The HALO Network

Broadband wireless millimeter wavelength services provided from a High Altitude Long Operation (HALO) Aircraft are now feasible. Our talk will emphasize the conceptual design of a "bandwidth-on-demand" wireless network whose data rates to and from the subscriber will measure in the multi-megabit per second range. A variety of metropolitan area spectrum bands offer the needed bandwidth. An attractive choice is the LMDS band near 28 GHz and system characteristics at this frequency will be described.

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The High Altitude Long Operation (HALO) network is a broadband wireless metropolitan area network consisting of HALO aircraft operating at high altitude and carrying an airborne communication network hub and network elements on the ground. The HALO network will be located in the atmosphere, at altitude miles above terrestrial wireless, but hundreds to thousands of miles below satellite networks. It will provide broad Band services to business and small offices in an area containing a typical large city. The HALO network infrastructure is simple, having a star topology with single central hub. Consequently, the deployment service to the entire metropolitan area can occur in the first day. The network deployed and subsequent maintenance cost is expected to be low. The system capacity can be increased by decreasing the size of beam spots on the ground while increasing the number of beams with in the signal foot print or by increasing the signal bandwidth beam.

The System Architecture of the HALO Network

As shown in fig.1, the HALO/Proteus aircraft servers as the hub of the wireless broad band communication network. It carries the borne network elements including an ATM switch Spot beam antennas, and multi beam antennas, as well as transmitting and receiving electronics. The antenna array provides cellular like coverage of

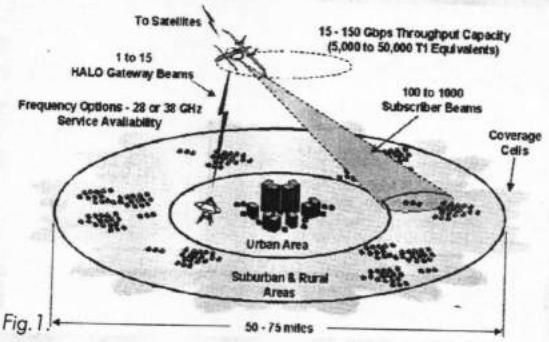

Fig. 1

large metropolitan area. Asynchronous transfer mode switches, now available, have capacities sufficient to satisfy the traffic volume requirements of the first network deployment and margins for growth.

The HALO/Proteus airplane shown in fig.2 has been specially designed to carry hub of the HALO Network. The airplane can carry a weight of approximately 2000lb (90 kg) to its station keeping. The airplane is essentially an equipment bus from which commercial wireless systems will be offered. A fleet of three aircraft will be cycled in shifts to achieve continuous service above an isolated city. In a multi city deployment an average of two aircraft will be allocated to each city, and the fleet operations will be conducted from a common primary flight Base as a "hub and spokes" operation to achieve continuous service. Each shift on station will have an average duration of approximately 8 hr.

the antenna array would be fixed on the ground, and there would be no overlapping area between adjacent cells. The cellular pattern would cover a metropolitan-scale area. The altitude of aircraft be 16Km. it would have an orbit diameter of 14.8 Km (ring 3level) by assuming a constant ground speed; the orbit would have a period of approximately 6 min. Each cell on the ground is covered by one spot beam. However, the spot beam that covers a particular cell changes due to the motion of the aircraft. A given beam covers a given cell on the ground for duration of time called dwelled time. Once the duration is exceeded, the Beam must ratchet over by one or more beams to cover a new cell on the ground.

The System Reference Model of the HALO Network

The major elements of the conceptual HALO network are the airborne communications hub carried by the HALO/Proteus airplane, the premises equipment or user terminals, the network Control station, the HALO gateway (HG) and the various interfaces. The reference architecture shows the topology of the interconnected network elements. The HALO network can be connected to non-HALO networks such as ATM networks, internet and frame relay via an HG/inter working unit (IWU).

