Revolutionizing Low Earth Orbit Satellite Systems

White Paper 3

Multi-Link Routing Protocol Summary

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StarMesh Global™ Multi-Link Routing Protocol

Connecting users worldwide through low-flying LEO and VLEO satellites requires a robust network of satellite-to-satellite connections. Traditional approaches rely on large fleets of costly, standard communication satellites—often numbering in the hundreds or thousands—driving fleet design, build, launch, and maintenance costs into the hundreds of millions, if not billions, of dollars. Furthermore, satellites operating at these low altitudes face rapid orbital decay due to atmospheric drag, resulting in short lifespans and frequent de-orbiting. This model is not only unsustainable but also unprofitable.

Current satellite communication systems are constrained by outdated methodologies that depend on centralized control. To maintain fixed routes, every satellite's orientation and position are meticulously managed through complex telemetry and thruster technologies. This approach, while effective, is resource-intensive and rigid, requiring satellites to be meticulously aligned to establish connections across long distances.

StarMesh Global introduces a paradigm shift. We offer a revolutionary freeform routing system by abandoning the traditional brute-force satellite communication methods. Our innovative approach leverages small, intelligent satellites capable of autonomous routing, drastically reducing manufacturing and deployment costs by orders of magnitude compared to current LEO and VLEO systems. This new model opens the door to a sustainable and scalable future for global satellite communications.

StarMesh Global Routing—The Basics

At the heart of StarMesh Global's technology is its groundbreaking approach to satellite radio connectivity. It challenges conventional wisdom by creating radio links "backward" from a receiving ground station to the sending ground station. The route creation process begins with signals transmitted from the sending ground station to a satellite and subsequently to a receiving ground station, directly or through intermediary nodes such as other satellites, drones, or balloons. Once the optimal route is established, the direction is reversed for data transmission, allowing the receiving ground station to act as the origin and the sending ground station to become the destination. This reverse-routing method optimizes signal quality and ensures flexibility in StarMesh's global network, which incorporates mobile devices, drones, and balloons to enhance signal strength and coverage.

While this may seem straightforward, its implementation involves a high degree of sophistication. StarMesh Global satellites are streamlined and cost-effective, equipped with only essential components—radio chips, antennas, solar panels, batteries, and microprocessors. StarMesh satellites and ground stations are equipped with multiple directional antennas capable of transmitting signals in discrete directions that form the system's backbone. Typically, a StarMesh system consists of 200 to 300 satellites operating in unrestrained orbits evenly distributed over the Earth's surface.

In a basic scenario involving terrestrial ground stations and satellites, the route creation process begins when a ground station transmits initial information signals from its antennas. Given the large number and wide distribution of satellites, it is highly probable that multiple satellites will detect these signals, even without precise geolocation or orientation control. The satellite that receives the signal records the antenna through which it was received and the signal strength or other relevant quality metrics.

The satellite then transmits a routing signal containing the address of the sending ground station and the associated quality metric. Other satellites and ground stations that receive this routing signal similarly record the relevant data. This chain continues until the receiving ground station applies an algorithm to evaluate the quality of all received routing signals, selecting the optimal route based on the highest combined signal quality. The system can also discard routes below a certain quality threshold, ensuring only the best available route is chosen.

Once the optimal route is established, data transmission begins "backward" from the receiving ground station to the sending ground station via the pre-selected satellites, using the antennas recorded during route creation. This dynamic, adaptive routing method significantly reduces the need for complex telemetry and orientation control systems typically required in traditional satellite communications. Instead, StarMesh's approach leverages simplicity and efficiency by utilizing the inherent distribution of satellites to create reliable, cost-effective routes.

This process scales efficiently, even when simultaneously creating multiple routes between numerous ground stations. All satellites within the constellation transmit and receive routing signals concurrently, adhering to the same principle of forward route creation followed by reverse data transmission. As a result, StarMesh Global's decentralized, adaptive routing approach enables robust, scalable satellite communications across a wide range of applications and environments.

The Power of StarMesh Global Routing

The strength of StarMesh Global's freeform routing paradigm lies in its versatility and efficiency, extending beyond satellite-only systems to include drones, balloons, and multi-altitude networks. These systems enable cost-effective, scalable communications for individual users and large-scale networks. Low-altitude drones and balloons (operating at 5–6 miles) can initiate route creation by connecting directly with terrestrial users, forming localized networks that can seamlessly integrate with higher-altitude satellites. StarMesh Global's flexible architecture allows direct connections between drones, balloons, and geostationary satellites (GEOs) to facilitate long-distance communication. Figure 22 from U.S. Patent No. 10,979,136 (shown here) illustrates these powerful configurations.

