Synchronization validation mechanism in multimedia document presentation

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ABSTRACT

Synchronization is the major processing task during multimedia presentation, which defines the time relation between multimedia objects. There are many synchronization specification methods, and each has different advantages and disadvantages. Those methods work well for simple and specific synchronization case, but when consider to large complex multimedia presentation, there lack effective method to deal with complex time relation. In this paper, a synchronization point based specification method (SPM) is proposed, and based on it, static and dynamic validation mechanism for synchronization relation is given. In SPM, synchronization relation is defined in synchronization points (SP). Multimedia presentation control is based on SP's status during presentation. According to the order of SPs, SPM gives the static and dynamic validation algorithm, which can avoid conflict relation between SPs. SPM give a way to define non determined synchronization relation between multimedia objects, and proposes static and dynamic validation mechanisms for complex synchronization control. This synchronization point based mechanism can extend the capability of synchronization definition and controlling in multimedia system.

Keyword: synchronization mechanism, synchronization validate, multimedia, multimedia presentation.

1. INTRODUCTION

Multimedia means a synthesis of different type of media objects, such as text, graphics, image, animation, audio and video media object. Usually, there are broad and narrow sense concepts of multimedia [1]. In broad sense concept, multimedia is a synthesis of more than two type media objects, but in narrow sense, more emphases is paid on the consists of media type with time attribute, and the time-based media is prerequisite of multimedia. In fact, before the broadly use of multimedia term, there was information system made up of Text, Graphic and Image objects. Only combine with audio and/or video media, that information system is so called multimedia system.

Synchronization is the major processing task during multimedia presentation. In multimedia system, synchronization between objects can be divided into intra-media synchronization and inter-media synchronization, or live synchronization and synthetic synchronization [1]. Live synchronization focus on replay nature scene, and synthetic synchronization dedicate to combine different type media object into a presentation. In synthetic synchronization, component media objects are created independently, synchronization relation is defined before presentation, and thus it is very important to describe and monitor synchronization.

There are many methods to describe synchronization relation, such as time-based, event-based, Petri net based and so on, those methods are only suitable for special field or simple case. There are increasing needs of effective method for large complex case. Especially those can support time non-limited event such as user interaction [2,3]. To answer this question is trade-off of flexibility difficult of synchronization mechanism.

This paper proposes a synchronization point based synchronization description and control mechanism (SPM), its hierarchy specification can deal with complex synchronization relation, and static and dynamic validating mechanisms are provided to aim at synchronization validation. Static mechanism can avoid inconsistency during synchronization specification, and dynamic mechanism can guide the process of multimedia presentation,

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2、SYNCHRONIZATION SPECIFICATION

Generally, there are four basic specification methods [1]:

1. Interval based specification. The duration of media presentation is interval, relation between two intervals can divided into 13 types [4], such as Before、Meets、Overlaps、During、Starts、Finishes、Equals and revise of the former six types. An improvement of this specification has 29 types of interval relations. Interval-based specification can easily deal with open duration media object, such as user interaction, but can not deal with sub-component of media object, and its flexibility may result in inconsistency in synchronization relation, especially when deal with complex presentation.

2. Axe-based specification. This specification can be divided into two classes: global time-based and virtual time-axes based, and all are based on one idea, synchronized objects are referred to time-axe, synchronization relation is determined by the reference points of the media objects. The difference of global time-based and virtual time-axe based methods is that virtual time must be mapped into real world time during presentation. Axes-based method is simple and easy implemented, and because of independent relation between presentation objects, the modification of synchronization relation is very simple, but this method is difficult to deal with open object (presentation time is not determined).

3. Control Flow-based specification. In this method, the flow of the concurrent presentation threads is synchronized in predefined points of the presentation, such as hierarchical specification, reference point-based specification and timed Petri-nets. The granularity of synchronization is important in those methods, small granularity result in the consideration of content type of objects, and big granularity affects the applicability of those methods. But control flow-based specification can deal with user interaction and time-independent objects. [2,5,6]

4、Event-based specification. In this type of specification, presentation is initiated by synchronization event. The event may base on status change of presenting objects, and the event may result in other object to change presentation status. This method can integrate time-independent objects and interactive objects. The main drawback of this method is that: it is not suitable for complex synchronization and hard to change the relation after defined.