With in HALO network, four types of network elements can be connected to the onboard switch:

- **Customer premises equipment (CPE, low rate user terminals):** Since this terminals equipped With the necessary interfaces to the HALO wireless channels, they have direct access to HALO networks the terminals can support either ATM or IP end users if it is a an IP User, IP over ATM will be implemented in the terminals.
- **Business premises equipment (BPE, high rate user terminals):** This type of premises equipment is provided for a user group such as company, university, factory, or another type of User group. For example, company has a private ATM network and its employees will have access to that network if the private network has HALO network compatible BPE to serve as a bridge between the corporate network and the HALO network all of users with in the company will be able to gain access to the HALO network.
- **HG/IWU:** The equipment provides the porale and interfaces between HALO and non HALO Network; only public ATM network will have direct connection to the HALO gate way because other networks are not compatible with the HG/IWU. Therefore internet and frame relays services have to be connected to the ATM networks before they are connected to the HG/IWU.
- **Network control station:** It is responsible for the maintainances, operation and administration of HALO network. Also the connection admission control (CAC), processing of time slot reservation are the request generated by the medium access control (MAC) protocol, handover processing and location management of mobile users are all managed in the controls center.

HALO Network Services

The HALO network accommodates the following design objectives:

- Seamless ubiquitous multimedia services.
- Adaptation to end user environments.
- Rapidly deployable to sites of opportunity.
- Band width on demand for efficient use of available spectrum.

Many types of organizations schools, hospitals, doctors, offices, and small to medium sized business around the world will benefit from the low pricing of broadband services provided by the HALO network. Moreover, HALO can be used as a wireless local loop for mobile telephone services, two-way paging, one way broadcasting, low-data-rate acquisition, and a satellite concentrator. Standard broad band protocols such as ATM and synchronous optical network will be adopted to interface the HALO network as seamlessly as possible.

The HALO Network Advantages

The HALO aircraft can be thought of as a very tall tower or very low altitude satellite. Through the use of only one airborne network hub, versus hundreds of towers for an equivalent terrestrial wireless network, the HALO Network will revolutionize wireless communications by expanding coverage to thousands of square miles and by providing capacity to serve thousands of simultaneous multi-megabit data exchanges. Contrasted to terrestrial broadband networks, the HALO Network offers ubiquitous, anyone-to-anyone, broadband linkages throughout the footprint. All subscribers within the service area will have full access to the network on the first day it is activated.

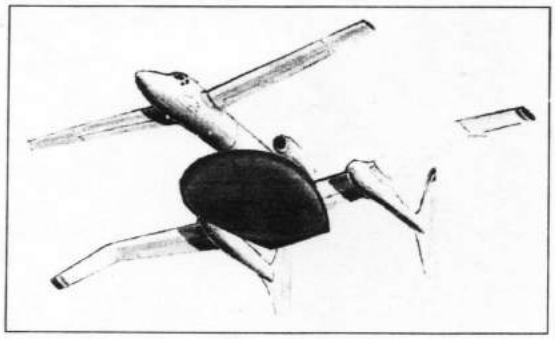

Fig. 2. shows the HALO/Proteus air plane.

The HALO/Proteus airplane will maintain station at an altitude of 51,000-60,000 ft by flying in Steroidal volume of airspace with a diameter of about 5 to 8 nautical mi. The look angle, defined to be the angle subtended between the location horizon and the airplane with the user terminal at a vertex, will be greater than a minimum value of 20 degrees. The minimum look angle (MLA) for a given user terminal along the perimeter of the service footprint is defined to occur. Whenever the airplane achieves the longest slant range from the terminal while flying with in its designed airspace. Under these assumptions the signal footprint will cover an area of approximately 2000-3000 mi^2, large enough to encompass a typical city and its neighboring communities. Such a high value for the MLA was chosen to ensure a line of sight connection to nearly every rooftop in the signal footprint, and high availability during heavy rain fall for the major cities in North America, especially for broadband data rates propagated by selecting millimeter wavelength (MMW) frequencies, a broadband network of high capacity can be realized, since carrier frequency bandwidths on the scale of 100-1000MHz have been licensed and may be made available through partnerships.

