M3POC : a multimedia multicast transport protocol for cooperative applications

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Abstract. Recent experiments in collaborative working have shown some technical limitations that delay the massive deployment of such applications. These limitations concern the support of a variable multimedia quality of service (QoS) that is often insufficient, multicast services badly adapted to the group requirements, and over all, the cooperative features of persons involved in a group work session that are not taken into account. This paper then proposes an architecture resolving these problems, that relies on a new transport protocol : M3POC. The mechanisms and services provided by this transport are presented and confronted to the exposed problematics, and, as an example, it is shown how a cooperative videoconference application - ***Confort*** - can benefit from such transport service.

1. Introduction

Since a few years, new information technologies are expanding quickly in economic and business life, and also for residential users, with more and more people using telematics services (minitel in France, vocal mail), electronic mail, web, etc. They thus can use a wide range of asynchronous services to communicate, inform themselves and for electronic commerce. Nevertheless, the new high speed networks and real-time multimedia cooperative applications (videoconference, white board, application sharing, etc.) open new ways ; even if residential users are not strongly concerned by synchronous applications, many companies have performed experiments to evaluate the benefits they can gain (CANET [OWE97], TOPASE [VIL98a], TEAM, ... projects) and begin to deploy these tools on their intra-nets.

However, all these projects put forward some limitations, and this at the communication network, transport protocols and applicative tools levels. These limitations concern :

- the absence of mechanisms guaranteeing multimedia QoS (reliability level, intra and inter-streams synchronisation constraints, etc.) ; for instance, communication network supports (as ATM or Internet) do not provide guaranteed classes of services (CoS) for each media at the connections level, and current transport protocols as UDP and TCP are respectively not reliable enough and too slow for interactive multimedia applications ;
- the absence of powerful multicast services at the WAN ATM level for instance, or at the transport protocols level. These services are however indispensable as soon as the cooperative activity concerns large groups or a group activity strongly interactive ;
- the absence of group activity management mechanisms. In fact, collaborative working experiments have shown that the group members have different roles, functions and importance, but these features are not taken into account by the communication layers or the cooperative applications.

New technical and technological solutions are urgently expected by socio-economic performers that plan to exploit these information technologies to improve their productivity. Thus, at the communication support level, solutions are under study following the ATM as well as the Internet approaches. Members of the ATM Forum are working on solutions allowing to implement mechanisms for guaranteeing the CoS defined in ATM. In the same way, two IETF groups - IntServ and DiffServ - are working on the introduction of guaranteed CoS in the Internet (at IP level).

On top of these communication supports, this paper proposes new kinds of transport and applications aiming to provide services that are currently missing. Thus, a new architecture is proposed. It allows (1) to guarantee the QoS of applicative multimedia streams, (2) it provides multicast functionalities suited to multimedia data and large cooperative groups, and (3) takes into account the cooperative features of each group member depending on his function and activity in the group. This architecture takes advantage of a partial order multicast transport protocol (M3POC : Multicast MultiMedia Partial Order Connection) that relies on the partial order multiconnection notion, and that, thanks to *partial* and *cooperative reliability* mechanisms, provides a service suited to the strongly interactive multimedia and cooperative applications requirements. This paper then aims to present the services offered by M3POC, to justify them with regard to cooperative multimedia applications needs and to propose some mechanisms and solutions to implement them. In addition, it will be shown how a cooperative videoconference application (***Confort***[1]) can benefit from such a transport service.

This paper is structured as follows : first, a state of the art of transport protocols and communication networks is presented (section 2). With regard to the problematic explained in the introduction, these protocols and networks functionalities are compared to the applications requirements in terms of multimedia QoS, multicast services and cooperative QoS. Then, the M3POC protocol is detailed (section 3), and it is shown how this protocol solves the exposed problematics. In section 4, the videoconference application is described. Its cooperative characteristics are first briefly shown, and then it is presented how the application uses the

[1] ***Confort*** is the new version of the TSVS [OWE96] and N-TSVS [VIL98b] videoconferencing applications, designed and developed at LAAS.

service provided by M3POC. Section 5 describes the state of this work, and finally section 6 concludes the paper.

2. State of the art

This part that deals with the state of the art does not perform an exhaustive study of all the existing protocols and networks. It presents only the ones that solve one or more points of the exposed problematics, and that, have influenced the M3POC design.

