Impact of Gaming during Channel Zapping on Quality of Experience

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Abstract—**This paper belongs to a research program started in 2006, dealing with Quality of Experience (QoE) aspects of channel zapping. The program, which has relevance for the broader topics Quality of Service and Next Generation Networks, started with quantifying the QoE expressed as a so-called Mean Opinion Score (MOS) for situations when a black screen is visible during channel zapping. Based upon the observation that the QoE is (possibly) increased by showing information while the user waits for the target channel to appear, the program continued with assessing the QoE in case advertisements are shown during channel switching. In this paper, we quantify the impact on QoE when offering users an interactive game during channel zapping. Our subjective experiment shows that for zapping times greater than 2.25 seconds, offering games during zapping instead of the usual black screen, leads to a better QoE. For zapping times larger then about 3 seconds, the MOS for the 'game' scenario is larger than 3.5, indicating the onset to acceptable quality. For zapping times below 1 second, the MOS for the 'game' scenario is very low, indicating that it is a bad idea to show games in case of such short zapping times. The scenario where during zapping advertisements are shown is always outperformed by either the 'black screen' or 'game' scenario.**

For small zapping times, the ease of play is much too low. For instance, for a zapping time of 1 second, only 18% of the test subjects managed to play the game in time. For zapping times of 3 seconds the ease of play becomes higher than 80%. At zapping times of 5 seconds, the game score is as high as 82%.

Keywords - Channel Zapping; Quality of Experience; Mean Opinion Score; IPTV; gaming.

I. INTRODUCTION

This paper belongs to a series of papers, the first of which was published in 2006 [1], that all deal with Quality of Experience (QoE) aspects of channel zapping. In the highly competitive market of Triple Play (i.e., the commercial bundling of voice, video and data on a common IP based network infrastructure), Service Providers, which are offering high quality IPTV services, need to address the QoE requirements of IPTV. QoE takes into account how well a service meets customers goals and expectations rather than focusing only on the network performance.

One of the key elements of QoE of IPTV is how quickly users can change between TV channels, which is called channel zapping. The zapping time is the total duration from the time that a viewer presses the channel change button, to the point the picture of the new channel is displayed, along with the corresponding audio. Minimum quality requirements for many aspects related to IPTV have been specified by both the ITU [2] and the DSL Forum [3]. However, in the ITU document there are no recommendations at all related to zapping times, while in the DSL forum document it is recommended to limit zapping time to an arbitrary maximum of 2 seconds. Additionally it is noticed in the document that providers should strive for zapping times in the order of 1 second.

Because these quality requirements are rather vague Kooij et al. [1] started a research program in order to get insight in the relation between QoE and zapping time. In [1], a number of subjective tests was described, in which, during channel zapping, a black screen, which contained the number of the target channel, was visible. The QoE was expressed as a so-called Mean Opinion Score (MOS). The test subjects (21 in total) could select one of the following five opinion scores, motivated by the ITU-T ACR (Absolute Category Rating) scale, see [4]: 5: *Excellent zapping quality*, 4: *Good zapping quality*, 3: *Fair zapping quality*, 2: *Poor zapping quality*, 1: *Bad zapping quality*.

The main result of [1] is an explicit relation between the user perceived QoE and the zapping time. From this relation it was deduced that in order to guarantee a MOS of at least 3.5, which is considered the lower bound for acceptable quality of service (see [4]), we need to ascertain that the zapping time is less than 430 ms. Note that for MOS = 3.5 the average user will detect a slight degradation of the quality of the considered service. The requirement on the zapping time mentioned above is currently not met in any implementation of IPTV (see, for instance, [5] and [6]).

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In [7], new subjective experiments were described where the zapping took place under different conditions. These experiments included ‘lean backward’ zapping, that is, zapping while sitting on a sofa with a remote control. The subjects are more forgiving in this case and the requirement for acceptable QoE could be relaxed to 670 ms. In addition, [7] reports on subjective experiments where the zapping times were varying. It is found that the MOS rating decreased if zapping delay times were varying.

The research program on QoE and zapping continued based on the observation that in order to increase the QoE of channel zapping, two approaches are possible. In the first approach, the actual zapping time is reduced. An example of this method is given by Degrande et al. [8]. They suggest to retain the most recent video part in a circular buffer and display this video until the incoming channel is ready.