Those methods are usually used in simple synchronization case, but hard to deal with non-determined factor in complex case, such as user random interactive event and other random event of synchronization. In complex synchronization cases, it may involve multiple user interaction, and various kinds of media type, those may lead to non-determined factor in presentation. In CAI system, student's question and teacher's answer may occur during presentation, synchronization control system can not know the exactly time point it occur, and can not determine the relation between this synchronization point and the others. This leads to difficult in validation of synchronization relation. In [3], reference point and synchronization element is defined based on object-oriented mechanism to deal with complex synchronization relation, but leak of validation mechanism.

3. SPM SYNCHRONIZATION SPECIFICATION

SPM is a synchronization point based synchronization control mechanism. Synchronization presentation of media objects can be considered as that independent presentation of objects should keep consistence at some special point (synchronization point). This special point can be defined as time point, event or message. In SPM, a synchronization point is defined to represent the special point, thus SPM integrate advantage of both time-based and event-based synchronization specification, and may suitable for the need of various type of synchronization.

3.1 Objects in SPM

Objects in SPM are divided into two category, basic objects and compound objects. Basic objects can be a single multimedia data unit, such as text objects, video objects and etc. Compound objects may consist of several basic objects that have special presentation relation. Following is the definition of SPM objects:

SPM object ::=<basic object>|<compound object>

Basic object ::=<text object>|<image object>

|<graphic object>|<audio object>|<video object>

|<other presentable object>

Compound object ::= <synchronization information>

{<SPM object>}

According to definition, basic object in SPM can be any presentable object, such as executable program object. Compound object is a recursive defined object, it can consist of basic object, and also other compound object. Because of the compound multi-layed relation of objects, SPM can apply to complex synchronization presentation. In fact, the whole presentation can be considered as a compound presentation of objects.

Compound object contain the presentation control information of component objects, this presentation control information is acted as synchronization information of objects in SPM. It contains synchronization information of object in time, layout and content aspect. But in this paper only time aspect is considered.

3.2 Synchronization point in SPM

In SPM, presentation relation of objects is defined by synchronization points (SPs), SP is the special point during object presentation, and can be set according to the need and/or limitation of object (limitation here means the implementation limitation). Generally, the start and end point of presentation is certainly SPs of an object. All SPs in an object can be ordered according to presentation of the object and each SP contain a set of synchronization control condition (waiting condition). When a SP is reached during presentation, the presentation will be stop until the synchronization control condition of this SP is satisfied, in the mean while, a SP reached message is sent to the objects which need this message.

In SPM, compound object can also has SP definition as basic object, only that the waiting condition and the receiver of SP reach message are complex. Compound object controls the synchronization presentation of its basic objects. For example:

Given synchronization information as below:

p1(a,b,c), p2(a,b), p3(a,c), p4(b,c),

p5(a,c), p6(a,b,c)

pi (I=1..6) are SP of a, b, c objects.

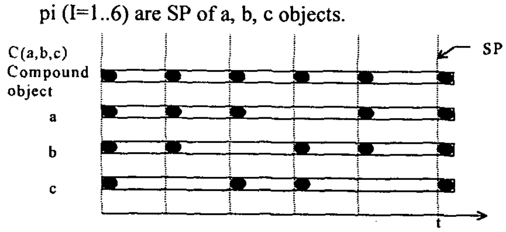

Figure 1. SP in compound object

In figure 1, SPs of a, b, c objects are defined separately, but each SP has its mapping point in compound object, so the relation between three objects is also defined. Compound object locally controls the presentation of the object below it. A complex synchronization need can be divided into several lay of compound object, each only control their own presentation, the whole complexity of presentation can be cut down.