2.1. Multimedia communication services

Since the beginning of the nineties, many protocols and networks have been designed to take into account the transmission of multimedia data. The main characteristics required for that are :

- the network and protocol speed because they have to compute large amount of data ;
- the variable reliability level, often high, that is difficult to obtain given the throughput required by multimedia data ;
- the temporal synchronisation constraints that appear in each stream and between parallel streams of a multimedia connection (intra and inter-streams synchronisation).

With these constraints, it is clear that the traditional architectures of the Internet with TCP/IP and UDP/IP are out of consideration because they do not provide the required services with variable reliability and do not respect synchronisation constraints. Nevertheless, future evolutions seem to be interesting. Two approaches are under study at the IETF : the IntServ approach aiming to define CoS and to guarantee QoS constraints using the RSVP signalling protocol, and the DiffServ approach that aims to integrate, in a native way, statistically guaranteed Classes of Services.

The IntServ approach is very similar to the one of the ATM that integrates CoS for the different data flows : ABR, CBR, VBR, etc. for ATM, best effort, controlled load and guaranteed service for IntServ. In addition, ATM, as it is defined seems to provide an almost ideal solution for transmitting the data of multimedia cooperative applications, thanks to the throughput and reliability level it provides, the CoS proposed, and a multicast support in a connection oriented mode that offers to users the same services than point to point connections. However, experiments on ATM WAN (in particular MIRIHADE/SAFIR [OWE98a]) have shown the gap between theory and reality of available hardware. Thus, in MIRIHADE/SAFIR, important limitations concerning the congestion management, and then concerning the reliability level, have been put forward, as well as limitations concerning the CoS that are not always respected.

Other studies have conduced to the creation of other protocols. For instance XTP [PRO92] is a lightweight transport protocol (with integrated routing functionalities) designed for distributed (RPC), real-time or multimedia applications. This protocol provides to the service designer a set of mechanisms that can be switched on or switched off. User can then select and switch flow control, error detection, error recovery mechanisms, etc. Nevertheless,

XTP service remains best effort or fully reliable, and does not integrate synchronisation mechanisms. It is then the same for architectures that rely on XTP, as Berkom [BER93] and CIO [MIL93].

The best approach for transmitting multimedia data and respecting their constraints is certainly MMPOC (MultiMedia Partial Order Connection) [OWE98b] [CHA95] [AME94]. MMPOC relies on the partially ordered delivery of the objects of each streams, introducing then logical synchronisation mechanisms. In addition, thanks to the partial reliability notion that allows to define a minimal QoS on each stream and on the whole multimedia connection, a given loss level can be accepted on each stream, as it is tolerated by multimedia data. Partial reliability, thanks to its earliest loss and delivery mechanisms, also allows high speed communications by reducing as much as possible waiting times and retransmissions.

2.2. Multicast services

Changing from a point to point to a point to multipoint connection introduces several new problems and increases the difficulty of some already existing. Many studies have been published on problems due to multicast communications. The main problems are :

- routing problems : the multicast protocol has to take advantage of the underlying network in an efficient way to minimise the used bandwidth, sending duration, etc. ;
- the problem of the “sender overflow”, also called “scalability problem” : the multicast protocol has to support a great number of receivers without being overflowed by the computing induced, for instance, by the acknowledgements ;
- the management of the receivers reliability that as to be made independently from one receiver to the other ;
- flow and error controls : there is not only one but many receivers. The protocol has then to implement suited mechanisms for flow and errors control on a multiconnection.

Interested reader can refer to [PAS98] for a more detailed description of the multimedia multicast transport problems.

In fact, protocols described in the following try to answer the fundamental question : “How is it possible to ensure data transfer from a sender to a set of receivers in an reliable or unreliable way ?”. Each protocol then provides a specific solution depending on the hypothesis made and on the applicative requirements.

Reliable protocols

Among reliable protocols, one of the first that appeared is XTP [PRO92] that allows to multicast data with several reliabilities : full reliability or best effort. XTP assumes that the underlying network provides a multicast service. *Slotting*, *damping* and *leaky buckets* mechanisms allow to reduce network load, using in particular communications between receivers, that nevertheless induce a sort of “pollution” for some of the receivers.

The SRM protocol described in [KAS96] strongly relies on the group notion for data sending and retransmissions. It expects then to maximise benefits from the use of multicast communications. It avoids then the pollution of satisfied receivers ; this study has been made

using the open multicast IP groups. In addition, it remains sensitive to the scalability problem. In fact, during the transmission of data, the number of retransmission groups is growing, and the sender is rapidly no more able to manage the large number of connections and acknowledgements.

