Design of a Smart TV Logging System Using Beacons and Smartphones

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Abstract
In this paper, a smart TV logging system comprising a beacon system and smartphones is proposed. To investigate the feasibility of our strategy, we designed and implemented a prototype system and conducted a trial study. The study results show that the prototype can unobtrusively capture viewers' various events embedded in TV viewing behavior. The results of the study also suggest that the proposed method allows more robust and accurate data to be collected than do the TV viewing behavior analysis approaches used in existing qualitative research studies, such as surveys and interviews.

Author Keywords
TV viewing behavior, Smart TV, Beacon, TV rating, Audience measurement, Indoor Location-based services

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Introduction
TV rating is often measured by traditional research methods such as *People Meter* [6], surveys, etc. However, the capability of existing methods to observe and measure viewers' behaviors is limited, since they are obtrusive. Recognizing a viewer's behavior pattern could benefit both viewers and TV rating firms: viewers can receive a personalized service based on sophisticated observed data, while TV rating firms can

collect more precise data to build enhanced business models.

To address the issue, we design a novel system for observing the viewer's behavior when located in front of a TV by using a smartphone and Beacon [2]. In this research, we are motivated to use common digital devices to collect TV viewing behavior robustly and unobtrusively. We also collect app usage logs to investigate a person's multi-tasking activities on his/her smartphone while viewing TV. To verify the feasibility of our strategy, we conducted a trial study in a single-occupant household. The results show that a viewer's accurate location can be measured unobtrusively using smartphones and Beacon technology.

Related Work

Earlier approaches to research on TV viewing behavior
TV viewing behavior has been investigated by many researchers and organizations. Abreu et al. examined the TV ecosystem through a survey in order to understand people's TV viewing behavior when simultaneously using smart devices [1]. Ericsson Consumer Lab conducted an annual TV and Media study using quantitative and qualitative methods. In the study, the lab interviewed 23,000 people in 23 countries via online surveys and performed in-depth interview with 22 people in San Francisco, London, and Stockholm. They also interviewed 11 experts in the media industry [3]. However, survey methods have limitations in that the collected information does not suffice for investigating complicated behavior patterns.

A number of research studies have, however, been conducted to investigate viewers' behaviors by using digital devices. The analysis of log data generated by these digital devices allows researchers to measure audience activities beyond only the TV medium, broadening measurements to include the multi-screen experience and various other media systems [8, 9]. Among these devices, the people meter has been regarded as the de facto standard tool for measuring TV ratings [5].

People meter
The people meter is an audience measurement tool invented by a British company called Audits of Great Britain Ltd. (AGB) to measure TV viewing behaviors. It is an electronic device that records when media are being used and who is viewing them. Members of participating households can transmit information about their TV viewing activities by pushing a button on the device. By collecting logs obtained through these devices, rating firms can observe and analyze behavior patterns in households. However, the people meter can introduce bias and noise in the gathered logs. The device has a simple push-button interface for collecting the viewer's status and information. Because of fatigue or ignorance of registering their behavior, viewers may avoid participating in the measurement system [6]. Thus, more unobtrusive systems that do not force viewers to participate have been developed, as follows.

Portable People Meter and audio matching technology
The Portable People Meter (PPM) is an electronic device developed by the Arbitron Company to track audience's exposure to broadcasts, cable TV, and many types of digital media. Inaudible signals hidden in broadcast signals are detected by the PPM or software that can be downloaded to a mobile device. Unlike the people meter, this portable device can be carried around all day and therefore can unobtrusively track viewer's exposure to all media by analyzing the inaudible signals [4]. However, the auditory measurements contain potential biases due to environmental features. For instance, although a person is not viewing TV, the system can regard his/her behavior as viewing TV because of errors in the detection signals. In addition, auditory signals can be disrupted by noise in the person's environment. Thus, more robust measurement systems to collect TV viewing behaviors need to be established.