In SPM, SPs of an object may have ambiguous time order, but this order relation should be consistence. Here, the time order of SPs has three type:

- Pm *before* Pn, recorded as: Pm<Pn
- Pm *after* Pn, recorded as : Pm>Pn
- Pm and Pn has no order, recorded as: (Pm,Pn)

Pm and Pn are two SPs in an object. Obviously, relation of SPs is transfer, and all SPs in an object form a SP sequence. Generally, SP relation in basic object can be easily determined, but no time order SPs often occur in compound object, so a group SPs (GSP) is proposed, the definition is that: a GSP is a set of SPs which has same time order relation. For example:

Given a compound object has A, B, C, D objects, and

(p1 p3 p4 p5) are SP set of A object,

(p2 p3 p4) are SP set of B object,

(p1 p3 p5) are SP set of C object, and

(p2 p5) are SP set of B object,

the sequence of all SPs are:

(p1,p2)<p3<p4<p5.

(p1,p2) are GSP of the compound.

3.3 Synchronization control mechanism

3.3.1 Status of object

In SPM, multimedia presentation progress can be descripted as status transfer of set of objects. Object status can be one of following six type: ID(le), RE(ady), RU(ning), WA(iting), FI(nish) and CO(mplete), figure 2 shows status transfer of an object.

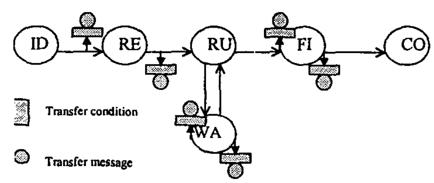

Figure 2. Status transfer of an object.

The status transfer start from ID and end with CO. Except the RU status, all others are temporary status, in those status, presentation is stop until the transfer condition is satisfied. Status transfer is based on SP of a multimedia presentation, when a SP is reached, status of object will transfer from RU to WA; when leave a SP, status of objects may transfer from WA to RU. Status transfer condition is based on SP relation, and the presentation of multimedia object is based on the control of status transfer at SP, so SP relation or status transfer condition is the synchronization information in SPM.

There is a status variable in SP to record presentation status. It is BOOL type, and TRUE represents that object is waiting at this SP, FALSE means current presentation point is not at this SP. Only one status variable in an object can be TRUE, thus, it is easy to determine where an object presentation reach. Status transfer condition is represented by status variable in SP.

Let $\cup$ and $\cap$ to be logical OR and AND, status transfer condition of p1 SP in A, B and C object is:

A object: $B.p1 \cap C.p1$

B object: $A.p1 \cap C.p1$

C object: $A.p1 \cap B.p1$

A, B and C object consist of a compound object D, the status transfer condition of p1 can change to:

A object: D.p1

B object: D.p1

C object: D.p1

That is to say, synchronization of basic object can be fulfilled by compound object. Compound object can be treated as basic object, synchronization information specification is the same as basic object, p1 is also in D object. Status transfer condition of p1 in D object is:

D object: $A.p1 \cap B.p1 \cap C.p1$

All objects reach p1, can compound object D pass p1, and in the meanwhile send the D.p1 message to all objects waiting for it. The message sent from objects to compound and the reserve is not same, the former is sent upward and latter is sent downward. In SPM, the upward and downward messages are used to control the synchronization presentation.

3.3.2 Algorithm of synchronization control in SPM

Synchronization control algorithm is:

1. All objects involved in synchronization presentation are initialized. The initial status of all objects is ID, and all status variable is FALSE.
2. If it is not a compound object, jump to step 4.
3. The compound object will wait for SP reach message of component objects, if status transfer condition is satisfied, then go to next step.
4. If this compound object is not contained in another compound object, then jump to step 6.
5. The compound object sends SP reach message to upward compound object, and wait for upward object SP reach message. Status variable of this SP is turn to TRUE. After the status transfer condition is satisfied, then status variable is turn to FALSE.
6. Compound object send downward message to all objects under this compound object, and status turns to RU.
7. During presentation, if reach SP, then jump to step 2; if presentation is over, status of object turn to CO.

This algorithm can apply to all objects in SPM, but there is a presupposition of this algorithm:

All the presentation of object is single direction, and all SP can is judged.

