I-Vote: An Audience Voting System

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Abstract
In this paper, we describe the I-Vote system for audience response voting at the Olympic Games. The audience members vote by using a $2 handheld device that they can keep as a souvenir. The devices are simple to use, come in multiple designs, and are tradable. These devices do not hold any personal information so privacy is never an issue. The vote results are presented on a large public display, which is loaded with information in the form of graphs that are quickly understood. People can retrieve their personal votes later on the Internet. The system was designed through a process involving brainstorming, creating scenarios, searching for information, doing cognitive walkthroughs, developing prototypes, and revising and refining ideas.

Categories & Subject Descriptors: H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – prototyping, user-centered design; B.4.2 [**Input/Output and Data Communications**]: Input/Output Devices – image display; H.1.2 [**Information Systems**]: User/Machine Systems – human factors; D.2.m [**Software Engineering**]: Design Tools and Techniques – rapid prototyping, user interfaces.

General Terms: Design, Human Factors.

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INTRODUCTION
Mr. and Mrs. Bial pick up their tickets to the Floor Exercise event and are handed two voting devices with their tickets. "Where do we return them when we are done?" asks Mr. Bial. "Oh, you can keep them as souvenirs! The instructions are on the back, in French, English, and Greek. Enjoy your day," replies the attendant. As usual, the couple is running late. They walk in to the stadium just as a Korean athlete finishes his floor exercise. Seconds later their voting devices begin vibrating and the large public display board indicates it is time to vote. Mrs. Bial watches the replay of the last contestant and decides to give Joo-Hyung Lee 3 out of 5 via her device. Mrs. Bial notices that the 3 remains lit on her device and glances at her husband's. He shows her his vote was a 4. Suddenly all the numbers on the devices flash briefly and then stop: the voting period has ended. The couple watches the display board as it continues to count the votes and take the judges' scores. In the end, the audience agrees with Mr. Bial. However, the judges agree with Mrs. Bial, giving Joo-Hyung Lee a lower score.

Later, back at the hotel room, the kids return. They have their voting devices too. The image on Jorgè's device shows the Olympic mascots wrestling. "Hey Mom, tomorrow, can you get me a volleyball one?" asks Maria. "How do I do that?" asks Mrs. Bial. "Trade them! Swap with someone else." "Hey Look. I just checked on the website. Here are the votes I cast. I should give Grandma my device's identification number so she can see that I gave her favorite athletes high scores."

Audience participation during Olympic events is currently limited to applause. Official judges are the only ones who give scores. Recent allegations of score fixing [4] have left audiences feeling cheated and alienated. There is a need to reengage the audience. The current state of the art leads one to believe that technology could intervene and enhance the audience experience through increased participation. Audience polling and voting systems exist for use in small scales. To what extent could an audience voting system be implemented in a large capacity stadium as found at the Olympic Games? To test the feasibility, a pilot system (I-Vote) is proposed for the Summer 2004 Olympic Games in Athens, Greece. I-Vote must embody several key aspects to be successful.

The 5 parts of the I-Vote system are 1) thousands of wireless handheld devices, 2) numerous receiver nodes placed equidistant throughout the stadium, 3) a server that collects and compiles the data, 4) a large public display, and 5) a database that can be accessed from the Internet.

THE PROBLEM
Commercial audience response systems like Meridia® and Quick Tally® exist but are limited to small audiences in a specific environment. The Proteus® system that will be

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used to poll the audience at the Super Bowl [6] is designed for a specific stadium. These systems leave many problems to be solved such as scalability issues, social issues, human-computer interaction issues, and cost. Each of these issues is described in detail below.

Scalability

I-Vote must accommodate large audiences in a wide variety of indoor and outdoor facilities.

Crowds ranging from 15,000 people for a given event up to 75,000 people at the opening and closing ceremonies must be able to vote. Some event locations do not have seats to which voting devices can be attached. Also, some of the events are outdoors. For all these reasons, the personal voting devices must be handheld and need to be wireless so that they do not restrict movement within the sporting arena.

Social Issues

I-Vote will be anonymous so that the votes cannot be tracked back to a person. Unlike the IntelliBadge™ system [1], no personal information will be taken for any part of the system.

People who visit the Olympics enjoy collecting souvenirs and mementos from the events. The voting device will also act as a souvenir. The different patterns/designs on them make each a collectible item and keep people involved in the whole system.

Human Computer Interaction Issues

The main Human Computer Interaction (HCI) issues identified by the I-Vote team were accessibility, ease of use, intuitiveness, and understandability of the feedback. For accessibility, people of a wide range of ages, nationalities, languages, and physical abilities must be able to use and interpret the handheld device and the public display. Ease of use demands a simple interface [2,5,7], intuitive usage that is easy to learn [2,5,7] and can be understood just by glancing at it [2,5,7], comfortable to hold, and an ergonomically sound device. The comparative visualization should be informative without taking the attention away from the athletes and events that the people came to see. Universal usability issues were considered in designing the various interfaces and the system as a whole.

