Key LEO protocols typically include mechanisms for dynamic routing, inter-satellite links (ISL) for data relay between satellites, error correction methods, and efficient handoff management to support uninterrupted connections as satellites move in and out of range.

### **Use Case: Tracking and Monitoring Arikomban, the "Rice Tusker"**

Arikomban, a male elephant in Kerala, became notorious for raiding rice shops. To manage his relocation and ensure health monitoring, he was fitted with a radio collar. However, the collar was ineffective in remote forest areas due to signal limitations, complicating real-time tracking, especially after tranquilizer administration.

### **Why This Topic**

I chose this use case to explore how technology can improve wildlife conservation efforts, particularly in tracking and monitoring endangered species in remote areas. The case of Arikomban highlights the challenges faced by traditional tracking systems in dense forests where satellite signals are obstructed. By leveraging **Low Earth Orbit (LEO) satellites** and **Peer-to-Peer (P2P) networking**, we can develop a more reliable and scalable wildlife tracking solution.

### **How I Will Work on It**

I plan to integrate **LEO satellites** to offer frequent, real-time communication and tracking in remote regions, overcoming the limitations of traditional tracking systems. The combination of **P2P networking** will enable wildlife tracking devices to relay data even when direct satellite communication is not available. I will focus on:

1. **Enhancing Tracking Capabilities**: Use LEO satellites for continuous monitoring, ensuring that data on an animal’s location and health is always up-to-date, even in challenging terrains.
2. **Improving Network Reliability**: Leverage P2P networks to allow devices to store and forward data when not in satellite range, ensuring no critical information is lost.
3. **Designing Scalable Systems**: Build scalable systems that can be expanded as more wildlife tracking devices are deployed across large conservation areas.

This integrated system will ensure that conservationists can respond quickly to potential threats like poaching or health risks, significantly improving real-time interventions and monitoring.

### **Key Benefits of LEO Satellites and P2P Networking**

* **Frequent Data Transmission**: LEO satellites’ proximity allows for consistent data transmission, crucial for real-time tracking.
* **Remote Area Coverage**: These satellites can cover areas without cellular networks, such as forests, oceans, and deserts.
* **Cost-Effectiveness**: Operating LEO satellites is cheaper compared to traditional geostationary satellites, making them more accessible for conservation projects.

P2P networking will complement this by ensuring resilience, as devices can communicate with each other even when direct satellite links are unavailable, providing a more robust solution in remote wildlife habitats.

### **Five Communication Systems for Wildlife Conservation Using LEO Satellites and P2P Networking**

#### **Direct LEO Satellite Communication**:

* + **How It Works**: Wildlife tracking collars or monitoring stations directly communicate with LEO satellites, sending data such as location, health metrics, and behavioral patterns.
  + **Benefit**: Real-time monitoring even in remote locations, where terrestrial networks fail, ensures timely interventions in case of distress or poaching activities.

**Wildlife Collar Node:** Each collar sends tracking and health data (e.g., location, temperature, heart rate) to a satellite whenever in range.

**Satellite:** Acts as the receiver of the data and stores or processes it for real-time monitoring.

**P2P Simulation:** To simulate the scenario, we will assume that the data will be stored and sent directly to a "satellite server" when the node is in range. The P2P aspect can help in scenarios where devices might temporarily relay data to a "satellite server."

Steps for Communication:

1. **Wildlife Collar Node:** Collects data (location, health metrics) and attempts to send it to a satellite.
2. **Satellite Communication:** Simulates satellite communication, which is always available in this case (no relays needed).
3. **Data Transmission:** The collar node will attempt to send data at regular intervals, simulating real-time monitoring.

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#### **P2P Mesh Network with Satellite Handover:**

* + **How It Works**: A network of P2P devices (collars, drones, or monitoring stations) communicates with each other to relay data to satellites. Devices can store data temporarily and forward it when in range of a satellite, ensuring that communication is seamless even when a direct satellite link is not available.
  + **Benefit**: This system provides resilience against connectivity issues, making it particularly useful in dense forests or mountainous regions where signal loss is common.

#### **Satellite-Drone Relay Systems**:

* + **How It Works**: Drones equipped with communication relays can receive data from tracking collars or sensors and forward it to satellites in areas where direct communication with the satellite is not possible. Drones can also be used to patrol large areas and relay data to monitoring stations.
  + **Benefit**: Drones extend the range of communication networks, covering vast areas where wildlife is dispersed. They also help in areas with dense vegetation where satellites might struggle to establish direct links.

#### **Integrated Wildlife Monitoring and Early Warning System**:

* + **How It Works**: Tracking collars on endangered species like elephants, tigers, or rhinos can transmit real-time data about their location, speed, and health metrics (e.g., body temperature, heart rate). In addition to using satellites for direct communication, the system uses P2P devices placed along migration paths or park boundaries to create a network that can alert conservationists to potential poaching or health issues.
  + **Benefit**: Immediate alerts in case of abnormal behavior or poaching risks, such as when an animal enters a dangerous area or becomes unwell, can lead to faster intervention and protection.

#### **Satellite-Based Data Store-and-Forward System**:

* + **How It Works**: When wildlife tracking devices are outside the direct line of sight to a satellite, they store data locally and forward it when the satellite is in range. In the meantime, nearby devices in a P2P network can help relay data.
  + **Benefit**: This system works efficiently in areas with intermittent satellite visibility. The store-and-forward feature ensures no data loss, even during periods of connectivity issues, which is critical for long-term wildlife monitoring.

### **Conclusion**

By integrating LEO satellites and P2P networks, wildlife conservation efforts can be significantly enhanced. These technologies offer a scalable, reliable, and cost-effective way to monitor wildlife, ensuring timely interventions to protect endangered species like Arikomban.

**Sources**:

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