Single direction is that all SP in a object can be ordered. When an object reaches a SP, it should know that is a SP; otherise synchronization can be kept,

SPM can also easily deal with having no time relation, so it can process synchronization based on random event like event based specification. An event can be treated as a SP in SPM.

4. SYNCHRONIZATION VALIDATION IN SPM

In multimedia presentation, synchronization information should be considered carefully, any inconsistency would cause system turn into endless waiting. To keep consistence in synchronization, first should keep synchronization relation in reason when defined, then should keep consistence during presentation.

In SPM, the rationality of synchronization is that the order of SPs in an object should be in reason, to keep this relation, synchronization information process should keep to following criteria:

1. The order of SPs in an object must be in reason. (static consistency)
2. The order of SPs in an object must be in reason at any

time during presentation. (dynamic consistency)

4.1 validation of static consistency

Static inconsistency can be occurred during SP definition, for example:

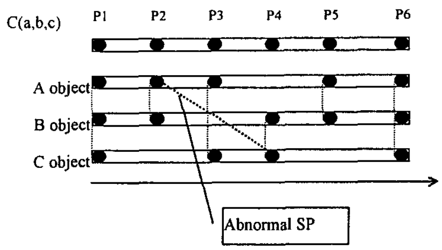

Figure 3. Abnormal SP definition

In figure 3, A.p2 and C.p4 can not have synchronization relation; this relation will result in abnormal order of p2, p3 and p4.

According to A object ====> p2<p3

According to B object ====> p2<p4

According to C object ====> p3<p4

So there will be p2<p3<p4. But if A.p2 and C.p4 is SP, then p2=p4, it will cause endless waiting during presentation, so A.p2 and C.p4 can not be SP.

The key to solve this problem is to validate the synchronization relation. In SPM, all SPs of synchronized objects are mapped into compound object, so to validate synchronization relation is to validate SP order in compound object. The problem is:

Problem 1: given all SPs in a compound object has normal order after defined. In case of Pi {I=1..m} SPs, their order is:

P1<P2<P3.....<Pi<Pi+1<...<Pm

When a new SP name Pj is added, if it can be inserted into the sequence of current SPs, then it is normal SP, otherwise it is abnormal SP.

Algorithm to solve this problem is:

Step 1. Suppose Pj fall into the area of Q, Qmin=P1, Qmax = Pm, execute step 2 to all object contain Pj.

Step 2. To find the nearest SP before Pj in the object, suppose Px.

Step 3. To find the nearest SP after Pj in the object, suppose Py.

Step 4. If Qmin<Px, then Qmin=Px; if Qmax>Py, then Qmax=Py.

Step 5. If there are any object has Pj, then go to step 2.

Step 6. In compound object,

if Qmin>=Qmax, then Pj is abnormal;

if Qmin<Qmax, then Pj is normal, and has Qmin<Pj<Qmax order.

If Qmin and Qmax are GSP, then Pj is normal, It has Qmin<Pj<Qmax

In SPM, compound object can contain another compound object, so this algorithm can be executed from bottom to top through hierarchy structure of compound object to validate synchronization relation.

Problem 2: given all SPs in a compound object has normal order after defined. In case of Pi {I=1..m} SPs, their order is:

P1<P2<P3.....<Pi<Pi+1<...<Pm

When a SP name Pi is deleted, how to rearrange the order of others SPs.

If a SP is deleted, others keep the order not changed, there will be abnormal when new SP is added. For example:

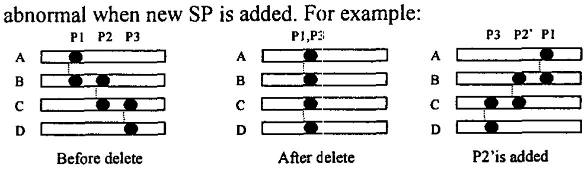

Figure 4. Rearrange order of SPs after P2 is deleted.

In figure 4, after P2 is deleted, if keep the order of SPs not change, P2' can not be added.

