Fostering Engagement in Asynchronous Learning Through Collaborative Multimedia Annotation

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Abstract: This paper presents an experimental test of a prototype system for asynchronous distance learning. The prototype allows viewers of audio and video to create and share text annotations that are synchronized with the multimedia. We extended the system to support group exercises and conducted an experimental study with three conditions: groups working asynchronously; groups working face-to-face; and individuals working alone. The results suggest that the use of group exercises can promote engagement and system use, and also suggest possible further improvements to the annotation system.

1 Introduction

Current efforts to use digital technology to produce and deliver effective distance education are expanding rapidly as the demand for distance education grows. This demand is fed by increasing student populations and greater emphasis on "life-long learning" as a way to manage careers amidst rapid change. Communication technologies also make it possible to deliver education to people for whom it has been out of reach.

Distance education is not new. Televised and videotaped courses have long been available, and courses have been conducted using the web, email, chat, and in virtual worlds. The recent spike in interest reflects the capabilities of the current generation of disks, networks, and computers. Video increasingly can be archived inexpensively and made available over intranets and the Internet. Richer interaction among participants can be supported.

Email and chat are not fully satisfying tools for interacting around digital content. Comments are not linked to the germane part of the content: The author of a comment must specify the context and readers must then locate it. Annotation systems address this by integrating text commentary or even real-time chat with documents or web pages. (E.g., the Bellcore Quilt system, Leland et al., 1988; FXPAL Anchored Conversations, Churchill et al., 2000.)

It is more challenging to support "in-context" annotation of audio and video than text, but it can be more important because multimedia is more difficult to skim. The MRAS annotation system (Bargeron et al., 2001; Bargeron et al., 1999), described below, allows people to easily create and share notes that are linked to specific points or segments in a multimedia object, such as a videotaped lecture.

For distance education courses, especially those in which students view lectures on demand (asynchronously), two challenges are to maintain student engagement and reduce procrastination. This paper describes an experiment with a system and process that address these challenges.

1.1　Multimedia & Distance Education

Often a new technology is first used to reproduce or enhance pre-existing practice; then, as its capabilities are better understood, new practices emerge that exploit it more effectively. This is certainly true for educational technologies. Much education today is lecture-based. Early use of analog and digital technologies has focused on enhancing and extending lectures. This will change, but at present a principal use of multimedia technology is to enable lectures to be viewed in different places and times.

Technologies enabling asynchronous viewing of lectures need not replace face-to-face interaction. Viewing a lecture video in advance could enable classroom time to be spent more interactively – fielding questions, discussing the material, and going into depth on particular points of interest. The video can be viewed when and where students have the

opportunity. Unlike a live lecture, students can view it at their own pace, skimming segments or viewing them more slowly. The principal disadvantage, apart from possible social or motivational aspects, is that a lecturer cannot be interrupted with a question or comment. Overall, digital multimedia presents an opportunity to enhance the existing capabilities of distance education, which are discussed next.

1.2　Paradigms for Distance Education

Distance education via analog video

Research has shown that television and video are as effective as live lecturing in reaching educational goals when engagement and motivation are maintained (for an extensive review see Wetzel et al., 1994). However, engagement and motivation often flag when students are left to pursue material alone or with reduced capability to interact.

An interesting illustration is a tutored video instruction (TVI) study at Stanford in the 1970's. In comparing class performance, students who attended lectures did better than those watching the lectures as they were broadcast, and the latter did better than students given videos to watch when convenient. But the students who performed best of all were those who met to watch and discuss lecture videos together (Gibbons et al., 1977). Each Stanford group had a discussion leader or tutor, but similar results have been obtained by groups of students meeting without tutors (Sipusic et al., 1999). TVI is only partially distributed in space and partially distributed in time – only subsets of students congregate.

Text-based distance education

The Internet has enabled the postal system to be supplanted by more rapid and efficient web, email, and chat-based interaction. Its use in education has been limited, usually supplementing live lectures or focusing on discussions and exercises around written materials. A major question, often an assumption, is whether or not the addition of multimedia will greatly increase the utility and impact of digital technology in education.