Small antenna apertures on the scale of 1ft will provide beams with narrow beam widths; thus, user terminals can be compact but offer high gain. Also, a multi-aperture antenna array can fit in an airborne pod with dimensions practical to aerodynamicist.

A variety of spectrum allocations could be utilized by a HALO network. The choice of which spectrum to use will be driven by pragmatic technical and business factors. But not limited to practical link margins, licensed band width, maturity and affordability of the user terminals teaming agreements, spectrum access, and regulatory law.

The following two spectrum allocations as examples for creating a high capacity HALO Network offering wireless broad band services:

- Local multi megabit data service (LMDS) at 28GHz
- The microwave point-to-point allocations at 38GHz.

The antenna array produces beams on the ground of two types:

- The shared beam provides services to 100-1000 subscribers.
- The dedicated beam provides a connection to gateway serving high band width users, or to the network gateway through which a user from a non-HALO can access the Services of, and exchange information with, any end user of the HALO network.

The HALO network utilizes multiple beams on the ground arranged in a typical cellular pattern i.e. each cell covers more than several square miles of area. Adjacent cells have different frequency sub bands. The Pattern has a periodic nature and each sub band in the set so chosen (i.e., each sub band of the Frequency reuse plan) is used multiple times with in the service area. Through frequency Reuse, about 2800 mi^2 of area can be covered. The total capacity can be in the range of 10-100 Gab/s. In Fig.3 we provide a map of the shared beam cells for the purpose of modeling and assumed to be produced by the antenna array carried by the HALO air craft .

We have assumed that there would be six rings of cells composed of 125 beams. The cells created by

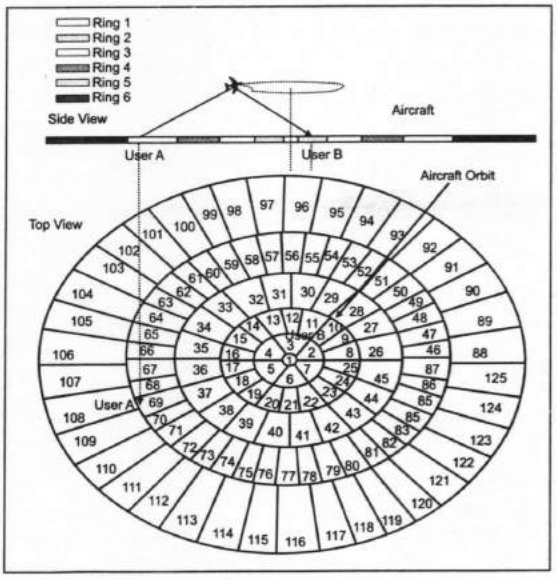

Fig. 3.

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The HALO Network can augment and supplement satellite systems. The HALO Network allocates its capacity directly to population centers and thus can serve as a traffic concentrator for satellite systems or can relay gigabit-per-second data traffic to satellites by using space-to-earth licensed millimeter-wave frequencies. Unlike global satellite systems which necessitate an all-or-nothing deployment and financing.

Applications

- Last-mile, high data rate services without requiring large setup costs
- Two-way multimedia, video, data sound
- Provide low-cost connectivity to Internet users and service providers
- Standard broadband and PSTN interfaces

Conclusion

The HALO network will provide wireless broadband communication services. The Feasibility of this network is assured due to convergence of technological advancements. The key enabling technologies at hand include ATM/SONET technology, digital signal processing of wide band signals, video compression, ultra dense memory modules, light wave aircraft technology. These technologies available to a great extent, from vendors targeting commercial markets.

The HALO network is predicated on the successful integration of these technologies to offer communications service of high quality and utility to small and medium-sized business at reasonable prices. Customers will be able to access the HALO Network unobstructed by buildings and terrain features that affect ground-based systems and fill-in coverage when terrestrial infrastructure is incomplete or missing. In the developing world, airborne deployment will make wireless telephony services possible. In developed countries, new broadband data services including real-time, high-definition video conferencing; telephone calls; broadband Internet connections; and large file transfers can be accessed at substantially reduced cost and at extremely high speed.

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