In the second approach, the QoE is (possibly) increased by showing information while the user waits for the target channel to appear. The displayed information could be about the target channel, personalized content or advertisements (see also [9]). Subjective tests following the second approach have been described in [10]. The main conclusion of [10] was that by showing advertisements during channel zapping, instead of the usual black screen, users rated the experience higher, at least for realistic values of the zapping time.

Kooij et al. [5] extended the results of [10] in the following way: the number of persons that participated in the subjective experiments was increased from 12 to 30, the measurements were added that provide insight about zapping times for today’s digital television services, and a completely new section was added about how the finding of this research could be used to design a system for optimal zapping experience. This system for optimal zapping experience has two patents pending.

The aim of this paper is to assess the QoE of channel zapping when, during zapping, the user is offered interactive content in the form of a game, instead of the usual black screen. To our knowledge, this paper is the first ever that deals with interactive content during zapping.

The rest of this paper is organized as follows. In Section II, the possible effect of gaming on IPTV perceived quality is analyzed and various factors that contribute to the results are listed. In Section III the experiment performed to quantify the user perception is described. In Section IV, the results obtained from the subjective tests are presented. Finally, conclusions are given in Section V.

II. QUALITY OF EXPERIENCE AND GAMING

Using content such as advertisements or gaming during IPTV channel zapping is an approach that tries to increase the QoE while the service quality or zapping time remains unchanged. Obviously, not all people would be happy to see advertisements during zapping. People are probably more open to gaming during zapping because through a game educational or entertaining content can be presented. Although the business driver for advertisements seems of high impoprtance we anticipate that gaming during zapping can also boost the QoE, in two different ways.

a) Users playing games during channel zapping, will not be bored with the longer zapping times. Hence the QoE of the users for the channels with games could increase with respect to the black screens. This is actually what we have measured in the conducted subjective experiment.

b) The second consequence is that the providers might earn money from these games, through a similar business case as apps for smart phones. Therefore, they can lower the price of the service. Obviously, a lower price is one of the factors that can boost the QoE.

It should be noted that the effect of games (if they were implemented) on QoE is not just straightforward. Rather, it depends on various factors, which could affect the QoE positively or negatively.

a) The type of game: A particular user could like some sort of game and dislike other type of games.

b) The difficulty of the game, in relation to the length of the zapping time. For example, if the zapping time is very short, then it is probably not even possible to play the game, hence a game in this scenario could be quite annoying. On the other hand, if the zapping time is very long and the game is too simple, users may not be challenged enough to appreciate the game.

c) Obviously, the game that is offered to the user should not be exactly the same all the time. Probably it is best to offer different variations of the same game to the users.

Some of the factors above could positively affect the user perception. However, the implementation complexity also increases if all these issues are to be properly addressed. The best approach to use these games is to select a game randomly from a set of pre-rendered games stored in the Set-top Box (STB) when the user zaps to a different channel. It is recommended to use games that the user likes. Using pre-rendered games is important because the zap screen can then be displayed immediately.

III. THE EXPERIMENT

A. *Design of the experiment*

For the TV channel zapping experiment, a HTML page containing two frames is implemented. Through the lower frame the user can switch between 5 different TV channels. The TV channels are implemented as Flash files in the upper frame of the HTML page. The TV channels contain the following content: a dancing girl, a cartoon, three men in a suit, a room service scene and a dancing man.

Figure 1 shows the HTML page with the dancing girl channel being on. Although the Flash files contain audio, sound is switched off during the experiments. Audio might be added to the experiment but the synchronization problem will be another cause for quality degradation. So, to assess the quality experienced for zapping times, we felt it is better to make the experiments with no sound, because otherwise the test subjects opinions might be biased by the synchronization quality. The videos within the upper frame are displayed in a screen of size of 550x400 pixels.

