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ABSTRACT

Frequency Comb Multiple Access (FCMA) is a new combined modulation and multiple access method which will allow cheap hubless Very Small Aperture Terminal (VSAT) networks to be constructed. Theoretical results show bandwidth efficiency and power efficiency improvements over other modulation and multiple access methods. Costs of the VSAT network are reduced dramatically since a hub station is not required.

2. INTRODUCTION

VSAT networks have become increasingly important in the satellite communications arena over the last decade[1]. Predominantly, VSATs have been arranged in hubbed satellite communications networks: either single-hop to or from a hub station or double-hop systems. FCMA is a new combined modulation and multiple access technique which lends itself to a meshed, hubless satellite communications network configuration. FCMA has been investigated in several papers[2345]. This paper briefly describes VSAT network configurations, FCMA and why FCMA is a suitable modulation method for hubless satellite communications networks.

3. VSAT NETWORK CONFIGURATIONS

VSAT networks have typically been arranged in a star configuration as shown in the figure below. In this configuration a number of VSATs communicate through or via a hub station.
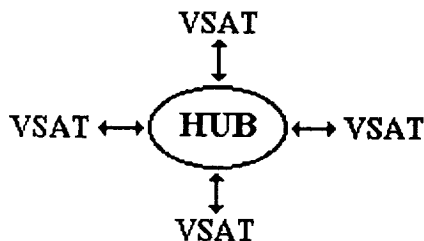

In a single-hop system the VSATs communicate with the hub station only. For example: a hub station could be located at company headquarters and VSATs at each company outlet. Information is only communicated between the VSATs and the hub station and not

between VSATs. Another example is satellite television. In this case information is transferred solely from the hub station to the VSATs.

In a double-hop system VSATs communicate with each other via the hub station. In a network such as this a VSAT sends data to the hub station which then sends information to a second VSAT. The second VSAT sends information back to the first VSAT via the hub station. An example of this type of network is a satellite telephone service.

In a meshed VSAT network there is no hub station as shown below. Many of the applications which have used double-hop networks can be used with a meshed network.
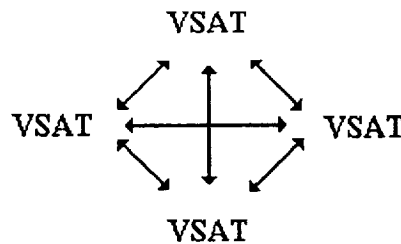
VSAT

VSAT   VSAT

VSAT

Previously, meshed networks have not been a viable option as VSATs are power limited and hence link budgets could not be met. VSATs are power limited because they use small dish antennas and low-power transmitters to reduce cost. Hughes Network Systems have developed a meshed telephony network using frequency division multiple access (FDMA). Because FDMA is not as power efficient as FCMA, the Hughes system requires larger antennas to meet link budget requirements than would be required for an FCMA system. The only other modulation method which lends itself well to use in a meshed environment, direct sequence code division multiple access (DS-CDMA), is bandwidth inefficient. FCMA can meet link budget requirements and is bandwidth efficient.
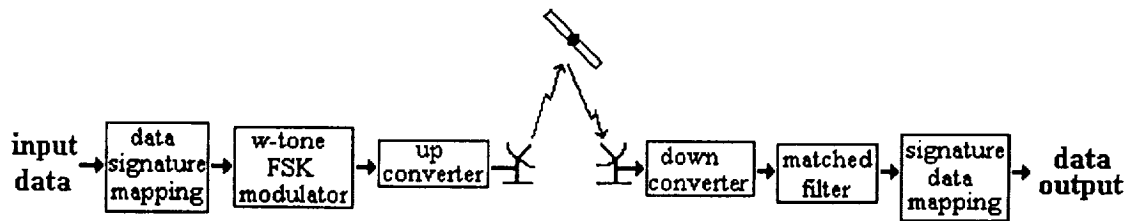
Meshed VSAT networks are cheaper than star VSAT networks because no hub is required. This reduced cost will allow new applications of VSAT networks to evolve.

4. FREQUENCY COMB MULTIPLE ACCESS

FCMA symbols are transmitted as a set of w frequencies called a signature. Each receiver has 2^k signatures in its received signal set where the data transmission rate is k bits per symbol. When a VSAT transmits data to another VSAT, it transmits signatures which belong solely to the recipient VSAT.

The diagram below shows a basic FCMA transmitter - receiver block diagram. Input data is mapped to the received signal set of the VSAT which is to be the recipient of the message. The signature frequencies are then created by a w-tone FSK modulator. The signal is then up-converted, amplified, transmitted to a satellite, retransmitted by the satellite and finally received and down-converted by the receiving VSAT. Signatures are

detected by a combination of a matched filter and a detector. The detector decides which signature has been received by a criteria of magnitude and phase. The received signature is mapped to a data sequence which is then outputted.

input data → | data signature mapping | → | w-tone FSK modulator | → | up converter | → ⊻ ... ⊻ → | down converter | → | matched filter | → | signature data mapping | → data output

5. FCMA AND HUBLESS VSAT NETWORKS

In an FCMA system the number of frequencies which can be used for signatures is finite: 256 being common. If the number of frequencies per signature is five (w=5), if there are sixteen signatures per signature set (k=4), and if there are 256 frequencies available then only three users can be accommodated without overlap ($3 \times 5 \times 2^4 = 240$). So that many users can be accommodated, overlap of one frequency per signature is allowed. This overlap of signatures between users causes inter-user interference. When more users are transmitting, there is more inter-user interference causing more data errors. Hence, as the number of simultaneous-users increases, there is a graceful degradation of service. This is required as without a hub controlling the network, there must be someway to ensure service can still be provided even in times of peak usage.

FCMA is able to meet link-budget requirements where other modulation methods can't because it uses powerful encoding methods. The encoding methods which can be used with FCMA require a multi-signal, mutually orthogonal signal set. This criterion is generally not available with other modulation methods. Hence, the power efficiency of FCMA allows it to be used in a hubless network.

6. CONCLUSION

Frequency Comb Multiple Access is a combined modulation and multiple access method which is well suited to use in hubless satellite communications networks. Due to powerful encoding methods, it enables VSATs to communicate in a single hop without need for a hub. A graceful degradation of service is inherent in this multiple access technique.

Since a hub station is not required, the satellite communications network is cheaper than other VSAT networks. This will allow new and innovative applications of VSAT networks.

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7. ACKNOWLEDGMENTS

8. REFERENCES

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