Project	IEEE P802.16 Broadband Wireless Access Working Group	
Title	Supporting STM in the IEEE 802.16 standard	
Date Submitted	25 June, 1999	
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Re:	Functional requirements call for contributions	
Abstract	Given the large amount of access traffic which is still based on STM, it is very desirable to support STM directly, in addition to packet formats such as ATM and IP. Scheduling STM transmission is straightforward; examples are given.	
Purpose	Argument for including STM in Functional Requirements document.	
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Supporting STM in the IEEE 802.16 Standard

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POTS, as we all know, stands for Plain Old Telephone Service, as distinguished from PANS, or Positively Amazing New Services[1]. POTS may be unglamorous these days compared to Voice over IP and its cousins, but its total volume for many years into the future will be very substantial. PANS will not take over the world for a long time. An estimate by IDC shows that converged networks (the PANS side) carried only 1% of voice traffic in 1998; by 2013 the amount will still be only 13%.[2]

For this reason, any service operator who wishes to sell broadband wireless links to business customers must be prepared to support the plesiochronous or synchronous transmission mode (STM) used by nominal voice circuits: T1, E1, and so on. By no means all of the STM access links are actually used for voice; many are used by other applications in order to take advantage of the switched POTS infrastructure: dialup modems and video conferencing are two common examples. Assuming that the application is voice and applying voice compression, such as G.723.1 at 6.3 kbps, will rule out any other application.

To ask the customer to move to VoIP immediately in order to take advantage of the economies of wireless is a difficult proposition to sell. Likewise, moving the customer to ATM faces another barrier: ATM is complex and it adds cost that can be avoided in other approaches. To the average customer, switching access lines to wireless is risk enough without incorporating other unfamiliar technologies at the same time.

Even in the case of data, not everything drops right into the ATM or Ethernet/IP format. Frame relay is a very successful service, but it does not always carry IP over it; IPX is one example. SNA on IBM mainframes is another example of data frequently carried on STM circuits. While these formats are not cutting-edge, there is a large embedded base that will be present for a long time. It can be served easily by carrying it over the air link in STM format, but not otherwise.

Hence it is important that the 802.16 standard support STM as well as formats that fall into the PANS category. It will be many years before STM traffic can be ignored in new development work, and in the meanwhile we need to provide standards for the equipment that service operators will buy to support real production applications. The bulk of the traffic carried now by existing wireless access networks is STM.

[1] Credit for the acronym belongs to Gary Nelson of Ameritech.

[2] Quoted in *Voice 2000* supplement to *Business Communications Review*, April 1999.

Data Formats

In short, we need to support three data formats in the standard:

STM bytes
ATM cells
packets

Synchronous bytes are needed for STM, ATM cells should be supported since that is what carriers tend to prefer, and packets because of the great and still rising importance of the Internet for all services. Ultimately, as service classes become well supported in the Internet, IP packets may become the dominant form of transmission, but for the next few years the ability to support all three formats in 802.16-compliant systems will be necessary.

This is not to say that a given service provider will always offer all three formats, or that a customer will opt for all three services, but the standard should cover all of them.

Service classes and scheduling

Service classes are linked to data format, but loosely. STM is considered a fixed-bit-rate technology, but there are modifications that can be applied to improve efficiency, for instance silence suppression for voice, resulting in STM with "holes" that might be filled with other traffic. IP has generally been used as a best-efforts technology, but the new work in Differentiated Services (DiffServ) makes it possible to have multiple service classes and priorities, ranging from best-efforts through priority variable-rate and constant-rate. Finally, ATM covers essentially the same service categories as IP with DiffServ.

Scheduling transmission in either the upstream or downstream direction is a matter of handling priorities properly. This is independent of the data format issue. Scheduling of STM can be done easily by including it with constant-rate ATM and packet traffic.

Downstream scheduling

We assume that scheduling is done in cycles. For downstream traffic, the scheduler can take each service class in priority order. It can assign transmission times to the constant-rate traffic first, then high-priority variable-rate, low-priority variable, and finally best-efforts traffic. The formatting of the traffic is a secondary issue: it may be desirable to block together all the synchronous byte traffic at the head of a cycle, then all the ATM cells, and then packets, etc. Packets and cells (treated as fixed-length packets) can be intermixed if desired, but the STM traffic must go first after the cycle start flag if connections are identified by timing rather than headers. This is shown in Figure 1 for base-station transmission.

Time →

Figure 1. Scheduling cycle for the base station or a single user station showing allocation of STM connections after a start flag, then fixed-rate, variable-rate, and finally best efforts packets. ATM cells and packets can be segregated or intermixed.

Upstream scheduling

Because of the physical-layer overhead in the upstream direction (inter-user time gap and receiver synchronization) each user should be allocated a single burst in each cycle. Within that burst, traffic can be ordered as with the base station, although it is unlikely that all traffic types will be present within a given burst.

During one cycle, the base station queues up transmission requests; these are mapped onto time slots within the overall cycle length, then in the next cycle the allocation map (for upstream transmissions) is sent out to the users, who then use this map to schedule their transmissions in the third cycle.

The need for cycles is obvious in the case of TDD, where there is a natural send/receive cycle alternating between the two directions. But scheduling cycles are also the norm in FDD systems such as cable modems, since use of the cycles makes it possible to handle priorities in a natural way.

The difference between TDD and FDD is that in TDD the transmission cycle length may vary. The length of the cycle is a parameter in the scheduling algorithm in both cases: when the cycle is full, any unassigned requests carry over to the next cycle. If this parameter is changed from time to time in the TDD case due to traffic changes, it does not make the scheduling algorithm more complex.

One usual effect of the scheduling cycle is to compact all the traffic for a given connection into a specific time within the cycle, rather than allowing it to spread uniformly throughout the cycle. This results in a granularity in the transmission equal to the scheduling cycle. A typical value for the cycle length would be one millisecond; jitter up a millisecond will occur, but this is within the tolerance of almost all applications. (For comparison, note that the cell-filling delay for an ATM cell at 64 kbps is 6 milliseconds.)

Conclusions

Legacy STM traffic will not disappear from access networks for a long time. The 802.16 standard needs to support STM as well as ATM and IP traffic in order to support circuits like DS0 and T1 over the access network. This does not add significant complexity to the transmission scheduling procedure.