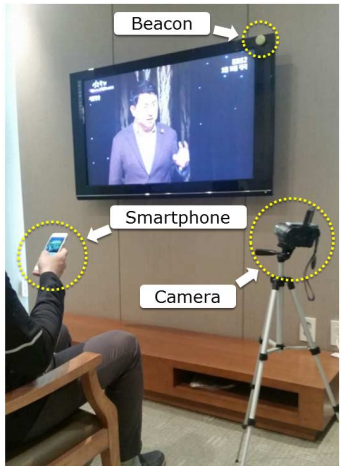

Figure 1. A prototype of Smart TV logging system

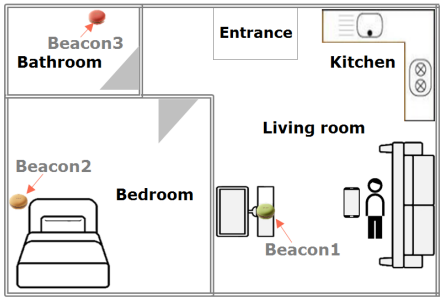

Figure 2. The deployment of Beacons for the trial study

Design of a Smart TV Logging System

In this paper, we propose a smart TV logging system that is capable of precisely detecting the TV viewing activities of each individual in a household. People meter-based survey methods have limitations in the following cases.

- A viewer is outside the TV watching zone, but the TV is not turned off.
- A new viewer does not register her/himself as a viewer when another person is already watching the TV.
- A viewer is not watching TV although s/he is located in front of it.

In order to address these issues, we designed a system that comprises a beacon system and smartphones. Figure 1 illustrates the research prototype system we designed. The system procedures include: 1) collecting the TV content information by recording the TV screen; 2) checking the location of the study participants through installed multiple beacon devices[1], as shown in Figure 2; and 3) gathering the smartphone usage logs by using the *App Usage Tracker*[2].

The beacon system is a short-range communications technology for a next-generation smartphone that uses BLE. The technology can determine a user's location with an accuracy of a 1-m margin of error in an indoor environment. The use of beacon systems in indoor environments such as shopping malls is widespread. As shown in Figure 2, using beacon signals, researchers can accurately determine viewers' locations when they carry a smartphone. The fact that a smartphone can receive beacon signals without a pairing procedure allowed us to design the unobtrusive system that we propose in this paper.

The system assumes that people carry around their smartphones in the house. According to the Nielsen Cross-Platform Report of 2012 [7], 85% of tablet/smartphone owners use their device while watching TV at least once a month, while 40% do so daily. The survey implies that the design of our system has significant potential.

An issue that was not previously addressed is that related to the third case in the list above where a person is not watching TV when s/he is located in front of it. In order to analyze this case, we collected smartphone usage logs to identify the relationships between using a smartphone and viewing TV. We implemented a prototype system in a real-world context.

Trial Study

To investigate the feasibility of our design, we conducted a trial study using one volunteer (male, 33 years old). The study was conducted using the prototype system in a single-occupant household for one hour (21:00–22:00) in the evening of a typical weekday. We selected a house that has one living room, one bedroom, and one bathroom. Three beacon devices were installed: in front of the TV, in the room, and in the bathroom (Figure 2). This setup allowed us to identify the viewer's location accurately. We collected three types of data simultaneously for one hour as follows. 1) We recorded the TV screen with a video camera, 2) we collected beacon signal logs, and 3) we gathered smartphone usage logs by using the "App Usage Tracker" app on the participant's smartphone. We also developed and installed a beacon collector app on the participant's smartphone. Figure 3 shows an example of the collected beacon signal logs. Figure 4 shows the usage log of the "App Usage

[1] Reco Co., Ltd: http://reco2.me/reco/?lang=en

[2] App Usage Tracker: https://play.google.com/store/apps/details?id=com.agrvaibhav.AppUsageTracking&hl=ko