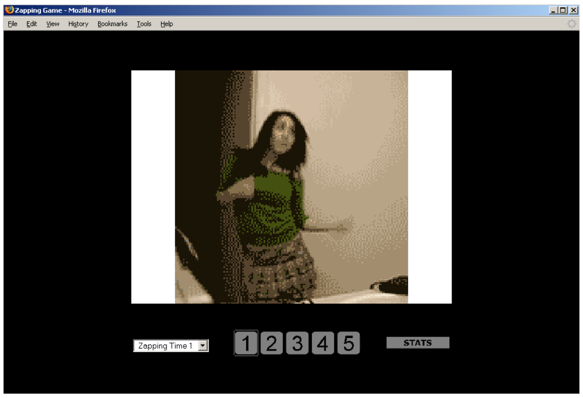


Figure 1: HTML page used in the experiment

In the experiments reported in [1] and [10], seven zapping times between 0 and 5 second were implemented in arrays in the javascript code. These zapping times were 0, 0.1, 0.2, 0.5, 1, 2 and 5 seconds. Moreover, a random ordering of these zapping times was implemented for each of the test subjects that participated in the subjective experiments. The number of test subjects in [1] was 21 while 12 test subjects participated in [10]. Additional subjective experiments with 18 test subjects, including also the zapping times 3 and 4 seconds, were reported in [5].

When the user zaps to a new channel, the page sleeps for a time corresponding to the implemented zapping time before the requested channel is displayed. During this time, either a black screen is shown [1], [7], or an advertisement [5], [10]. This paper assesses the impact of having an interactive game on display during channel zapping. The game consists of a traffic situation where the user has to determine whether or not it is allowed to follow the direction that is indicated by the arrow. The perspective of the user is that of the driver of the car in the bottom of the picture (see Figure 2).

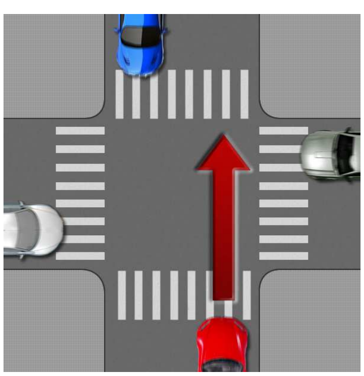
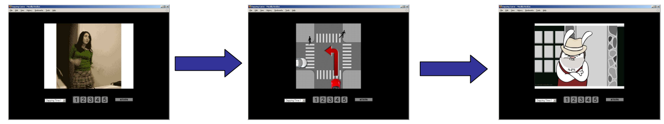


Figure 2: Example of a game situation

The chain of events is depicted in Figure 3. All games situations are depicted through pictures of size 400x400 pixels.



Original channel　　Game during zapping　　Target channel

Figure 3. Showing a game during zapping

For the experiment the zapping times were 0.5, 1, 2, 3, 4 and 5 seconds. We left out some of the original zapping times used in [1] and [10], in order to keep the length of the test sufficiently short, thus preventing fatigue of the test objects, and because zapping times of 0.1 and 0.2 seconds are presumably too short for interactive gaming.

B. *The actual experiment*

In this subsection, we describe the details of the subjective experiment. The test subjects consist of a total of 21 people at TNO in Delft, the Netherlands and at the second author’s house in Breda, the Netherlands. The test subjects vary in age (17 – 57 years), gender (14 male, 7 female) and experience. According to [4] at least 15 observers should participate in subjective testing of multimedia services. They should not be directly involved in quality assessment as part of their work and should not be experienced assessors. These conditions are met for the group of test subjects.

To view the channels a laptop (Core i3, 4GB RAM, windows XP, 1600x900 pixels screen resolution) is used as a TV set. The experiment that we have conducted is of ‘lean backward zapping’ type. That means the user will sit back in a chair and use the remote control to zap between the channels. A Sony Ericsson w660i with the Bluetooth Human Interface Devices (HID) protocol implemented on it, is used as a remote control device. The mobile phone is depicted in Figure 4.

