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CDMA on Phase 4?

Discussion

Paul Williamson KB5MU and I began a discussion about heterogenous modulation possibilities for Phase 4 (where any station could request some bandwidth from the satellite for any 1 of n allowed modulation types, and communication for that modulation type would commence).

The counterargument is that for an expensive limited resource such as a satellite system, one should design to maximize users. This means picking the most efficient modulation scheme and allocating bundles of channels of this scheme. When there are fewer users, each user gets a larger bundle of channels. When there are more users, everyone gets whatever minimum number of channels that user needs for minimally acceptable communications. This could vary per station and could vary over time.

This is boring but effective. Since the problem is one of multiple access, we then discussed multiple access schemes.

TDMA means you have to pay in terms of guard time. There is a hard limit on the number of users, and once a slot whizzes by, it's gone forever. The finer you slice up the time, the more the guard times cost in terms of efficiency. TDMA on the downlink doesn't have guard times because there is only one "talker". The guard time problem applies on the uplink. The simplest thing to do on the ground is to demodulate everything, and throw away what you aren't listening to. Lower power receivers will have to rely upon a lot more coding in order to receive. A strong pilot signal, with system time, and something like a paging channel, where order wire would be transmitted, would be required.

If everyone has a user ID, then the hash of that user ID provides some kind of abstract channel number. This tells low power stations where to go to listen for heavily coded bits.

Another way to do it is to carve out a number of narrowband channels and use them for low power mode. In essence, punch out very narrow sections and allocate those to the low power stations as needed.

FDMA means you have to pay in terms of guard band. This is less costly than it used to be, due to digital filtering.

CDMA means users interfere with each other. CDMA creates a near-far problem. With all users about the same distance from the satellite, one could say that there wasn't a near-far problem on the satellite, and that the primary objection to CDMA doesn't exist. However, with a big variety of power classes of stations, there is essentially the same problem. Some stations are much weaker than others. The weaker stations present as if they were farther away. Hence, this looks like a near-far problem, which is solved in CDMA by power control.

CDMA Groundsat systems definitely have a near-far problem. A simple evasive action can be taken if the development user terminals are not mobile. In other words, if their location is fixed, or transmitted to the Groundsat, then fixed power control settings could be assigned so that all user terminals present with equal power at the Groundsat. It then came up in discussion that 10GHz path loss varies with weather. So, dynamic attenuation (power control) might be necessary even for fixed stations. If you have to have power control anyway, then why not use CDMA?

Accommodating a large variety of station capabilities doesn't have to be done with CDMA and power control, but then the problem must be solved with system design, access policies, overhead channels, and this puts more demands on the space segment. Solving it in the system design will reduce the number of maximum simultaneous users.

A characteristic of CDMA is that the bandwidth usage is decoupled from the number of users. Since you are already spreading, you have all these extra bits that can be allocated to coding or code division. As a consequence, of that, you generally end up using a big fat channel. In a typical scenario, you only have room for one of those channels. We have room for more than one. The most important question to answer is whether or not CDMA can attract enough users to make it worthwhile. For a small number of users, you don't get all the statistical advantages of CDMA. What that number is, and how it compares with other multiple access schemes, is a very important thing to know in order to evaluate CDMA for Phase 4.

TDMA is less efficient because of the unpredictability of users. You have to budget worst case in order to guarantee a quality of service to the users. CDMA can be allocated statistically, taking advantage of things like voice activity factor to cram in more bits.

A problem that we have inherent to a satellite is that the scheduling latency is much greater. If one has to ask permission to use the channel before using it, then the potential added delay might make voice communications unpleasant. It's not just voice, but chatty data protocols suffer as well. For example, SMTP over Starband was unpleasantly slow. Web browsing is another chatty protocol. If there is lots of back and forth involved, like loading a webpage cluttered up with ad trackers, then the overall throughput becomes much slower than it should or could be. Starband used bundling in order to address this. If you asked for a webpage from Starband, it made an attempt to figure out all the different actions that you might take, and then sent all of those things down in one blob. All the embedded images, any immediate repercussions of clicks on the page, things like that. This made the page appear to load much faster. One complicated webpage could have up to 60 potential transactions. If each of these required .25 additional seconds to do, then it would be obnoxious.

We too need to be clever about how we allocate channels. Especially voice channels, since extra delay makes voice communications not fun.

Within certain constraints, CDMA could mitigate the delay. You have a delay at the beginning when channel allocation is made, but after that you might simply be able to transmit and receive whenever you like, without having to pay much in terms of additional delays for channel access. This is a very tenuous assertion to make without additional usage models.

Our conclusion wants to be that CDMA should not be ruled out as a multiple access scheme for Phase 4. It may provide superior efficiency on the satellite when compared to TDMA or FDMA. We want a better analysis of what we're talking about here. Comment and critique welcome and encouraged.