Digital delivery of multimedia content

Audio and video can be used for more than lectures. Distance education efforts at the Open University (www.open.ac.uk), Oxford University (www.ox.ac.uk), and UNext (www.unext.com), for example, incorporate multimedia while shying away from traditional lectures. Nevertheless, remote lecture presentation is a relatively popular and economical extension of current practice, widely used via analog broadcasting. Digital technologies, which support interaction, offer opportunities not provided by analog video.

One technology that facilitates collaboration around multimedia is distributed tutored video instruction (DTVI), in which students meet "virtually" to watch and discuss a lecture video. Sun and Microsoft researchers have tested systems that allow viewers in different locations, linked by a telephone conference call, to simultaneously watch and control videotaped lectures (Sipusic et al., 1999, Smith et al., 1999, Cadiz et al., 2000). When a video is stopped, reversed, or moved ahead, everyone sees the same thing. As with TVI, this is only partially asynchronous: a subset of students engages at the same time. There is no persistent record of the collaboration and no built-in way to extend the interaction to other class members.

Annotation on multimedia

Another approach to facilitating collaboration around multimedia is annotation, allowing viewers to pause a video at any point and enter a comment, which is saved and linked to that point in the video (Bargeron et al., 1999; 2001). An annotation is then seen in context by subsequent viewers of the video, like a note written on a text and passed around. With such a system, students can view lectures when convenient, take notes indexed into the content for later review, and share questions and comments. Our study is based on annotation technology.

2　The MRAS Annotation System

In this section we briefly describe the interface and principal features of the annotation system used in the study. Detailed descriptions of the system architecture and design can be found in (Bargeron et al., 2001; Bargeron et al., 1999).

2.1　System Description

Figure 1 shows the MRAS interface prior to our modifications. The video in the upper left of the browser window is displayed with a standard media player. The slides on the right are synchronized with the video. In the lower left is an annotation set: comments, questions, and replies made by previous viewers of the video. Each annotation is linked to the specific point in the video at which the video paused when the annotation was created. The red arrow points to the annotation that was created closest to the current position of the video; the reply below it is also highlighted. To the lower right is the annotation preview window, which automatically shows text associated with the currently highlighted annotation. As the video plays, annotation titles scroll by. A viewer can click on an annotation and read it in the
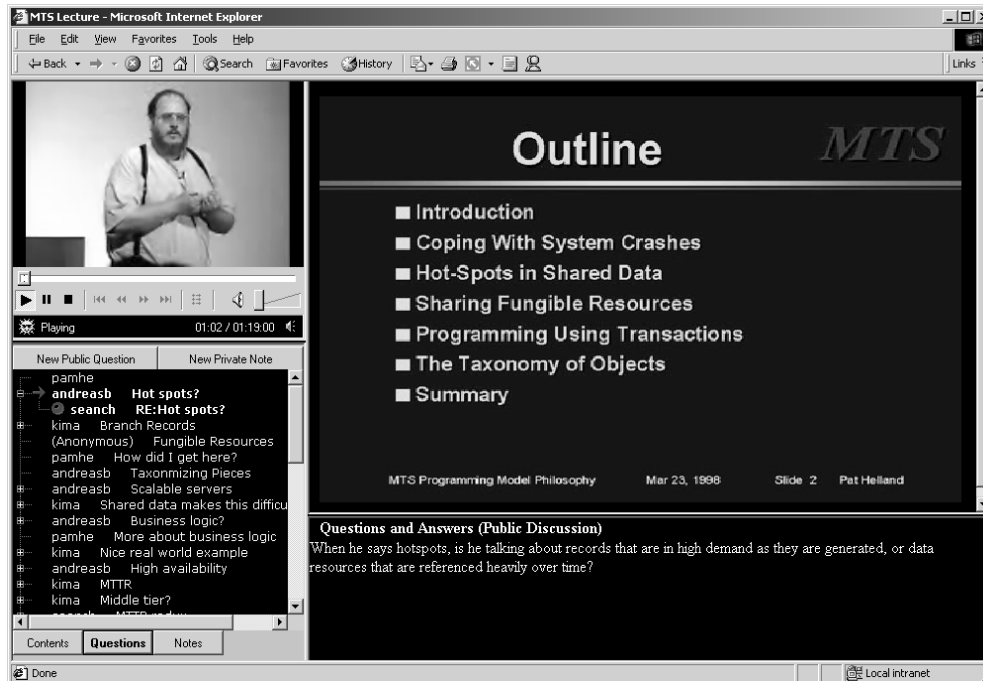
Figure 1: A student's view of the web-based MRAS annotation system, with frames for the video, slides, annotations, and the annotation preview.

preview frame, right-click to seek to the point in the video where an annotation was created, or reply to it.