The LGC [HOF96] and RMTP [LIN96] protocols try to solve the scalability problem by creating a hierarchy of receivers sub-groups. Sub-groups consist of receivers that can be geographically near, or that verify some properties on criteria as a short delay between them, or belonging to a local network having a given kind of topology. This hierarchy allows to implement local and then fast error recovery mechanisms.

The FRM protocol described in [REZ96] is based on an algorithm that allows to ensure a full reliability when transmitting data to a group of receivers (or to a sub-group of receivers that have priority). FRM is independent from the multicast distribution model provided by the underlying network. Note that this protocol is the first that has introduced and used, for communications management, some features belonging to the cooperative work domain, taking into account the importance of each receiver in the group. In fact, FRM defines two members families : the ones that can tolerate losses and the ones (the most important) that cannot (these later belonging to the sub-group having priority).

Unreliable protocols

This second kind of multicast transport protocols is the most interesting for multimedia and cooperative applications. Two of them seem to be of real interest :

The SRTP protocol described in [LAV96] has been designed and developed for real-time DIS[2] applications. It defines several CoS : *best effort*, *reliable multicast* and *reliable transaction-oriented unicast* for the unicast retransmission of lost data. This protocol allows to release reliability constraints and then to adapt the reliability level to the type of transmitted data. However, this protocol does not solve the scalability problem, because the sender is the central point for all the retransmissions.

Presented in [REZ96], the M-Connection service proposes several types of reliability defining different CoS. Thanks to the grouping of the receivers depending on their required QoS, and thanks to an algorithm independent from the receivers number, this protocol solves the scalability problem. In addition, the regrouping of receivers by QoS allows to reduce the time required for managing each of these QoS.

2.3. Services for cooperative work

However, even if multicast is an indispensable service for communications in large groups or for strongly interactive communications, other functionalities are required for collaborative work. Many studies on the subject of cooperative activities have been done, but very few have studied the problems due to collaborative applications at the communication protocols level.

The work of [DIA93] has nevertheless conduced to a definition of cooperation relying on data exchanges, and that conduces to the creation of a cooperation graph representing the existing relationships between the members of a cooperative group. This graph in fact

[2] DIS : Distributed Interactive Simulation.

represents the hierarchy that appears between the group members depending on the current cooperative activity. This, added to the role of each member of the group, almost all the cooperative characteristics are taken into account.

Nevertheless, this work has not been extended to map these cooperative features at the communication protocols level, whereas they can be very useful to adapt the communication services to the collaborative work needs. Thus, M3POC proposes to adapt its transport mechanisms for individual and group QoS management, its retransmission mechanisms, etc. depending on cooperative criteria of client applications.

3. M3POC

The M3POC protocol then proposes to solve all the problems expressed in the introduction. The principles allowing to provide such a service are described in the following. However to be able to guarantee this service, some hypothesis have to be done concerning the network support on which M3POC relies. Thus, we assume we can take advantage of a network service providing multicast functionalities in a connected mode, with pre-defined and guaranteed CoS ; it is in fact a network service similar to the one provided by the theoretical definition of ATM. It is over such a network service that the M3POC principles are going to be defined.

3.1. Multimedia constraints

The M3POC protocol has to transfer multimedia streams. The partial order and reliability mechanisms described in [CHA95] seem to be very well suited for our requirements. Usually, multimedia streams do not need a fully reliable transport service, even if a good quality is nevertheless necessary, and need important throughput. Partial reliability allows to provide such a service. In addition, using partial order and reliability mechanisms allows to reduce the network load thanks to a minimal number of retransmissions. This aspect is of great importance in particular in a multicast context. Partial order and partial reliability also allow to reduce the generated traffic due to disordering or loss problems. In addition, they allow to increase the final presentation quality at the applicative level [OWE98b]. [FOU97] presents results of the performance evaluation of such an architecture.

However, the multimedia partial order and reliability mechanisms are only defined in a point to point context. The partial reliability principle is sufficient in point to point connection because only two entities are concerned by data exchange. As soon as one of the participants has its partial reliability not respected and decides to stop the session, the connection is released. In a group context, an additional problem appears : what kind of behaviour must have a participant with regard to the group activity when his partial reliability is exceeded ? Some concessions seem possible in some cases : thus, if the quality of the group activity remains satisfying, it seems to be normal that the receiver that has a degraded behaviour allows some additional losses in order to keep active the global activity and to avoid to stop the group work session (collective interest has to prevail over individual comfort). Thus, M3POC performs the extension of partial order and reliability concepts to multicast multimedia connections.

