- Signal processing, studying behaviors of random processes, and relating functions from one domain to another.
- Determine Power of Signals.

Q4: Evalute Fourier Transform of following and their applications
Ans: A Fourier transform is a mathematical tool or method which used to analysis frequency variation of signal from one domain into other. It is used to convert time domain function or signal into frequency domain and to enquire its behaviors.

1. $\mathcal{F}[\boldsymbol{\delta(t)}]$

Sol:

By using Fourier formula

≫ $X(\omega) = \int_{-\infty}^{+\infty} x(t)\, e^{-j\omega t}\, dt$

≫ $X(\omega) = \int_{-\infty}^{+\infty} \delta(t)\, e^{-j\omega t}\, dt$

≫ $\therefore X(\omega) = \int_{-\infty}^{+\infty} 1.e^{-j\omega t}\, dt$

(As the unit sample function is unity at t=0)

≫ $\therefore X(\omega) = \int_{-\infty}^{+\infty} 1.e^{-j\omega .0}\, dt$

≫ $\therefore X(\omega) = \int_{-\infty}^{+\infty} 1.e^{0}\, dt \qquad \Rightarrow \mathbf{1}$

$$\boxed{\mathcal{F}[\boldsymbol{\delta(t)}] = \mathbf{1}}$$

Ans.

Applications of Impulse function:
- In acoustic and audio applications, impulse responses enable the acoustic characteristics of a location, such as a concert hall, to be captured. Various packages are available containing impulse responses from specific locations, ranging from small rooms to large concert halls.
- In the real world, an impulse function is a pulse that is much shorter than the time response of the system. The system's response to an impulse can be used to determine the output of a system to any input using the

time-slicing technique called convolution.

2. $\mathcal{F}$**[Cos(ωct)**]

   $\boldsymbol{Sol}$:

   $As\ we\ know\ \ from\ identity\ that$:

   ≫ Cos(wct) = $\frac{1}{2}(\ e^{j\omega ct} +\ e^{-j\omega ct})$

   ≫ $\therefore\ \mathcal{F}T[Cos(wct)]\ \ = \frac{1}{2}[\ \mathcal{F}T(e^{j\omega ct}) +\ \mathcal{F}T(e^{-j\omega ct})]$

   ≫ ∴ X(ω) = $\frac{1}{2}[\ 2\pi\ \delta(w - wc) +\ 2\pi\ \delta(w + wc)]$

   ≫ ∴ X(ω) = $\frac{2\pi}{2}[\ \ \delta(w - wc) +\ \ \delta(w + wc)]$

   ≫ ∴ X(ω) = $\pi\ [\ \ \delta(w - wc) +\ \ \delta(w + wc)]$

$$\boxed{\mathcal{F}\ [\mathbf{Cos(\omega ct)}]\ =\ \boldsymbol{\pi}\ [\ \boldsymbol{\delta}(\boldsymbol{w} - \boldsymbol{wc}) +\ \ \boldsymbol{\delta}(\boldsymbol{w} + \boldsymbol{wc})]}$$

Ans.

Application of Cosine Function:
A cosine functions can be used to model many real-life scenarios – radio waves, tides, musical tones, electrical currents

3. $\mathcal{F}$ [Cos^2(wct)]

   $\boldsymbol{Sol}$:

   By using formula

   ≫ X(t) =$\frac{1}{2\pi}\int_{-\infty}^{+\infty} x(\omega)\ e^{-j\omega t}\ d\omega$

   ≫ ∴ Cos^2(wct) = $\frac{1}{2\pi}\int_{-\infty}^{+\infty} Cos^2(\text{wct}).\, e^{-j\omega t}\ d\omega$

   Putting the values in Fourier formula

   ≫ X(ω) = $\frac{1}{2}\ [\sqrt{\frac{\pi}{2}}\ \delta(w - 2wc) + \frac{1}{2}\ \ \sqrt{\frac{\pi}{2}}\ \delta(2w - wc) +\ \ \sqrt{\frac{\pi}{2}}\ \delta(w)]$

   ≫ X(ω) = $\frac{1}{2}\ \sqrt{\frac{\pi}{2}}\ \ [\delta(w - 2wc) +\ \delta(2w - wc) +\ \ \delta(w)]$

   Assume $\boldsymbol{w\ and\ wc\ are\ Positive}$

$\gg$ $\therefore$ X(ω) = $\frac{1}{2}$ $[\sqrt{\frac{\pi}{2}} \quad \delta(w - 2wc)]$

$\gg$ $\therefore$ $\boldsymbol{\mathcal{F}}$ $[Cos^2(w\text{ct})]$ = $\boldsymbol{\mathcal{F}}$ $[Cos^2(w\text{ct})]\ (w)$

$$\Longrightarrow \frac{1}{4}\ \sqrt{\frac{\pi}{2}}\ \int_{-\infty}^{+\infty} Cos^2(\text{wct}).Cos \quad (\text{wct})\ e^{-j\omega t}\ dt$$

$$\boxed{\Longrightarrow\ \therefore \frac{\mathbf{1}}{\mathbf{4}}\ \sqrt{\frac{\boldsymbol{\pi}}{\mathbf{2}}}\ [\ \boldsymbol{\delta}(\boldsymbol{w} - \mathbf{2}\boldsymbol{wc}) + \ \boldsymbol{\delta}(\mathbf{2}\boldsymbol{w} - \boldsymbol{wc}) + \mathbf{2}\ \boldsymbol{\delta}(\mathbf{2}\boldsymbol{w} + \boldsymbol{wc}) + \ \mathbf{4}\ \ \boldsymbol{\delta}(\boldsymbol{w})}$$

Ans.

4. $\boldsymbol{\mathcal{F}}(\mathbf{10})$

Sol:

By using Fourier formula

$\gg$ X(t) = $\frac{1}{2\pi}\int_{-\infty}^{+\infty} x(\omega)\ e^{-j\omega t}\ d\omega$

$\gg$ $\therefore$ $10 = \frac{1}{2\pi}\int_{-\infty}^{+\infty} x(\omega)\ e^{-j\omega t}\ d\omega$

$$\Longrightarrow \frac{1}{2\pi}\int_{-\infty}^{+\infty}[2\pi\ 10\ \delta(w)]\ e^{-j\omega t}\ d\omega$$

$$\Longrightarrow \frac{2\pi\ 10}{2\pi}\int_{-\infty}^{+\infty}\ \delta(w)\ e^{-j\omega t}\ d\omega \qquad (\therefore\ \delta(w) = 1)$$

$$\boxed{\Longrightarrow \mathbf{10}}$$

Ans.