Currently displayed is the 'Questions' annotation set, which can be written to and read by all students in the class, in this case a lecture on transaction servers. The 'Contents' button will bring up a read-only set of annotations that consist of the slide titles, a table of contents for the lecture. Using these, students can skip from one topic to another. The 'Notes' button on the right brings up a set of personal notes for this particular viewer. Each private note, like other annotations, is linked to the point in the video at which it was created, much as a written note in a book is clearly linked to its context, the page or paragraph on which it is written.

2.2 Supporting Collaboration

Prior experimental studies and field trials with MRAS have demonstrated the power of the annotation system to provide fluid, fully asynchronous, fully distributed, and persistent collaboration around multimedia.

Bargeron et al. (1999) contrasted text annotations, voice annotations, and handwritten notes. Annotations synchronized with multimedia proved successful, with text generally preferred to voice. An unexpected finding was that the likelihood of a person leaving an annotation rose with the number of annotations left by previous viewers.

The same authors reported a study contrasting the use of MRAS in two 4-session training courses with the same course given live (Bargeron et al., 2001). In the MRAS courses, students met briefly at the beginning and end of the course and watched the lecture videos on demand, asking questions using the system. The MRAS courses were well received and suffered less attrition than the live version.

2.3 Potential for Group Exercises

Although viewers using this fully asynchronous and distributed system can see and add to comments left by others, the viewing experience is solitary. Motivation and engagement may be reduced. Also, the on-demand format facilitates procrastination. Last-minute viewing is not only pedagogically undesirable, it reduces the utility of shared notes. Several students in the MRAS field study had not finished viewing the lectures at the end of the course.

To avoid a passive lecture viewing experience, instructors in MRAS field trials took advantage of the on-demand format by weaving exercises into their presentations. The exercises were designed for individual students, but point to an opportunity to increase interpersonal interaction and engagement through small-group exercises.

If students assigned to do an exercise together can meet, they can use MRAS to view the lectures and distribute results to the class. Groups who could

not meet could also use the annotation system to work together. In both cases, groups will use the annotation system on a stage smaller than the full class, as the exercise guides them in viewing the lecture and thinking about the material in a timely fashion. In this scenario, students enjoy the advantages of working in groups shown by TVI and DTVI. The system also provides a persistent record of interactions, as with email discussions, but in this case the notes and exercise products are linked to relevant lecture content.

2.4   Extension to Support Exercises

Our principal change in MRAS usage was to incorporate group exercises. To support exercises in which people can work asynchronously, we adapted MRAS itself, adding a 'Group' annotation set that can be viewed and added to by group members. This required buttons for viewing a 'Group' set and for adding a 'New Group Comment.'

3 Study of Small Group Work

We wanted to determine the feasibility of doing group exercises in an asynchronous multimedia context, and to contrast that experience with individual exercises. In a real distance-learning course, groups of students assigned to do an exercise together might arrange to meet in real time (face-to-face or online), even when the entire class cannot meet; alternatively, group members may have to work exclusively asynchronously. To simulate these circumstances, we designed two group exercise conditions, one in which participants met together live and used MRAS to view lectures and report results, the other in which they used MRAS to conduct the exercise asynchronously. A control condition in which participants completed the exercise alone was included.

3.1   Procedure

16 beginning to advanced computer users participated in this study in exchange for a software gratuity. Each was randomly assigned to the asynchronous group (N=6), "live" group (N=4), or "solo" (N=6) condition.

All participants role-played taking an economics course through a university distance-learning program. They were told they would use a system to view and annotate two short pre-recorded lecture videos and then complete an assignment. Each participant completed a short training session in which they learned the core functionality of MRAS:

how to take notes, seek to the point in a video where a note was taken, and edit an existing note.

Participants then watched two 8- to 9-minute lectures on economic issues related to the Microsoft antitrust case. They then generated two arguments supporting the position that Microsoft is a monopoly and two arguments supporting the position that Microsoft is not a monopoly, based on the lecture content. After viewing both lecture segments, they had a 10-minute review session and were given 5 minutes to complete the assignment by annotating the lectures with their four arguments.