Cost

The complete I-Vote system and implementation costs must be within the hundreds of thousands of dollars range rather than in the millions. The system should not demand a high investment for infrastructure. Since the handheld devices are going to be given away to the people who will use them, they need to be designed to be very inexpensive and still accomplish the essential task. The infrastructure should be reusable in other games and events. The wireless network should be able to handle inputs from tens of thousands of people at one time and process that information in real time.

THE I-VOTE SOLUTION

In this section, we describe the I-Vote system and how it solves the problems mentioned above. The 5 parts of the I-Vote system are:

1. Wireless handheld devices
2. Receivers
3. A server
4. A large public display
5. A database that can be accessed from the Internet

Each member of the audience is given a pocket-sized personal device that vibrates when voting for an event is permitted[1]. These handheld devices are equipped with 5 easy-use buttons, simple light emitting diode (LED) feedback, and a radio frequency (RF) transmitter.

Receivers must be positioned within 10 meters of all seats [3]. The receivers collect the votes for their section and pass them to the server. The server combines all scores and sends the results to a large public display board. The data visualization of the public display is packed with easy to read information. Our solution is simple, easy to use, inexpensive, efficient, and durable.

Detailed Description

Handheld Devices

Each handheld device is 3.5 inches wide by 2.5 inches long by 0.25 inch thick (or 8.9cm X 6.4cm X 0.6cm) and weighs approximately 0.5 ounces (14.2 grams). See Table 1 for more information.

The device is made out of molded plastic with a printed front. The "collectable" souvenir image on front depicts the official Olympic mascots playing various sports (Figure 1). There are 5 easy-push buttons in the Olympic ring arrangement. 1 is a low score, 5 is a high score. The number entry mechanism has very few moving parts (only 5 buttons), making it more durable and easier to use. An Olympic ring of 1-inch diameter (2.54cm) surrounds each button. The area beneath the LED lighted number is the actual button. The back of the device has a sticker containing instructions in several languages as well as the device's unique identification number and a URL for accessing personal vote information online.

Table 1. Additional details about the handheld devices as described by [2].

Power:	0.9 – 1.5 volts
Connectivity:	RF (433-434 MHz)
Bandwidth:	25 Kbps
Range:	10 meters indoors
Battery life:	Up to 2 years
Application protocol:	48 bit identification number 3 bit vote

[1] The voting period is also indicated on the large public display board.

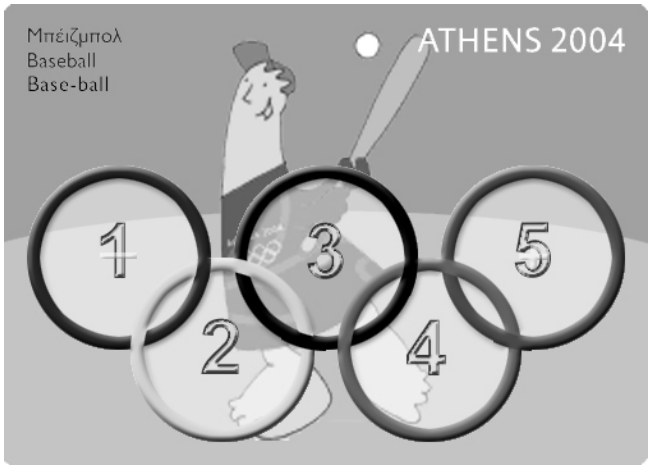

Figure 1. An example voting device as collectible souvenir. The device has 5 buttons featuring LED numbers and tactile navigation. The background in this example shows the official mascot for the Baseball event.

The devices are handheld and are small enough to fit in a pocket, but large enough not to get lost [1]. Each device is small and unique enough to not be misidentified as a potential explosive device. Each device is wireless and acts as a transceiver (it transmits and receives messages).

For most adults, these devices can be operated with one hand. After practicing a few times, the staggered button layout can even be operated without looking at the buttons. The buttons 1, 3 and 5 have a raised minus sign, full stop, and plus sign respectively to provide tactile navigation.

The cost of the device is kept at a minimum by the few moving parts and the fact that there is no display on the individual devices. All feedback is through the LED's and the public display. The public display will indicate when people are allowed to vote and simultaneously the devices will vibrate and blink. The LED's also indicate that the individual's vote was sent.

Receivers

The I-Vote handhelds will use the ZigBee® protocol for wireless communication. Each device has a transmission range of about 10 meters, requiring the receivers to be stationed throughout the seating area at approximately 16-meter intervals for consistent coverage. The receivers are connected to the server via a standard Ethernet network.