3.2. Multicast mechanisms

To solve the problems met with multimedia multicast communications, several mechanisms and architectures exposed in the state of the art and used in other protocols have been adopted for M3POC. To solve the scalability problem, the architecture defined in LGC and RMTP has been chosen. Nevertheless, several modifications have been made, in particular concerning the grouping criteria for the hierarchical structure of retransmission sub-groups. While LGC uses geographical criteria for the sub-group in the hierarchy, M3POC jointly uses two parameters to privilege interactivity, end to end delays, throughput, reliability and group QoS (parameters that can evolve depending on the client cooperative applications requirements). M3POC then creates sub-groups with regard to the RTT and the receivers QoS, to favour the time for error recoveries (and then also the delays, reliability and throughput), in particular for the CoS of the most important group members in the current cooperative activity. In these sub-groups, the QoS parameter is very useful for managing the receivers' QoS when the role, function and importance notions at the cooperative activity level are taken into account.

In each sub-group (depending on the LGC/RMTP hierarchy), a member (RG[3]) is chosen to serve as a relay between the initial sender and the other receivers of the sub-group. It replaces the initial sender by managing the acknowledgements (and by sending only one global acknowledgement for all its sub-group) ; it also performs retransmissions and is the unique interlocutor for all the members of its sub-group in the service of its hierarchical responsible. Thus, when a receiver asks for a lost data, it asks its RG for retransmission. The RG then retransmits the data, and if it has not it in its buffer, asks this data to its own RG, and so on. These sub-groups allow to support very large multicast groups and to solve the scalability problem by reducing the number of acknowledgements computed by the sender. Moreover, the local loss recovery mechanism allows to reduce the retransmission time, what is essential for multimedia and cooperative applications. In fact, [NON98] showed that multicast transport protocols have improved performances if a local loss recovery mechanism is used. An architecture example respecting the described approach is depicted on Figure 1.

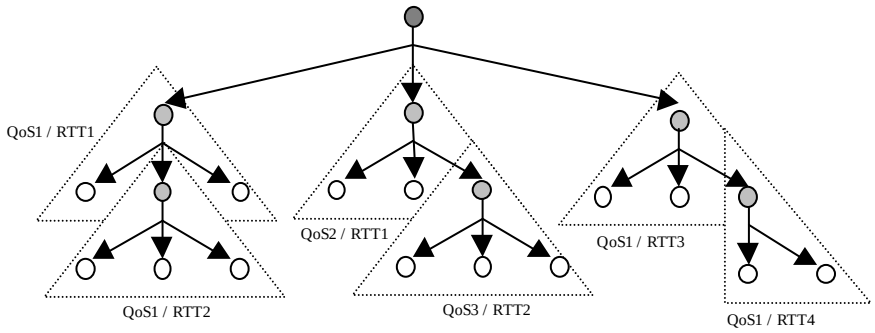

Figure 1. Example of sub-groups (depending on the RTT and QoS)

[3] RG : Responsible of Group

In addition, to have good performances and high throughputs, all the mechanisms used in M3POC are simple and fast. The central point for protocols that have to be used as a support for cooperative and multimedia applications, concerns the speed for data deliveries, in order to privilege interactivity, even if the presentation QoS is a bit degraded.

3.3. Cooperative reliability

Multicast transport implies the receivers group notion. It is clear, compared to social and human relationships, that this group notion leads to the establishment of behaviour rules for the group members, as well as concessions to do to belong to the group in an efficient way with regard to the work to perform. But in almost all the described transport protocols, the group notion is most certainly introduced, but no management mechanisms for the constraints and rules of the cooperative group activity are considered.

As said previously, partial reliability (PR) is not sufficient for group communications. The cooperative reliability (CR) notion is a consequence of this statement. This additional functionality has then to complete the partial reliability when delivering data to cooperative applications. This new reliability represents the degradations that can be tolerated to allow the group activity to continue, even if the individual QoS of some group members is not the one they expect. Of course, all the members do not have the same importance and then the management of these different classes has to be integrated to the cooperative reliability.