In the solo condition, participants worked alone on the exercise. In the asynchronous and live group conditions participants worked in pairs. To simulate students who meet face to face, pairs in the live group condition viewed and annotated the lectures together at a single computer, talking freely while watching and creating annotations and while generating their four arguments.

The asynchronous group condition simulated the case of distance-learning students who are unable to meet. Pairs worked asynchronously, communicating comments on the lecture material to their partner through MRAS. Each participant watched and annotated one lecture video while their partner watched and annotated the other. They then switched lectures. As they viewed their second lecture they could see and respond to their partner's comments made earlier. During the 10-minute review session, each participant could see their partner's responses to their comments on the first video they had watched. In a real distance learning class, a group might use email to discuss their choices. We approximated this by giving them 5 minutes to communicate using an instant messenger to reach agreement on the four arguments to be submitted as their final assignment.

After the task, all participants completed a questionnaire and comprehension test on the lecture material. The survey addressed feelings of engagement and enjoyment, satisfaction with work product and process, and sense of group cohesion.

3.2   Results

In all conditions participants completed the task with minimal difficulty. They mastered the MRAS interface assisted by the brief training, taking personal or group notes as appropriate. Groups working together asynchronously read and replied to one another's comments.

Proof of Concept

The ease with which groups completed the task suggests that the system is usable for group

exercises, even when students cannot meet face-to-face. Everyone in the asynchronous condition quickly and easily adopted MRAS, leaving contextualized comments and questions to which their partners could reply. Annotations were focused on the tasks – some addressed the lecture content, others the assignment (e.g., "This is a good point. We should use it as an argument that Microsoft…").

The results reported next suggest that the group exercises provide an educational experience equal to or better than that of working alone.

Participation

We predicted that people working in groups asynchronously would participate more by creating a greater number of annotations than those working alone. Participants in asynchronous groups did make significantly more annotations (t = 2.9, p < .01; see Table 1). Furthermore, the increase occurred in both the first lecture, before the partner had made comments, and the second. Thus, being in a group led to more original annotations.

# Annotations	Asynch	Live	Solo
Viewed 1st	4.67	2	2.17
Viewed 2nd	5.33	2	1.67
Review	2.67	4	2.83
Total	12.67	8	6.67

Table 1: Average number of annotations per person.

Interactions with a partner did elicit additional annotations. In the asynchronous condition, 2.8 annotations on average were replies to a partner's previous comments, constituting 22% of all annotations. The asynchronous group structure increased participation from the beginning and fostered further participation as the group annotation set grew.

Participant pairs working asynchronously ($\underline{M}$ = 26.3) also made significantly more annotations on the lectures than those working together live ($\underline{M}$ = 8; t = 2.4, p < .05). However, participants working together live shared verbal comments that were not added as annotations.

Survey Data

Survey results reported below are group medians from ratings on 7-point Likert scales anchored with 1 = Disagree and 7 = Agree. Participants estimated attention drift in 10-percent increments.

Work product and work experience

Seven questionnaire items addressed work product and process (Table 2). The group process generally

Measure	Asynch	Live	Solo
Overall, I am satisfied with my work product.	5	6	4
I am confident my final arguments are the best.	3.5	4.5	4
I am satisfied I considered all alternatives before choosing my final arguments.	4	5	3.5
It was easy to generate arguments.	5	4.5	4.5
I learned as much as possible from this lecture.	5	3	3.5
My primary job was to memorize facts.	2.5	2.5	2.5
This exercise really made me think and analyze the lecture material.	6	4.5	6

Table 2: Work product and process medians.

led to better ratings of subjective work experience than did working alone. Interestingly, each group condition appears to have unique strengths.

Participants working together live reported higher ratings of subjective satisfaction with overall work product than asynchronous groups (Mann-Whitney $\underline{U}$ = 3.5, p = .06) and those working alone ($\underline{U}$ = 2.5, p < .05). There was a trend ($\underline{U}$ = 5.0, p = .13) for groups working live to be more satisfied that they considered all possible alternative arguments than participants working asynchronously. On the other hand, participants in live groups reported that they thought about and analyzed lecture material less

Measure	Asynch	Live	Solo
I found the lecture stimulating.	5.5	4.5	5
I enjoyed the lecture.	5	5.5	5
I found the lecture boring.	2	3.5	2
I enjoyed the exercise.	5.5	5.5	5
I found the exercise stimulating.	6	5	5
% of time attention drifted.	30%	20%	20%

Table 3: Engagement and Enjoyment Medians

than did participants in the other two conditions, although the comparisons were not significant.