Server

The server tabulates all the votes. The server software normalizes and averages the judges' scores and the audience's votes. The software then produces the visualization. The server will most likely be a Linux system with a dual processor with custom software.

Large Public Display Board

All the Olympic stadiums are furnished with large scoreboards that display public information (e.g. the commercial JumboTron® system). I-Vote takes advantage of this large public display board (Figure 2) and expands its use.

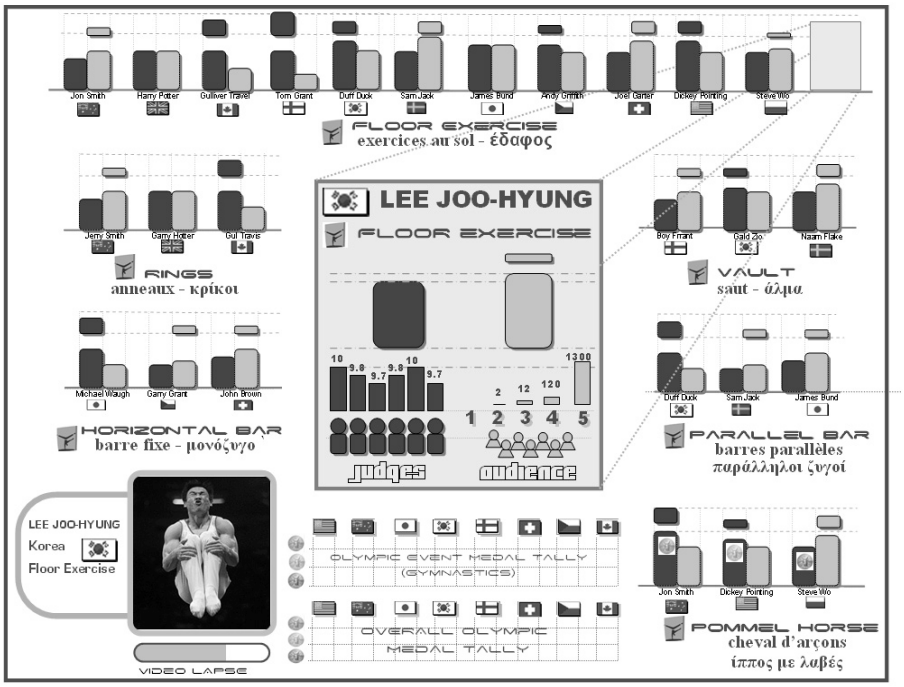

Figure 2. I-Vote's large public display. The audience voted slightly higher than the judges' for Lee's performance in the floor exercise.

The votes are collected in real time and displayed on the board. The events are listed along the sides of the display. The event that has just finished and is open for voting moves to the top and expands to show all the competitors for this event. The individual competitor's section is brought to the center of the board and becomes the focus (Figure 2 and the poster). The bottom left section of the display is reserved for a 30-second video replay of the event currently being scored. The video lapse bar indicates the amount of time remaining to vote.

The display is in the official Olympic languages (English and French) and the host country's language (Greek).

The center of the display also contains graphs. The scores and the votes are displayed side-by-side. Above these 2 graphs is a third graph with the normalized results. Dotted lines display the differences between judges' scores and the audience's votes. This difference is also indicated by a small chunk above one of the graphs. Whichever group voted higher has this chunk above their graph.

When the voting is over, the center section shrinks back to its official spot (indicated by the converging dotted lines).

Internet Accessible Database

When the fans return home, they can recall their visit to the Olympics by visiting the official Olympics website http://www.athens2004.com. There the fan can enter the unique identification number (from the back of their souvenir voting device) and check their votes.

Additional Features of the I-VOTE System

Alerting the User to Vote

A "go" signal originates with an official person sending a message to the server. The server then sends the message to the receivers who send it on to the handheld devices. The "go" signal results in a single short vibration in each of the handhelds, similar to the vibration of cell phones. This vibration (along with the changes on the public display) alerts the user that it is time to vote. The person can see which event is being voted on by looking at the large public display unit.

Single Button Submission

In order to increase the ease of use and attractiveness of the design, the input was limited to 5 buttons. A score is submitted by the push of a single button. A person can change their mind or correct a vote simply by voting again. When multiple votes for a voting period are received from a single handheld device, the last vote received is final. This also eliminates the problem created when a handheld's message is picked up by multiple receivers.

Immediate Feedback

The receivers send a "received" message back to the individual handheld units lighting the LED under the appropriate button. This 2-way communication allows for faster feedback to the user.