Figure 4: Sony Ericsson w660i used as remote control

Through the HID protocol, pressing the buttons 1 to 5 on the phone realize a channel switch to the corresponding channel on the HTML page. In order to play the game that is shown during zapping, the user needs to press the upper right button of the phone when he/she thinks it is allowable to

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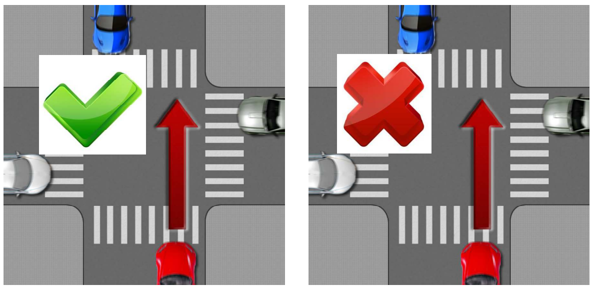
drive the car in the indicated direction. If he/she thinks it is NOT permitted to drive the car, the upper left button needs to be pressed (see also Figure 4). After the test subject has presses one of the two buttons, visual feedback is given by displaying either a "check symbol" (correct answer) or a "cross symbol" (incorrect answer) on top of the depicted traffic situation (see Figure 5).



(a) correct (b) incorrect

Figure 5: Feedback on user input

The experiment contains two parts, the training and the actual experiment. The training part is intended to familiarize the subject with the test environment. The training starts with a situation requiring immediate zapping, that is, a situation corresponding to MOS = 5. The test subject can switch between channels by pressing the buttons numbered 1 to 5 on the mobile phone.

In the second part of the training, the test subject is offered a situation with very long zapping time (i.e., 5 seconds), where during zapping a black screen is shown. This situation corresponds with MOS = 1.

In the third part of the training, the test subject is offered the traffic game during zapping. The aim of the game is to determine for each offered traffic situation whether the car can drive in the indicated direction or not.

After the test subject has switched channels a number of times (approximately ten times) he/she then presses the "stats" button (see Figure 1) to reveal the score of the games played by the test subject. An alert box then appears, containing the statistics of the gameplay (see Figure 6).

Note that it is possible that the number of zaps is larger than the sum of "number of correct answers" and "number of wrong answers", namely when the test subject was too late to press one of the answer buttons during zapping.

At this point, the test subject is ready to start the actual experiment. Below we show the literal text that is presented to the test subjects, who first had to do the 'black screen' scenario, and then the 'game' scenario.

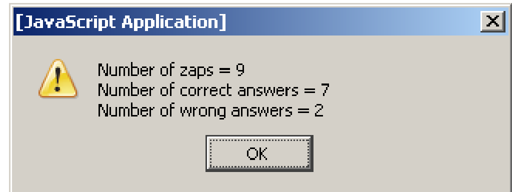


Figure 6: Statistics of the gameplay

<u>Black screen</u>

1. In this paper form, fill in your name, age, your experience with gaming and SMS and the date
2. Write down in this paper form the Scenario (for "black screen") you are in. You can see this in the URL in the Firefox browser
3. Select "Zapping Time 1" in the drop-down list on the left-bottom of the screen. Experience the zapping time, by pressing on the buttons numbered from 1 to 5. Try to do a total of about 10 zaps.
4. Write down your MOS value on the table shown on the form.
5. Then, select "Zapping Time 2" in the drop-down list, repeat steps 3 and 4, until you have assessed all 6 Zapping Times.

<u>Game</u>

6. Write down in the paper form the Scenario (for the game) you are in. You can see this in the URL in the Firefox browser
7. Select "Zapping Time 1" in the drop-down list on the left-bottom of the screen. Experience the zapping time, by pressing on the buttons numbered from 1 to 5. Also try to play, during the zapping, the game. Try to do a total of about 10 zaps. When that is done press the "stats" button.
8. Write down your MOS value in the table shown on the form. Also write down the statistics from the alert-box.
9. Then, select "Zapping Time 2" in the drop-down list, repeat steps 3 and 4, until you have assessed all 6 Zapping Times.
10. If you want to, you can write general comments in the box on the bottom of the form.

The order of the six zapping times (0.5, 1, 2, 3, 4, 5 seconds) was randomized into four different orders (denoted by A, B, C and D). Each test subject was offered a different order for the 'black screen' scenario and the 'game' scenario.

IV. RESULTS

A. *MOS results*

The results obtained for each zapping time are analyzed and averaged over the number of test subjects to obtain the

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MOS for each zapping time. This is done for both the 'black screen' and the 'game' scenario, that is, the case where, respectively, during zapping a black screen is shown and the case where the game is shown. The obtained MOS scores, together with their 95% confidence intervals, are shown in Figure 7.