To illustrate our purpose, we will take a reference example. This example is the one of a tele-design environment that integrates engineers, project managers, financial managers and heads of the companies involved in the project. During a technical session of the project, the technical staffs members must have a very high QoS, while financial managers, for instance, are of less importance, and do not need a so high QoS. The roles can be inverted when changing from the technical to a financial session. The essential principle of cooperative reliability is to implement some mechanisms for loss management and errors recovery in both individual and global ways, with regard to the function, role and importance of the concerned person in the current cooperative work session.

The principle of the cooperative reliability relies in the fact that it is possible that a receiver accepts to lose some additional data to guarantee to other receivers, that are of greater importance than him, the minimal required QoS, or to maintain the group structure and activity : if one receiver does not receive the data with the QoS he wants, it is not necessary to disturb all the group. The aim of partial reliability is then to allow a group management in term of a global group QoS instead of a simple juxtaposition of N individual QoS. A group member has then to make concessions if he wants that the group activity continues, even if the QoS he receives is not the one he expects. We have expressed this (“social”) principle with the cooperative reliability notion.

Note that cooperative reliability only works when the partial reliability tolerance is overstepped. In fact, this degradation induces some retransmissions to which the RG answers negatively. As the partial reliability allows to release constraints on multimedia data in order to continue data transfer, cooperative reliability allows an additional constraints release, this latter aiming to continue the transmission of data toward the group of receivers even if for some of them the individual QoS is no more respected. In addition, cooperative reliability, at the opposite of partial reliability, is dynamic : it evolves depending on the errors observed for

each receiver. This evolution, of course, depends on the receiver importance. This dynamic behaviour can allow a given fairness between members of the group.

Thus, it is possible to manage several behaviours for the group members, with regard to their importance and the QoS degradation they have seen. Figure 2 shows the example of 2 group members with different importances and then 2 different behaviours. Thus, the cooperative reliability makes the priority of an important receiver grows when it supports losses, while the one of a less important receiver is reduced in the same case.

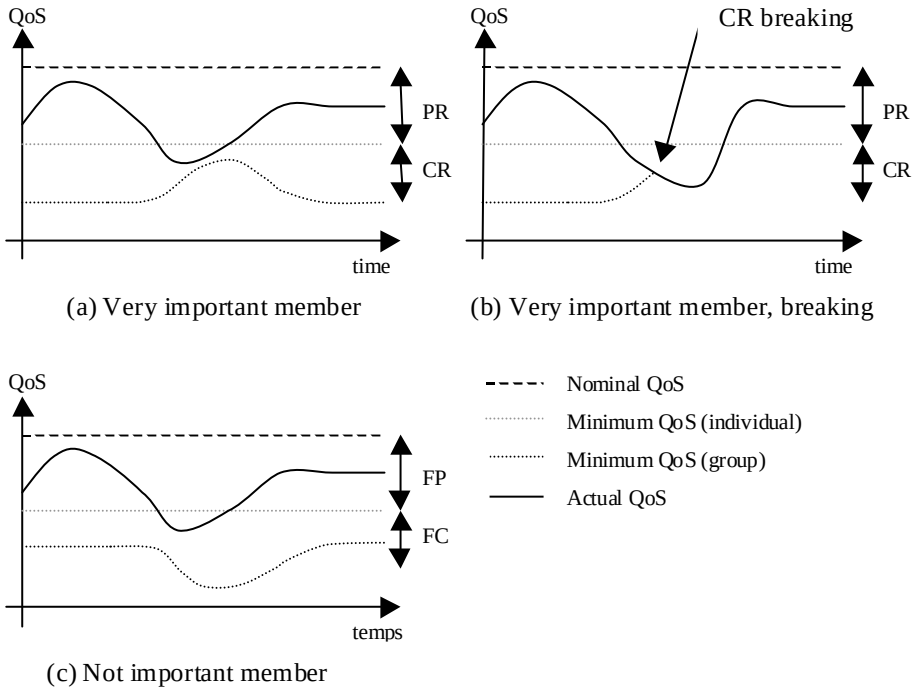

Figure 2. Examples of cooperative reliability behaviours depending on the importance of receivers

Cooperative reliability is then induced by the group structure, but each receiver defines its behaviour with regard to its role. In an ideal way, cooperative reliability is a continuous function, but in reality, an integer function as been used for its implementation. Thus, a priority mechanism has been implemented. These priorities have two functions :

- to implement at the RG level a queue with priorities allowing to schedule loss recoveries with regard to the receiver importance ;
- to implement at the RG and receiver levels a balancing mechanism for acknowledgements.