Asynchronous group members reported higher scores on feeling they learned as much as possible from the exercise than participants in either of the other conditions, although only the comparison to participants working alone constituted a very mild statistical trend ($U = 10$, $p = .19$).

Although not statistically definitive, these findings are consistent with our observations of the group dynamics (discussed in more detail below). The live groups took advantage of the ability to converse, which often included digressions that were enjoyed but took time away from the task.

Engagement and Enjoyment
Participants in all three groups found the lecture and the exercise stimulating, and reported minimal boredom and attention drift (Table 3). There were no significant differences among groups, although asynchronous groups tended to report the exercise to be more stimulating than the live groups ($U = 3.5$, p

Measure	Asynch.	Live
I felt I made a contribution to my group.	5.5	6
I felt connected to the other person in my group.	5.5	5
I interacted with peers more than I normally do in class/lecture settings.	4	4
I felt comfortable presenting my ideas to the other person in my group.	6	6.5
I found the experience of working in a small group enjoyable.	6.5	6
I found the interactions with the other person in my group enjoyable.	6.5	6
It was easy for my partner and I to resolve differences in understanding lecture content.	3.5	6.5
It was easy for my partner and I to come to agreement on which arguments to use as our final four arguments.	4	6
My partner and I contributed equally in creating our final four arguments.	6	6.5
It was helpful to work with a partner when generating the top four arguments.	6	7

Table 4: Group Interaction Related Measures

= .16). The lack of differences may reflect a ceiling effect, as ratings skewed toward high engagement.

Group Specific Comparisons
Participants in the two group conditions responded to ten questions about the work group experience (Table 4). Importantly, those in asynchronous groups report lower scores on resolving differences ($U = 3.0$, $p = .05$) and reaching agreement with their partner ($U = 3.0$, $p = .05$) than their live group counterparts. A ceiling effect may be obscuring other differences between the groups.

Lecture Comprehension
All participants completed the experiment by taking an 11-item comprehension test for comprehension of the lecture material. Scores averaged 6.85 across all participants, with non-significant differences among the conditions (Table 5).

	Asynch	Live	Solo
Average comprehension score	7	6.25	7.17

Table 5: Average lecture comprehension score (out of 11)

General Observations
The experimenters watched the exercise through a one-way mirror. Two observations stood out. First, in both group conditions, participants were very interactive. In addition to making more annotations, pairs working asynchronously used the chat heavily, averaging 18.3 dialogue entries in five minutes. Pairs working live conversed considerably while watching and reviewing the lectures, which is reflected in their high ratings of feeling comfortable voicing ideas.

Second, perhaps because live group members felt so comfortable voicing opinions, they tended to engage in off-topic conversations that appeared to disrupt attentional focus. Such conversations often started as discussions of the lecture, then shifted to distantly related topics. This tendency to digress may be reflected in the lower score of participants in live groups on the question of whether the exercise made them think and analyze the lecture material.

3.3 Discussion
Participants working in small groups succeeded in using MRAS to produce a single "assignment." We hoped to foster engagement via participation in an asynchronous environment, and participants in that condition made many more annotations than participants working alone. Two people working

together asynchronously produced more annotations than two people working independently.

Contrasted to pairs working together live, asynchronous collaborators also made significantly more annotations. As noted above, pairs working live made many comments that never became annotations. Verbal interaction obviously is a benefit of face-to-face collaboration, but there is also value in recording comments for later access. Especially in classes that extend over weeks or months, additional annotations could add value by aiding memory and increasing efficiency in reviewing past lectures.

Although not statistically significant individually, ratings of participants working asynchronously were equal to or better than those of solo participants on 5 of the 6 measures of engagement. In fact, they were equal to or better than the live condition on 4 measures. Engagement was not reduced and may have been increased by working asynchronously.