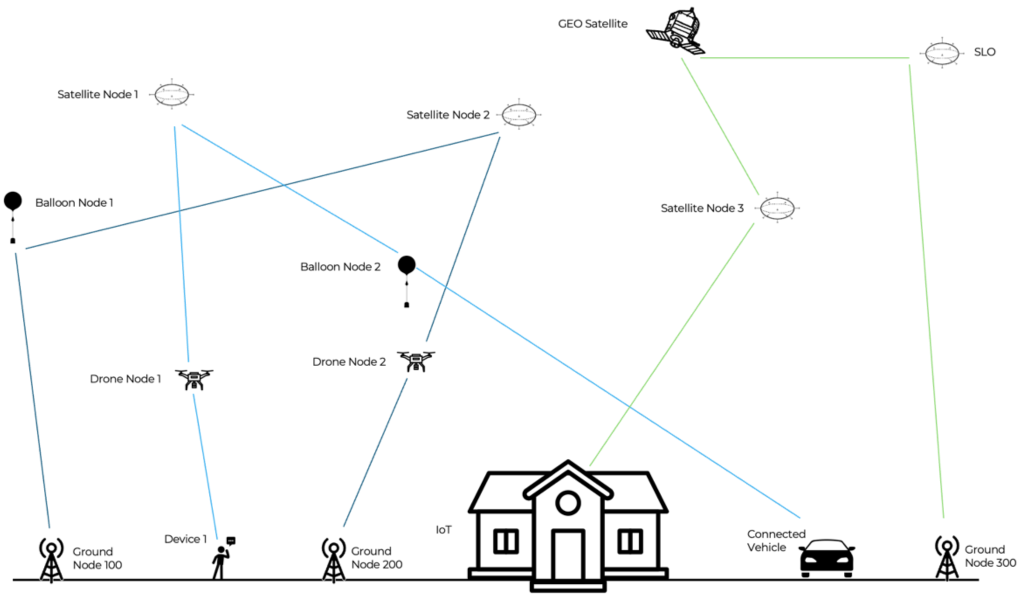

FIGURE 22

StarMesh Global's revolutionary multi-link routing protocols can also be applied to traditional satellite systems with fixed orbits and strict attitude control. Incorporating the innovations outlined in the StarMesh Global patent portfolio makes rapid route creation possible for mission-critical applications such as broadband communications. The system is adaptable to networks that feature satellites, drones, and balloons operating at different altitudes. Existing GEO satellites can play a key role in minimizing the number of nodes required for long-distance communication between users across the globe.

Tremendous Cost Savings of A StarMesh Global Satellite

The StarMesh Global system delivers significant cost savings through innovative design choices for its LEO/VLEO satellites. Unlike traditional satellites, StarMesh satellites do not require heavy, expensive rocket-fueled or electric thrusters, complex ground-based telemetry systems, or onboard sensors to maintain specific positions or altitudes. By eliminating this costly hardware, StarMesh satellites are smaller, lighter, and more affordable to launch and maintain.

These design efficiencies extend beyond reducing satellite size and weight. StarMesh Global satellites do not require the same level of engineering robustness as traditional satellites, and they are designed to withstand the intense forces of launch and the harsh conditions of space. StarMesh satellites also benefit from simplified deployment procedures. They can be placed into random or arbitrary orbits, reducing the need for the precise and costly deployment sequences typical of traditional satellite systems. This flexibility significantly lowers both launch and deployment costs.

StarMesh Global's LEO/VLEO satellites may eventually de-orbit due to their lack of onboard propulsion. However, their low cost makes replacing them far more economical than maintaining more expensive, hardware-laden satellites. Furthermore, StarMesh satellites are designed to operate at altitudes lower than installations like the International Space Station, eliminating the possibility of collisions as their orbits decay.

Ultimately, these innovations result in a satellite communication system that is more efficient, sustainable, and cost-effective, offering unmatched value in the rapidly evolving space industry.

In Summary

StarMesh Global's Multi-Link Routing Protocol introduces a revolutionary approach to satellite communication by employing freeform routing via small, intelligent LEO and VLEO satellites. This innovative system replaces traditional, costly methods with decentralized, adaptive routing that leverages the natural distribution of satellites to establish efficient and cost-effective connections across the globe.

By incorporating drones, balloons, and geostationary satellites, StarMesh enables robust communication across multiple altitudes and distances, minimizing the need for complex hardware and extensive deployment costs. The system's unique reverse-routing process optimizes signal quality, ensuring sustainable, scalable, and secure global communications. This delivers significant cost savings and contributes to a more efficient and environmentally responsible space industry.

About StarMesh Global

StarMesh Global has evolved from a conceptual think tank into a technology development and engineering leader, pioneering groundbreaking satellite designs and communications systems. Leveraging low-earth orbit satellite networks, StarMesh provides global connectivity at a fraction of the cost of traditional industry solutions.

With its extensive international patent portfolio, StarMesh drives innovation and disruption across the aerospace, defense, and communication sectors while enabling various commercial applications.

To learn more, visit www.starmeshglobal.com.

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