For each data, each RG is waiting for the acknowledgements coming from the receivers of its sub-group. Each receiver associates to its acknowledgement a balance equal to its current priority. This current priority is the addition of its initial priority (its role) and its dynamic priority (that changes with the losses or deliveries it supports). The RG knows the

current priorities of all the receivers, and when the sum of the received acknowledgements balances is greater than a given threshold, it acknowledges the data to its RG and frees the buffer. Thus, it is no more able to retransmit this data to receivers that have not received it. But this is acceptable with regard to the global group activity, because a RG frees its buffers only when enough receivers have received and acknowledged the data, and then, it means that the group work session can continue in good conditions. Of course, after this loss, the receivers that do not receive the data will probably increase their priority, because if one loss can be acceptable (even if it disturbs a bit the receiver comfort), long loss sequences are not tolerated, and would not allow the concerned group member to understand the group work. Thus, by increasing the receiver priority in case of loss, we can reach situations where cooperative reliability forbids for some receivers any kind of additional loss or degradation, to avoid to decrease the group work session efficiency (the acknowledgement balances become greater than the cooperative satisfaction threshold).

Cooperative reliability then requires an evolution of current priority that depends on the importance of the member in the group. For instance, we can imagine that the priority of a member with a very high importance increases in an exponential way, while the priority of a member of less importance increases only linearly. But every other behaviour evolution is possible ; an observer could even have a priority that decreases when he supports losses, and this in order not to disturb the other receivers that have a great role in the group activity.

The cooperative reliability is then a new notion. In fact, according to our knowledge, it is the first time that a multicast transport protocol implements communication mechanisms depending on the cooperative features of a group of users. Even if the M-Connection service [REZ96] included the new concept of different reliability levels for the receivers of the same group, M3POC provides a service with very good properties for multimedia and cooperative applications. Thus, it takes into account the notions of role, importance and function for each member in the cooperative work sessions, in order to ensure as much as possible a globally acceptable behaviour of this session. Cooperative reliability completes the partial reliability. This later has to manage the QoS for a unique receiver. No parameters extern to the receiver are taken into account. Cooperative reliability completes it by taking into account the group to which the receiver belongs, and above all by taking into account the global interest of the cooperative work session.

4. The *Confort* videoconferencing tool

4.1. Cooperative characteristics

To demonstrate the aim and performances of M3POC, it has been chosen to use the ***Confort*** videoconferencing software. As its forerunners [OWE96] [VIL98b] [BOY98], this application synchronises the audio and video streams and ensures a minimal QoS.

Experiments have been made on cooperative environments as CANET (automotive tele-design) or TOPASE (aeronautical tele-training), in which several cooperative tools run in parallel (videoconference, white board, application sharing tool, etc.). They have shown the necessity to have a single cooperation management tool for all the cooperative tools of the

environment, and the impossibility to have a cooperation management tool for each of the cooperative tools (at the opposite of what has been done in [VIL98b])[4].

Thus, in the framework of specific cooperative environments development, only the central cooperation manager would have to be re-written or reset. Each tool has nevertheless to perform its own cooperation management, what is incompatible with the centralisation requirements exposed just before. In order to make these two requirements match, it is needed to introduce in the applications ***auto-setting*** and ***opening*** functionalities. The auto-setting is a functionality that allows the application to extract information on the cooperation structure from the data it receives. Applied to ***Confort***, this means that the videoconference application is able, depending on the audio and video data it receives, to establish the current list of the videoconference participants, to dynamically add new comers that just joined the group, to extract participants that leave the session and, of course, to ensure for each member the asked QoS (this functionality is necessarily implemented by the videoconference application, because the high level cooperation manager is not interested by the data streams of the cooperative applications it controls in the cooperative environment). The opening functionality is the capability for the application to receive instructions coming from the global cooperation manager, that can, tanks to this mechanism, send set-up information to all the cooperative tools of the cooperative working environment (a generic service interface has been defined in this way). The ***Confort*** videoconference can then be controlled by external components of the environment, but is also able, when such instructions do not arrive, to configure itself.

4.2. QoS mapping between application and transport

Adding the preceding functionalities to cooperative applications allows them to be easily integrated into every cooperative environment. In addition, using a transport protocol as M3POC that takes into account the features related to the group activity may allow to improve the presentation QoS of the audio and video streams. However, in order to use this protocol, the application has to map its QoS parameters, and in particular the QoS parameters related to the cooperative activity, toward the transport layer and its own QoS parameters.