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Mode: Low Energy Scan Wed Dec 17 02:01:15
GMT+09:00 2014  Lat/Long:
37.2943569/127.0464035RSSI: -61
Mode: Low Energy Scan Wed Dec 17 02:01:14
GMT+09:00 2014  Lat/Long:
37.2943569/127.0464035RSSI: -69
Mode: Low Energy Scan Wed Dec 17 02:01:12
GMT+09:00 2014  Lat/Long:
37.2943569/127.0464035RSSI: -61
Mode: Low Energy Scan Wed Dec 17 02:01:11
GMT+09:00 2014  Lat/Long: -1.0/-1.0 RSSI: -58
Mode: Low Energy Scan Wed Dec 17 02:01:09
GMT+09:00 2014  Lat/Long:
37.2943598/127.046403 RSSI: -61
Mode: Low Energy Scan Wed Dec 17 02:01:08
GMT+09:00 2014  Lat/Long:
37.2943598/127.046403 RSSI: -52
Mode: Low Energy Scan Wed Dec 17 02:01:05
GMT+09:00 2014  Lat/Long:
37.2943599/127.046403 RSSI: -52
Mode: Low Energy Scan Wed Dec 17 02:01:02
GMT+09:00 2014  Lat/Long:
37.2943599/127.046403 RSSI: -54
Mode: Low Energy Scan Wed Dec 17 02:00:58
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Figure 3. An example of collected Beacon signal logs captured on the participant's

App Name	Start Date/Time (yyyy-MM-dd HH:mm:ss)	Duration
Messenger	2014-12-15 21:14	20s
Messenger	2014-12-15 21:14	7s
Messenger	2014-12-15 21:15	7s
Messenger	2014-12-15 21:15	15s
Portal Site	2014-12-15 21:15	2m 31s
Facebook	2014-12-15 21:18	1m 58s
Game	2014-12-15 21:33	8m 12s
Messenger	2014-12-15 21:56	17s
Messenger	2014-12-15 21:57	7s
Portal Site	2014-12-15 21:57	1m 10s
Today	**Total Usage Duration**	**14m 54s**

Figure 4. An example of collected smartphone app usage logs captured on the participant's smartphone

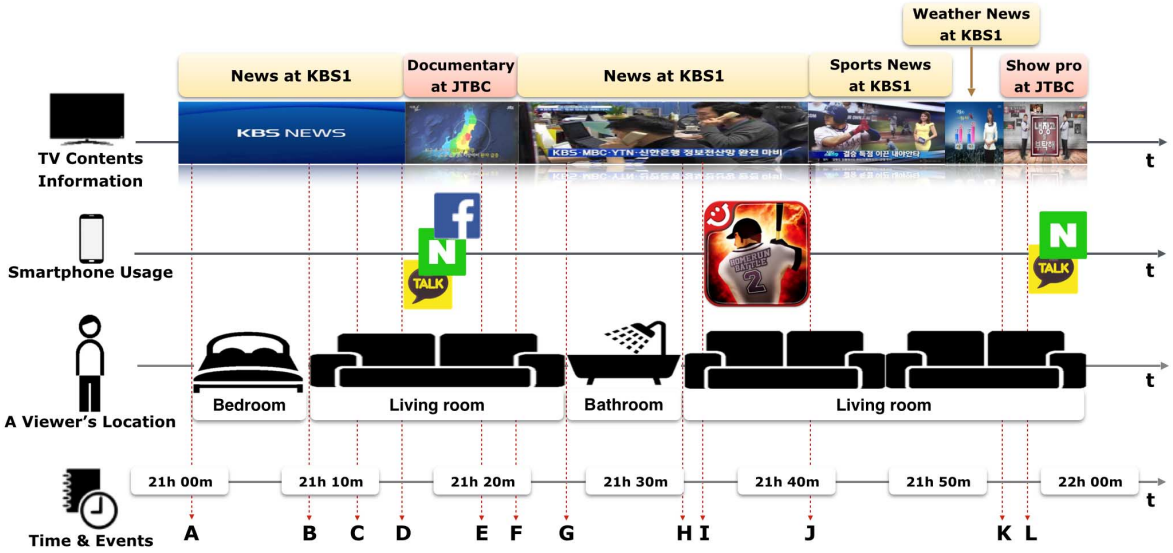

Figure 5. Time line of TV contents along with participant's locations and smartphone usage

Tracker" app. We analyzed the collected data to identify patterns of TV viewing activities.