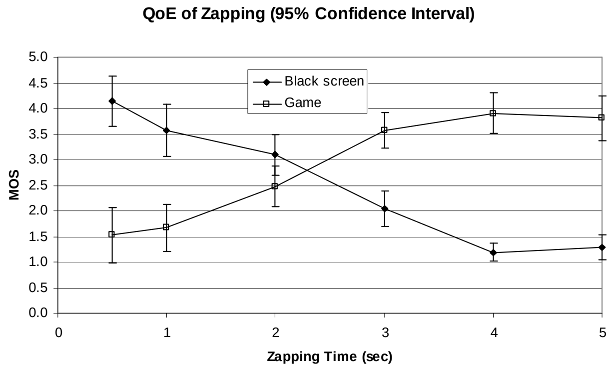

Figure 7: MOS for "black screen' and 'game'

The following important insights can be obtained from Figure 7:

- The MOS for 'game' exceeds the MOS for 'black screen' for zapping times greater than about 2.25 seconds. This implies that the users prefer 'game' only when the zapping time is sufficiently large.
- For zapping times larger then about 3 seconds the MOS for 'game' is larger than 3.5, indicating the onset to acceptable quality.
- For zapping times below 1 second the MOS for 'game' is very low, indicating that it is a bad idea to show games in case of such short zapping times.

B. Comparison with previous results

The 'black screen' experiment was conducted before, see [1]. The authors of [1] suggested the following model for the relation between zapping time (in seconds) and QoE (expressed in MOS), for the 'black screen' case:

$$MOS = \max\{1, \min\{-1.02 \cdot \ln(ZappingTime) + 2.65, 5\}\}\,. \quad (1)$$

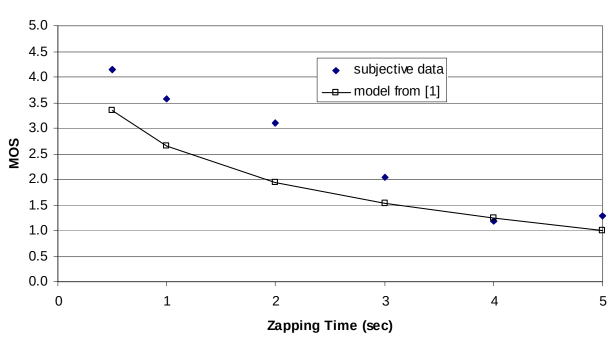

Figure 8. Comparing our 'black screen' results with the model from [1]

It is clear from Figure 8 that our new subjective data is much more optimistic than that predicted by model (1), especially for zapping times smaller than 4 seconds. We can think of three possible explanations for this. First, the experiment reported in [1] was 'lean forward', while our experiment was 'lean backward'. It is known from [7] that this leads to higher MOS scores. Secondly, the zapping times offered to the test subjects in [1] were on a logarithmic scale (0, 0.1, 0.2, 0.5, 1, 2, 5 seconds) while for our experiment we basically used a linear scale. This possibly might lead to a bias in the form of lower MOS scores for small zapping times. Finally, the tests described in [1] were conducted in 2006, while our tests took place in 2011. People may have become more accustomed to zapping times in the order of 1 to 3 seconds in the last five years.

In [5] and [10], we have also assessed the QoE for zapping in case advertisements were shown during channel switching. These experiments, using the same zapping times as in our experiment, took place in 2009, therefore we feel we can compare the results from [5] and [10] with our new results, see Figure 9. Note that the performance evaluation of the advertisement scenario did not take the reduction of user's cost into account.

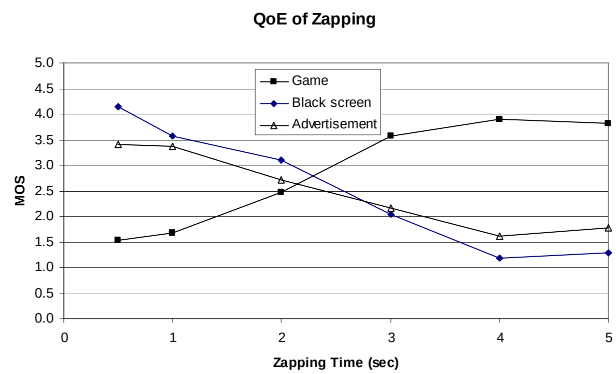

Figure 9: MOS for "black screen', 'game' and 'advertisement'

We conclude from Figure 9 that the 'advertisement' scenario never performs better than both the 'black screen' and the 'game' scenario at the same time. Note that it was anticipated in [5] that there could be a regime for which the advertisement scenario would be preferred but this is not reflected in Figure 9.