In ***Confort***, applicative parameters consists of the class of the local user, the QoS of transmitted media (as in [BOY98]) and the list of the members, required for the sender to identify all its receivers :

- it has been chosen to define the local user class as the composition of one priority describing its importance, and a priority evolution function. The application then provides several call-back functions that will be called when the cooperative reliability is overstepped. These functions have to modify the cooperative behaviour of the application in the presence of QoS degradations ;
- the application has also to provide the list of the receivers to the M3POC transport to make this later able to create the multicast tree with regard to the RTT between receivers and the cooperative users classes ;

[4] In fact, if each tool of the cooperative environment integrates its own cooperation manager, cooperative coherence problems appear. These problems are extremely complex to solve, and when they are solved, it is by introducing a global manager at a higher level. Nevertheless, these solutions often lead to performances decreases for the global environment.

- finally, the multimedia QoS is expressed in term of reliability : the application provides several parameters concerning the reliability of each media as well as call-back functions that will be called by M3POC when the partial reliability is overstepped. In the same way, as with cooperative reliability, these functions have to modify the behaviour of the application when facing degradation indications of the multimedia partial reliability, and to adapt it to the current context.

5. Work in progress

The work presented in this paper is at its early beginning, thus few realisations are currently complete. A modelling of M3POC using the OPNET modeller is in progress, but few simulation results have for the moment been obtained. An implementation of the protocol has just begun. Two approaches are under study : the first consists in coding the mechanisms directly using C/C++. The other consists in generating the code in a semi-automatic way starting from the OPNET model. For the moment, we do not have enough information to privilege one of these approaches.

Concerning ***Confort***, the project is more advanced, and a version of the software (coded in C++) runs over IP extensions for the multicast. This version of ***Confort*** integrates all the characteristics of auto-setting and opening required by cooperative work, as it has been explained in section 4. Confort has been developed on Sun Solaris 2 workstations equipped with Parallax or SunVideo boards (video formats being M-JPEG/JFIF or CellB). In terms of performances, ***Confort*** provides a QoS with 25 images/s (640 × 480 pixels and 16 millions colours) for sessions with 3 participants, a 64 kbps digital audio stream, and perfectly respected intra and inter-streams synchronisation constraints [OWE98b].

6. Conclusion

Returns of experiments of many projects in the collaborative working domain (in particular CANET and TOPASE) have shown many limitations of communication supports and cooperative tools compared to the needs of these collaborative working environments. These problems concern several aspects as :

- guaranteeing a minimal QoS ;
- integrating into communications supports and protocols some group communication functionalities (multicast) ;
- integrating into communication protocols mechanisms for delivery, retransmission, QoS management, etc. suited to the cooperative applications requirements. Features that appear in this kind of applications are related to role, functions and importance of each of the participants, and over all, related to the hierarchy, the group structure, etc. These features have to be taken into account and respected to allow the global activity to reach its objectives.

For that, the proposed communication architecture relies on the new M3POC transport protocol. This protocol solves the 3 expressed problems :

1) it integrates partial order and reliability mechanisms to provide a good support for the transmission of multimedia data with a reliability suited for each media, multimedia synchronisation capabilities and minimisation of delays thanks to earliest loss and delivery mechanisms ;
2) it integrates the multicast concepts of LGC/RMTP allowing, thanks to a hierarchical structure to solve the scalability problem in large groups. In addition, thanks to the principle for creating sub-groups of receivers with regard to their RTT and QoS (roles), M3POC creates a multicast tree suited to the needs of the cooperative structure (with local error recovery mechanisms) ;
3) finally, it defines the cooperative reliability notion (inspired by the partial reliability) that allows to adapt the transport mechanisms to the cooperative activity requirements. The goal is here to privilege the group interest instead of individual satisfaction.

This paper also presents the principles allowing basic cooperative tools to be easily integrated into every cooperative environment : these principles are auto-setting and opening principles, that have been applied to the ***Confort*** videoconference tool.

Finally, this paper introduces communication concepts, suited to the group work and very straightforward. However, a lot of work has to be done, in particular concerning M3POC. All the protocol mechanisms have to be chosen, simulated and evaluated (with OPNET). Then, the ***Confort*** application has to be re-written over M3POC, and this respecting the QoS mapping principles exposed in section 4.

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