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ATM Forum Technical Committee ATMF 95-1560

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Title: Combination of SSCOP and an AAL-Level FEC Scheme

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Abstract:

This contribution discusses the scope of SSCOP and the potential benefits of combining SSCOP with an AAL-level FEC scheme.

SSCOP is a data link level protocol that provides reliable point-to-point services. It is designed as an SSCS on top of AAL5-CPCS. Its mechanisms for error and flow control are suitable for a wide range of connection parameters, such as error rate, bandwidth, and round trip delay. SSCOP employs frame-based selective retransmissions.

Initially, SSCOP has been specified as an AAL protocol for signaling. It also can be applied for reliable communication between ATM end systems in general. In a pure ATM environment, SSCOP allows higher performance than TCP due to its superior error and flow control mechanisms.

While SSCOP can achieve better performance than TCP, erroneous frames lead to retransmissions that can severely degrade service quality. Combining SSCOP with an AAL-level FEC scheme allows to provide a better service quality by reducing the probability of retransmissions.

The reliable service of SSCOP is not suitable for several cases in which applications can not accept the error rate of an ATM connection. Examples are reliable multicast services, and the interconnection of routers. In these cases, an AAL-level FEC scheme such as [95-0326] can be applied beneficially.

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Notice:

This contribution has been prepared to assist the ATM Forum, and is offered by the above affiliations as a basis for discussion. The above listed affiliations reserves the right to add, amend or withdraw the statements contained herein.

1 Introduction

SSCOP is designed as a data link level protocol for reliable point-to-point services. Error recovery for the erroneous frames is performed by selective retransmission. This retransmission scheme allows for higher efficiency and lower delay than TCP, which is based on go-back-N retransmission policies. SSCOP is able to achieve good performance even for scenarios with significant frame error rate and significant round trip times.

While SSCOP can achieve better performance than TCP, retransmissions performed by SSCOP may lead to unacceptable delay characteristics. Therefore, the combined operation of SSCOP and an AAL-level FEC scheme allows to provide a better service quality to the user applications.

SSCOP is not suitable for some services (e.g., reliable multicast services, and connectionless transmission of datagrams), where an AAL-level FEC scheme can be applied advantageously.

Section 2 discusses the scope of SSCOP and clarifies for which areas SSCOP is not suited. Section 3 discusses the benefit of a combined operation of SSCOP and an AAL-level FEC scheme.

2 Scope of SSCOP

SSCOP has been designed for the efficient provision of reliable service by a connection oriented AAL protocol. It can provide services for signaling as well as connection oriented network and transport services [SSCOP] [I.365.2] [I.365.3] [SSCF1] [SSCF2].

The functional features of SSCOP are:

- Frame based selective retransmissions (i.e., SR-ARQ);
- Designed for connection oriented data flow and assuming in-sequenced frame delivery from source to destination entity;
- Sliding and dynamic window control;
- Receiver oriented arbitrary window control;
- Protocol for point-to-point data communication.

In comparison, the widely deployed TCP has the following features:

- Retransmission of frames based on a go-back-N policy;
- Designed for a connectionless network layer that does not provide in-sequenced delivery of messages;
- Sliding and dynamic window control;
- Sender oriented slow-start and fast-shrink window control;
- Protocol for point-to-point data communication.

Due to the selective retransmission policy, and to the receiver oriented arbitrary window control policy, SSCOP can achieve a better performance (e.g., throughput and latency) than TCP in most cases.

Since SSCOP generally assumes in-sequence frame delivery to the receiver entity, SSCOP can only be applied when source and destination entities have a direct virtual connection.

An AAL-level FEC scheme can be used advantageously for ATM connections between routers. SSCOP is not suitable as a general link level protocol in such scenarios, because SSCOP requires buffering of frames to allow for retransmissions. SSCOP will not be used for the case where either source or destination do not have direct ATM access, or where networks that do not provide in-sequence delivery of packets exits between source and destination host.

SSCOP also provides for the unacknowledged transfer of data units on point-to-point and point-to-multipoint ATM connections. In cases where the reliability of an ATM connection is not sufficient, the unacknowledged service can be advantageously combined with an AAL-level FEC scheme.

Regarding purely end-to-end ATM connection where SSCOP can be applied to, the following points can not be covered by SSCOP:

I. reliable point-to-multipoint and multipoint-to-multipoint data delivery;
II. error recovery without retransmission.

For some applications, an instantaneous performance (e.g., latency) is an important factor, as well as average performance. For these applications, even when the average performance seems to be sufficiently, a poor instantaneous performance may not be acceptable. While SSCOP will be able to achieve a good average (i.e., long term) performance. However, the performance of SSCOP over short time intervals may not be sufficient.

3 Combined Operation of SSCOP and AAL-level FEC Scheme

3.1 Benefits of AAL-level FEC Scheme for SSCOP

As briefly discussed in the previous section, SSCOP may not be able to achieve a sufficient instantaneous performance, since SSCOP needs to retransmit every corrupted frame. The additional use of FEC will diminish the need for SSCOP initiated retransmissions. In many cases, SSCOP with an AAL-level FEC scheme will be beneficial not only to achieve low latency, but also to improve instantaneous throughput.