Participants working live reported significantly higher levels of satisfaction with their work product. Face-to-face interactions may afford more opportunity to use partners as sounding boards for their ideas: Live collaborators reported greater confidence in the correctness of their final work product. Yet participants in face-to-face groups also reported lower levels of critical thinking and analysis, consistent with the observation that they were more likely to digress. This raises the possibility that satisfaction with work product is based more on subjective group dynamics than on objective self-analysis of substantive work. That asynchronous collaboration could lead to greater objectivity of work product appraisal is something to be explored.

Overall, for the seven measures of work product and process, group medians for the three conditions are similar. The asynchronous and live participants rated themselves evenly for one measure and each scored higher for three measures. Asynchronous participants rated themselves higher than the solo participants on 4 measures and lower on only 1; live group participants rated themselves higher than the solo participants on 3 measures and lower on 2. On no measure did participants working alone rate themselves higher than both group conditions. The group dynamics appears to be comparable with respect to self-appraisal of work, with each group condition enjoying particular advantages.

The difficulty of reaching resolution when working asynchronously is well known. Although asynchronous groups made comparable ratings on most measures of group cohesion and interaction, they reported significantly lower scores on the two measures of reaching consensus. Two approaches that could be applied are the categorizing or 'typing' of comments (labeling them as questions, arguments, supporting statements, etc.) and provision of prioritization and voting tools. The latter might be particularly effective for larger groups.

Meaningful testing of the effects of the technology on comprehension and learning will require long-term use, preferably in real classrooms. We tested for comprehension half an hour after the viewing of videos. Students typically have days or weeks between exposure to material and examination. Based on the number of annotations by participants working together asynchronously, we see grounds for optimism, both because of the engagement needed to create notes and because of the availability of notes for subsequent review.

In summary, this study suggests that a course taught asynchronously with an annotation system can benefit from small-group collaborations, and that benefits occur even when group members work asynchronously. Participation and engagement, areas of concern when students work remotely, were greater than with solo performance. Previous studies of this annotation system, including use in training classes, showed benefits from allowing students to view lectures at their own pace, even when they worked individually. Thus, the process changes we have examined are particularly encouraging.

4 Design and Process Implications

Group Exercises and Annotation Sets
Group exercises show promise in helping to offset the limited nature of interaction in asynchronous distance education. They may also surpass individual exercises in the pedagogical goal of spurring students to view videos in a timely manner, given the ability to procrastinate in on-demand settings. Small groups may be able to convene face-to-face. When they cannot, we have shown that exercises through asynchronous annotation can succeed. In addition, it provides experience with shared annotations in a less intimidating environment than a class discussion set

Although one study is not definitive, the MRAS extension to include group annotation sets merits further exploration. Additional system features are required for use in a class setting including a method for creating multiple group annotation sets and assigning students to them. In addition, annotations added to a group set should automatically be distributed to group members. The flexible MRAS architecture supports these, but requires an interface for instructors to carry this out.

Support for Discussion Resolution and Reporting

Digitally mediated interaction tends to favor some tasks, such as brainstorming, and not others, such as reaching decisions. This must be borne in mind in assigning and guiding group exercises. As noted above, improved system support for issue resolution is an area of research that could merge nicely with in-context annotations.

There could be considerable benefit to the instructor and class if exercise results are reported in context, linked to their multimedia support. Our exercises were designed to have solutions that are clearly tied to specific points or passages in the video. We found that students would benefit from a relatively detailed table of contents to help them find the appropriate video anchor for each solution. Other kinds of exercises might benefit from a capability for annotations to link to multiple video segments.

5 Conclusion

This is a tremendously exciting and interesting time in education. Whether education is carried out wholly at a distance or whether asynchronous activity is used to supplement live interaction, the opportunities for enhancing the experience are remarkable. We are clearly at the beginning of a long discovery process.

Digitally archived versions of live lectures will not be the final outcome. This study, although based on such lectures, shows the beginning of their erosion. By interspersing the viewing of content with exercises, for individuals and groups, and interweaving the reporting of results to other class members, we can glimpse the potential richness of the educational experience that will be available.

Laboratory studies such as this must be followed with use in real classes, as was done with the basic MRAS annotation system in the past. Nevertheless, this study has provided considerable guidance into features that should be changed before such trials and into process guidance that could enhance the classroom experience.

Acknowledgements

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