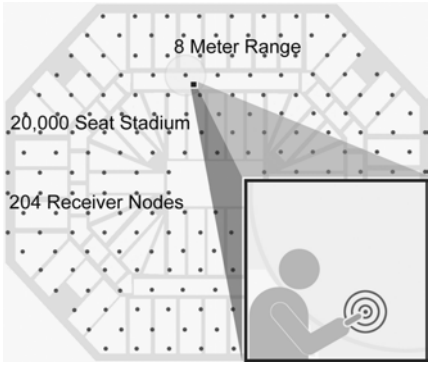

Figure 3. This diagram shows a generic stadium. Handheld devices send the vote. Receivers (displayed as dots) are placed every 16 meters.

Reduced Cost per Handheld Unit

With I-Vote's simplicity, the handhelds will cost approximately US$2 per unit. This could be added to the price of a ticket to help offset system costs. However, the increase in ticket price would be negligible.

Estimated Cost

We estimate 100 handheld devices per receiver and 204 receiver nodes for a 20,000 capacity stadium. We based these figures on Madison Square Garden's measurements of people per square feet. We estimate the server cost to be approximately US$10,000 and the specially designed software to be around US$5,000. The handheld devices are estimated to cost US$2 a piece. The receivers are estimated to cost US$20 each based on current prices of home Wi-Fi® access points.

DESIGN PROCESS

The I-Vote team spent many hours brainstorming, creating scenarios, searching for information, doing cognitive walkthroughs, developing prototypes, and revising and refining ideas. For simplicity, we will describe the design process of the handheld voting device, but keep in mind that we were simultaneously developing the entire system and that each choice we made influenced the other parts of the system.

During the brainstorming stage, the team considered numerous designs of the input devices including built-in devices, anchored devices, returnable devices, rechargeable devices, devices with ticket scanners, voting kiosks, and raising hands. All these were ruled out with scenarios of people moving around during long events, people of different heights, and varying seating situations for different stadiums. The raising of hands was ruled out when we tried to count more than 20 people at a time.

We ultimately decided against any anchored device for several reasons. Anchored units would mean that people would have to be at their seats in order to use them. Most events last several hours, and people must be able to move around. Anchored units would also be more difficult to

design for usability (what height would allow people to sit or stand? would anchored devices interfere with people getting to their seats?). The stands for the gymnastics events are built differently than the seating around the swimming pool. These differences would mean that the units would be mounted on the seats differently in each building, which would increase cost, increase possible design problems, and confuse the user. Based on these observations, the wireless, handheld device became the best option.

Through more scenarios we decided that people would want to use the handheld devices in multiple events. Scenarios also influenced the decision to make the devices as collector's items. Our research into the IntelliBadge™ system [1] backed up our decisions on size and cost of the devices.

A calculator-like interface was ruled out because it had too many buttons. Scores were originally assumed to be 1-10 including scores with decimal points. We also considered a movable dial or slider. Finally we decided that buttons are the least likely to break and are less confusing to the user. Entering numbers was made simpler when we eliminated the use of decimal points and the need for an "enter" or "submit" button. For these handheld devices, we created a list of basic requirements and then developed numerous paper prototypes before we settled on the very basic 5-button collectable souvenir device. We then made a physical prototype out of a man's wallet and quarters. Eventually we created cardboard prototypes for each of the team members to "try out." See our poster for digital photos of the "try out" session and many of other aspects of the design process.

Miscellaneous Aspects of the Design Process

The communication between members started with email, but was mostly to face-to-face complemented with computer-mediated communication and file-sharing. The hardware we used included laptop computers, digital cameras, and scanners. Two large whiteboards were indispensable to every stage of our design process. The applications we used include: Adobe Photoshop, various web browsers, Microsoft Word, scanning software, instant messaging software (to transfer information between co-located computers), Adobe Acrobat, and various file transfer methods. We created paper printouts and used many different materials for our prototypes.

References to Design Principles

Scenario-based design, cognitive walkthroughs, and the creation of prototypes are generally accepted methods for designing new systems [7].

ACKNOWLEDGEMENT OF PARTIAL OR INCOMPLETE SOLUTIONS

The system presented here centered mostly on the interfaces with the public. The technical information with the hardware specifications and database design is more appropriate for a technical report rather than a paper for CHI. The interfaces we created were very specific for the 2004 Olympics in Athens including the images and colors used for the handheld devices. All of the designs got to the cardboard prototype stage and not beyond. Before implementing any part of this system, working prototypes should be created and tested. From our reading of the existing commercial systems, the wireless radio frequency combined with the Ethernet network should work, but our team has not tested this. Our estimates for the cost of the system are just that: estimates.

CONCLUSION

The I-Vote system concentrates on the 2 user interfaces: the voting device and the scoreboard. The voting device is a simple solution for an input device. While the device itself is display-less, the lighted numbers and vibration give feedback. The scoreboard is the information center for the more complex communication. The I-Vote team developed several prototypes of both interfaces.

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