Particularly, as RTT increases, FEC will help in reducing buffer requirements. As the analysis in [Henderson95] shows, with increasing cell loss more buffers are needed to support larger windows to maintain the same effective throughput. To decrease the buffer needs in the case of high cell loss, the polling period (the Timer_Poll periods) need to be decreased which in turn reduces efficiency of the link throughput. By improving the effective frame loss using FEC, buffer requirements can be reduce using lower Timer_Poll periods, thereby increasing effective throughput.

[Kant95] gives insight into the delay properties of SSCOP, covering modeling, analysis and simulation. A number of different delays are of interest. The transmission delay is the delay needed for a receiver to correctly receive a user PDU. As SSCOP provides a reliable service with sequence integrity, user PDUs are always delivered in sequence to the higher layers. Therefore, a sequencing delay has to be added after the correct transmission of a user PDU before its delivery to the higher layer. The overall delay (also called delivery delay) is the sum of transmission and sequencing delay.

The mean and standard deviation of transmission delay and sequencing delay increase significantly for a growing frame loss rate. In particular for high loads, the overall delay increases dramatically for growing frame loss rate. An evaluation of the overall delay is fairly complex. In addition to the frame loss rate, also round trip time and load have an important influence on the delay. For the example of a link of 500 miles and a load of 50%, [Kant95] shows that mean and standard deviation of the delivery delay more than doubles for an increase of the error rate by one order of magnitude. [Kant95] also shows that for higher load and larger distances, an increase of the error rate by one order of magnitude can even lead to a delay which is four times higher. Applying a cell-based FEC scheme allows to reduce the frame loss rate significantly (e.g., see [95-1154]). Even a reduction of the frame loss rate by several orders of magnitude is possible by the use of FEC-SSCS.

For a given cell loss rate, the benefit of AAL-level FEC will increase with growing round trip time (RTT), and also with growing ratio of path capacity to receiver buffer size.

For long bursts of a given bandwidth, processing requirements for SSCOP are growing approximately linearly with the frame rate. Therefore, using large frames would allow to reduce the processing requirements. In the case of non-negligible cell losses, AAL-level FEC scheme would allow to use long frames. Of course, the additional processing costs of AAL-level FEC scheme have to be traded off against the processing costs of SSCOP. However, FEC processing could be performed by a relatively small extension of the AAL5-CPCS processing unit [95-1162]. In contrast, SSCOP processing is much more complex and will typically be implemented in software. Reducing SSCOP processing requirements might be of particular importance in cases in which a large number of SSCOP connections are to be maintained by a single processor.

To summarize, it can be said that in some cases, the combined operation of SSCOP and AAL-level FEC scheme will be beneficial.

3.2 Further Possible SSCOP Enhancement of AAL-Level FEC Scheme

The specification of SSCOP might be subject to following future enhancements:

1) It would be possible to simplify the existing specification of SSCOP to allow for Go-back-N retransmission. This would be a substantial simplification for both transmitter, and receiver implementation, by reducing processing requirements, requirements for storing of status information, and receiver buffer requirements. (Again important for a large number of SSCOP connections.) In the case of a Go-back-N SSCOP, an AAL-level FEC scheme would still allow for a relatively high performance.
2) It would be possible to extend SSCOP for reliable multicast operation. An AAL-level FEC scheme would allow for significantly better scaling properties for such a future Multicast-SSCOP.
3) As stated in [Henderson95], it is possible to extend SSCOP in order to allow operation in a heterogeneous internet, in which in-sequence delivery of SSCS-PDUs is not guaranteed. Then, a performance superior to today's TCP could be achieved in many cases. For the ATM-section of a connection which traverses routers, it would still be of interest to apply AAL-level FEC.

3.3 Implications on signaling

Performance aspects make a combination of SSCOP and FEC-SSCS attractive in certain cases. However, such a combination means the definition of an adaptation layer with two SSCS protocols. As current signaling standards do not consider such a case yet, it needs to be discussed how such a combination is to be identified. One possibility would be to use a new SSCS identifier, defining a new SSCS type consisting of the two protocols. Another possibility would be to extend signaling messages in order to allow for multiple SSCS identifiers within a single AAL entity.

4 Conclusion

This contribution discussed the scope of SSCOP and potential benefits of combining SSCOP with an AAL-level FEC scheme. Even though SSCOP has highly sophisticated error control mechanisms and can achieve better performance than TCP in cases of substantial cell loss, the service quality offered by SSCOP will still be severely degraded by unreliable ATM connections. A combination of SSCOP and an AAL-level FEC scheme will allow significant improvement of the delay characteristic due to reduced probability of frame retransmissions.
The reliable service offered by SSCOP is limited to point-to-point communication between ATM end systems. There are many scenarios for which error recovery within the adaptation layer is desirable, but the use SSCOP is not appropriate. Examples are the interconnection of routers by ATM connections with significant error probability (e.g., UBR services), and applications that require reliable multicasting. In these cases, applying an AAL-level FEC scheme such as [95-0326] allows to provide applications with an improved service quality.

5 References

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