C. Results on ease of play and game score

As explained in Section III.B, we have also assessed the ease of play and the scores of the game played during channel zapping. The ease of play is quantified as follows. For each test subject we know, for a given zapping time, the total number of zaps (Z) and the number of correct (C) and the number of incorrect answers (I). The ease of play for this test subject and zapping time is defined as (C+I)/Z*100%. The overall ease of play for this zapping time is obtained by averaging this quantity over all 21 test subjects. In a similar way the overall game score is obtained by averaging the quantity C/Z*100% over all 21 test subjects. The results are depicted in Figure 10.

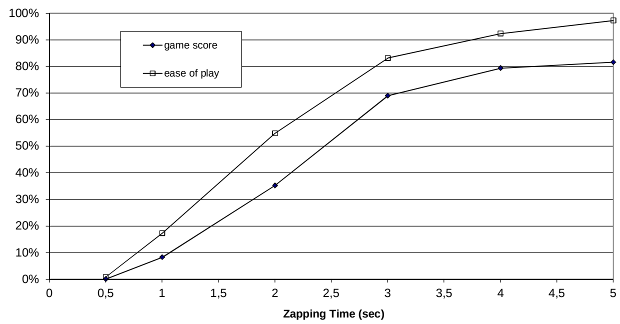

Figure 10: Ease of play and game score

It is clear that for small zapping times the ease of play is much too low. For instance, for a zapping time of 1 second, only 18% managed to play the game in time. Around zapping times of 3 seconds the ease of play becomes higher than 80%. The game score curve shows an s-shape with the inflection point around 2.5 seconds. At zapping times of 5 seconds the game score is as high as 82%. It is interesting to notice that the percentage of incorrect answers remains more or less constant at 18% for zapping times larger than 2 seconds.

D. Discussion on user comments

In addition to evaluating the MOS and keeping their gaming scores, users were asked to comment on the subjective experiments. The following are the main comments of the users.

a) More than 50% of the test subjects made comments on the positions of the “correct” and “incorrect” buttons on the mobile phone. As on most mobile phones the upper left button is green and the upper right is red, indicating some positive action (e.g., making a call) or negative action (e.g., terminating a call), they might have found it more intuitive if the “correct” and “incorrect” buttons would have been placed the other way around. A few test subjects remarked that the buttons on the mobile phone are too small to make the gameplay enjoyable.

b) A number of test subjects mentioned that for small zapping times it becomes impossible to play the game, which leads to irritation. Some suggest that it is better in these cases to show a black screen instead of the game. Of course this is completely in line with the system for optimal zapping experience we have suggested in [5].

V. CONCLUSIONS

From our conducted subjective experiment, it is found that for zapping times greater than 2.25 seconds, offering games during zapping instead of the usual black screen leads to a better QoE. For zapping times larger then about 3 seconds, the MOS for the ‘game’ scenario is larger than 3.5, indicating the onset to acceptable quality. For zapping times below 1 second the MOS for the ‘game’ scenario is very low, indicating that it is a bad idea to show games in case of such short zapping times. The scenario where during zapping advertisements are shown, is always outperformed by showing either the ‘black screen’ or ‘game’ scenario.

For small zapping times the ease of play is much too low. For instance for a zapping time of 1 second, only 18% of the test subjects managed to play the game in time. Around zapping times of 3 seconds the ease of play becomes higher than 80%. The game score curve shows an s-shape with the inflection point around 2.5 seconds. At zapping times of 5 seconds the game score is as high as 82%.

The results obtained in this paper are useful when implementing a system for optimal zapping experience, which is described in [5]. In the near future we want to implement the system in a field trial and conduct further subjective experiments with the system, taking into account longer time scales, i.e., we will assess QoE after a period of, for instance, 3 months. Finally, we suggest that the system might be adapted to function as a broader ‘System for Optimal Waiting Experience’. Hopefully this inspires others to improve the quality of experience in our day-to-day activities.

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