Algorithm to solve problem 2 is:

If Pi is in GSP, then

Step 1. If no SP has order with Pi, then no change of order is needed.

Step 2. If there are others SP in GSP, then according the following algorithm to process the order in GSP only.

If Pi is not in GSP, then

Step 1. Find the nearest SP before Pi, name Px, for each object that contains Px, and find the smallest SP which just after Px, name Pxmin.

Step 2. Find the nearest SP after Pi, name Py, for each object that contains Py, find the biggest SP which just before Py, name Pymax.

Step 3. Consider Px, Py, Pxmin, Pymax

If Px=Pymax or Py=Pxmin, no change of

order is needed.

Else all SPs from Pymax to Px and from Py to Pxmin are GSP.

With above two algorithms, static inconsistency can be avoided during definition. But to some complex synchronization presentation, which SP is defined, based on random event, static validation can not deal with it. There must be Dynamic validation algorithm.

4.2 Dynamic validation mechanism

In SPM, some SP may be defined based on random event, and GSP is used to record those SP, but static validation can not deal with GSP, so a dynamic validation mechanism is proposed.

Dynamic validation means the validation of synchronization relation is processed during presentation. Dynamic inconsistency in GSP can be explained as follow:

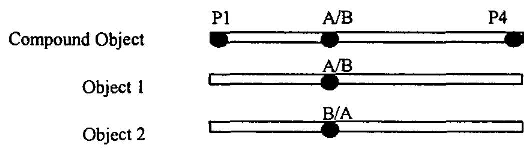

Figure 5. GSP in SPM

A and B in synchronized objects are based on random event, order can not be determined, So they are in GSP. During presentation, if object 1 reaches SP A and object 2 reaches SP B, then the presentation will be in endless waiting.

Algorithm to avoid dynamic inconsistency is:

- Step 1. Synchronized object reaches a SP, name Pi, if Pi is not in GSP, then this process end.
- Step 2. If there is no other SP in the GSP that is also in this object, then this process ends.
- Step 3. Suppose Pj is the SP in the GSP and also in this object, then set the temporary order of Pi<Pj to compound object, if no conflict occur, then this process end; else dynamic inconsistency occur, execute error process module.

Error process can temporarily disable the Pi SP, or restart whole presentation. The relation created during dynamic inconsistency validation is temporary relation, after presentation, this relation will be deleted.

5. CONCLUSION

In this paper, a SP based synchronization specification and validation mechanism is proposed. As SP is flexible to fulfill almost all synchronization need, SPM can apply to general multimedia presentation. Some presentation are based on real time, in SPM, a default object which named TIMER will be added to synchronize those object presentation. This is something like mechanism in PREMO[7].

The order of SP in SPM is proposed in this paper, and based on this concept, static and dynamic synchronization validation are given to deal with synchronization inconsistency during SP definition or presentation time. Those validation mechanisms are very useful in case of large complex multimedia presentation, and can also be extended to other synchronized system.

REFERENCE

[1] Ralf Steinmetz, Klara Nahrstedt. Multimedia Computing, Communications & Applications Prentice Hall, 1995

[2] B.Prabhakaran and S.V.Raghavan. Synchronization Models For Multimedia Presentation With User Participation. ACM Multimedia 93 /6/93/CA.USA p157-166

[3] Anund Lie, Nuno Correia. Cineloop Synchronization in the MADE Environment. SPIE Vol.2417. p225-232

[4] J. F. Allen, Maintaining Knowledge about Temporal Intervals. Communications of the ACM, 26(11) November 1983, p832-834.

[5] Naveed U. Qazi, Miae Woo, Arif Ghafoor. A Synchronization and Communication Model for Distributed Multimedia Objects. ACM Multimedia 93 CA, USA, p 147-155

[6] Yahya Y. Al-Salqant, Carl K. Chang, and Y. V. Reddy. MediaWare: On Multimedia Synchronization. 0-8186-7105-X/95 @1995 IEEE, p150-157

[7] Draft International standard, ISO/IEC DIS 14478,Information technology----Computer graphics and image processing----Presentation Environment for multimedia objects (PREMO)