

№2 lecture

Informational Characteristics of the Message Source and Communication Channel

Dosbayev Zhandos Makhsutuly, senior lecturer

E-mail: zh.dosbayev@satbayev.university

Outline

Introduction to Telecommunications and Information Transmission: Defining key terms and concepts.

1.Characteristics of the Message Source in Telecom:

Source Reliability and Authenticity

Message Encoding and Integrity

2.Characteristics of the Communication Channel in Telecom:Types of Channels: Wired, Wireless, and Digital

Bandwidth, Latency, and Noise

3.Source-Channel Interaction in Telecom Systems:

Choosing Sources and Channels for Optimal Signal Transmission

Examples of Network and Signal Reliability in Telecom

4.Summary and Key Takeaways

5.Questions

Introduction to Telecommunications and Information Transmission

Definition of Telecommunications:

Telecommunications is the transmission of information over distances using electronic and digital signals.

It includes services like phone calls, internet data transfer, radio, television, and satellite communication.

Message Source: The originator of the information, often involving machines or network nodes.

Communication Channel: The medium through which the data or signals are transmitted, such as fiber optics, radio waves, or digital networks.

Significance: Effective telecommunications requires a reliable message source and a clear, interference-free communication channel to ensure that information is received accurately and efficiently.

Characteristics of the Message Source in Telecommunications

Source Reliability:

Essential for preventing information corruption and security breaches.

Reliable sources use error-checking codes, encryption, and authentication protocols.

Source Authenticity:

Ensures that the information comes from a verified source, preventing unauthorized access.

Protocols like two-factor authentication and digital signatures can verify source authenticity.

Message Encoding:

The process of converting data into a secure format for transmission.

Encoding helps protect the message's integrity by reducing errors and securing data from unauthorized access.

Formula for Data Integrity: $\text{Error Rate} = (\text{Number of Errors}) / (\text{Total Transmitted Bits})$

Message Integrity:

Maintaining the accuracy and completeness of data from source to receiver.

Methods like checksums, hashing, and parity checks verify that data remains unchanged during transmission.

Characteristics of the Communication Channel in Telecommunications

Types of Channels: **Wired Channels:** Fiber optics, coaxial cables, and twisted-pair cables provide high reliability and low interference but may have physical limitations.

Wireless Channels: Radio frequencies, microwave signals, and satellite communication allow for flexible, mobile data transfer but can be prone to interference.

Digital Channels: Internet-based transmission, VoIP, and IP networks that are scalable and efficient for large data transfers.

Channel Bandwidth: Bandwidth defines the maximum rate of data transfer in a channel, measured in bits per second (bps). Higher bandwidth allows for higher data rates and supports high-quality transmission, especially for multimedia.

Formula: Channel Capacity (C) = Bandwidth (B) x $\log_2(1 + \text{Signal-to-Noise Ratio})$

Latency: Refers to the delay in data transmission, often critical in real-time applications like video calls or online gaming.

Measured in milliseconds, and lower latency indicates faster data delivery.

Noise: Any external or internal factor that disturbs signal clarity.

Includes thermal noise, electromagnetic interference, and atmospheric disturbances that affect wireless channels.

Noise can be minimized with filters, signal processing, and error correction techniques.

Impact of Channel Properties on Message Transmission

Bandwidth and Data Rate: Higher bandwidth supports faster data rates, allowing more data to be transmitted per unit of time.

Example: Streaming video requires higher bandwidth for smooth playback, whereas text transmission requires minimal bandwidth.

Latency and Real-Time Communication: Low latency is crucial for applications requiring quick data exchange, like video conferencing, online gaming, or financial transactions.

Example: Video calls require low latency to avoid delays in conversation and maintain natural interaction.

Noise Reduction Techniques: Signal Processing: Increases signal-to-noise ratio by filtering out unwanted frequencies.

Error Correction Codes (ECC): Adds redundant data to allow the receiver to detect and correct errors.

Examples of ECC: Hamming codes, Reed-Solomon codes, and CRC (Cyclic Redundancy Check).

Source-Channel Interaction in Telecom Systems

Optimizing Source and Channel Selection: Reliable sources combined with high-capacity channels maximize data security, speed, and clarity.

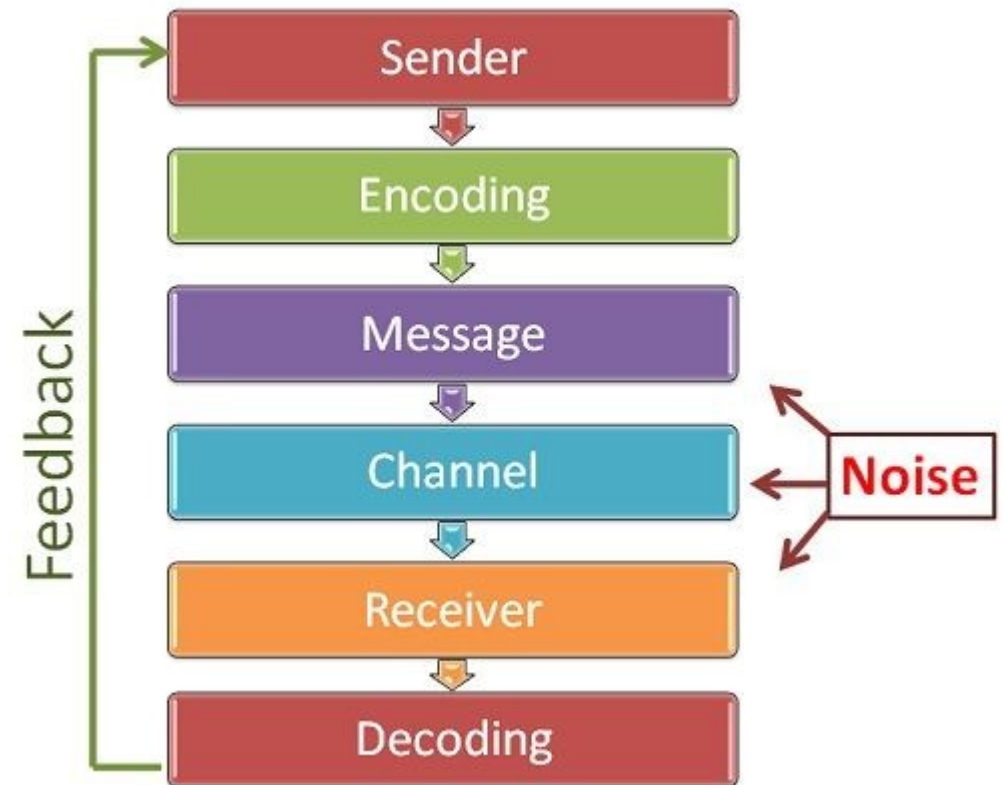
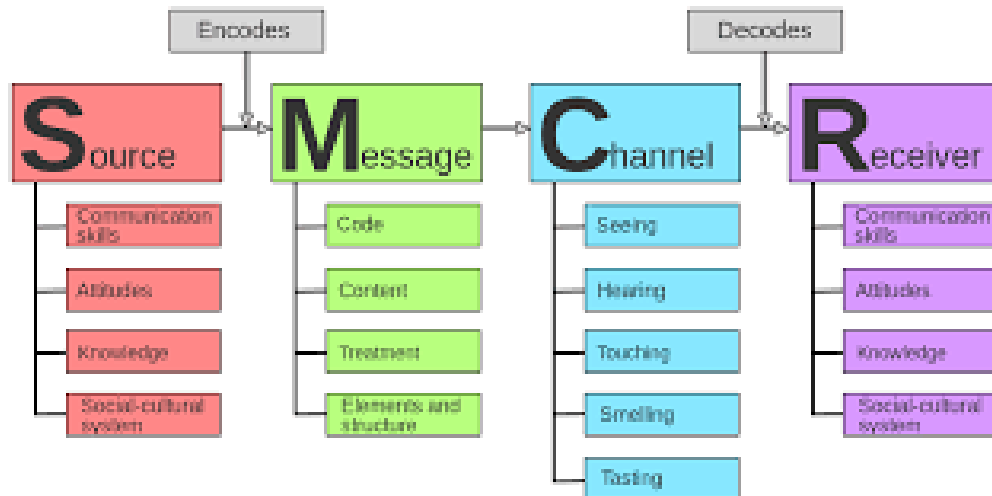
Channels are selected based on factors like required bandwidth, acceptable latency, and environmental conditions.

Example: Fiber optic channels for high-speed internet reduce latency and have minimal interference, ideal for fast, stable communication.

Case Study: 5G Networks: 5G technology enables low-latency, high-bandwidth connections by using millimeter-wave spectrum, ideal for real-time applications like autonomous driving.

Wireless vs. Wired Channels: Wireless channels are preferred in mobile or remote applications but may have higher noise.

Wired channels, though less flexible, provide stable connections and higher data rates, especially in controlled environments.



Error Detection and Correction in Telecommunications

Error Detection: Methods to identify errors in transmitted data.

Parity Check: Adds a single bit to check for data integrity.

Checksum: Sum of data blocks for error verification.

Error Correction: Techniques to fix identified errors.

Hamming Code: Detects and corrects single-bit errors.

Reed-Solomon Code: Commonly used in CDs, DVDs, and QR codes.

Formula: $\text{Data Accuracy} = (\text{Total Bits} - \text{Error Bits}) / \text{Total Bits}$

Importance: Ensures data reliability in noisy environments.

Case Studies in Telecommunications

Fiber Optic Communication: Known for high bandwidth and minimal latency. Used in high-speed internet and long-distance connections.

Key Success Factors: Low attenuation, resistance to electromagnetic interference.
5G Wireless Networks: Enhanced capacity, low latency, high data rates.

Applications: Real-time IoT applications, autonomous vehicles. **Satellite**

Communication: Provides connectivity to remote areas.

Higher latency but ideal for global coverage.

Example: GPS networks for navigation.

Emerging Technologies and Future Trends in Telecommunications

6G Networks: Expected to achieve speeds up to 100 times faster than 5G. Focus on even lower latency and advanced AI integration.

Quantum Communication: Uses quantum encryption for ultra-secure data transmission. Potential applications in high-security sectors like finance and government.

Internet of Things (IoT) Expansion: Growth of interconnected devices in smart cities, health tech, etc. Relies on secure, low-latency telecom networks.

Edge Computing: Brings data processing closer to the data source. Reduces latency and enhances real-time processing for applications like AI.

Summary and Key Takeaways

Reliable Sources and Channels: Essential for accurate and secure data transmission.

Channel Characteristics: Bandwidth, latency, and noise impact the quality and efficiency of message delivery.

Advanced Error Correction: Necessary to maintain data integrity in noisy environments.

Future Trends: Innovations like 6G, quantum communication, and IoT highlight the growing complexity and importance of telecommunications.

1. What techniques are used in error detection and correction to ensure data accuracy in telecommunications?
2. How do bandwidth and latency influence communication quality in real-time applications?
3. What are some emerging technologies in telecommunications, and how do they aim to improve data transmission?
4. Why is source authenticity important in telecom systems, and how is it typically achieved?
5. How does quantum communication differ from traditional communication in terms of security?