Results

The results of the data analysis showed that the participant's TV viewing activities were not simple. We built a timeline graph using the collected data, as shown in Figure 5. The figure shows various patterns related to the participant's TV viewing behaviors. We observed that many other activities are embedded in the participant's TV viewing behavior. The participant did not stay in one location: after turning on the TV, he went to his bedroom first and stayed there for 10 minutes; while watching TV in the living room, he left to spend 8 minutes in the bathroom.

The participant also used a smartphone several times while watching TV. He accessed several apps (e.g., the "Facebook" app, a portal site app, a messenger app, and a game app) while viewing TV (Figure 5). We observed that he played a baseball game for a few minutes. As soon as the sports news started, he stopped playing the game and resumed viewing the TV. These results imply that our design can more accurately measure TV viewing activities than existing people meters.

We digested various events of TV viewers and the data sources that can detect these events. As shown in Table 1, the "Moving the spot" event (A, B, G, and H in Table 1) can be easily detected by using beacon signal logs. Cases D, F, J and K, which denote the "Changing TV channel" event, can be recognized using TV content information. In addition, the "Immersive TV viewing" event and "Multi-tasking" event can be recognized by combining all the data sources.

Events	Case	Data Source
Viewer's location change	A, B, G, H	Beacon
Changing TV channels	D, F, J, K	TV contents
Actively engaged in TV viewing	B-C, E-G, H-I, J-L	TV contents, Beacon, App usage
Multi-tasking with smartphones	C, I, L	TV contents, Beacon, App usage

Table 1. Events in Figure 5 and respective data sources

After the experiment, we interviewed the participant to gain further insights. He reported that he did not feel any differences caused by all the apps for logging data that operated in the background of his smartphone. He also reported that the camera used for recording TV screen made him feel uncomfortable for the first few minutes of the experiment, but that as time went by he was no longer conscious of it. These results show that the participant found the prototype system unobtrusive.

The study results imply that our system is able to unobtrusively recognize various additional patterns related to TV viewing activities. Table 2 shows the detailed TV viewing activities.

Detected feature	Traditional System	Smart TV Logging System
Changing TV channels	O	O
Viewer identification	O	O
Viewer's location change	X	O
Actively engaged in TV viewing	X	O
Multi-tasking with smartphones	X	O

Table 2. Traditional research methods vs. the smart TV logging system

Design Iteration

The lessons learned from the trial study allowed us to identify a number of ways to enhance the system. First, a smart TV can be used to identify the content of the TV screen. The initial prototype was not able to recognize TV content information simultaneously. However, a smart TV can take advantage of the Transport Stream (TS) packet of the MPEG-2 systems used by many broadcasting systems [5]. The header in the TS packet contains TV content information and a smart TV can parse the TS packet and acquire the content information directly from broadcasting signals. In this design, the smart TV also acts as a beacon. After the smart TV parses the content information acquired from broadcasting signals, TV content information can be easily embedded in the TV beacon signal and transferred to smartphones

Second, detailed logging of smartphone usage can be collected for analysis. The engagement level of viewing

a TV program can be measured based on logs. For instance, participants can share ideas and emotions about a TV program with friends through a social network service (SNS) and search information related to a TV program. Advanced logging could measure the viewer's ignorance of and level of engagement in a TV program through the analysis of these logs.

Limitations

In this paper, we proposed a smart TV logging method for investigating viewers' watching behavior using a Beacon system, smartphones, and a smart TV. However, some limitations exist. First, the proposed method may not accurately capture viewers' activities that do not involve digital devices (e.g., reading a newspaper). Viewers may fall asleep while watching TV, or conversations between viewers may distract them from watching TV.

The second limitation is caused by the beacon method we employed. TV viewers do not necessarily carry their smart phones with them all the time. However, using smaller wearable devices may resolve this issue.

Lastly, we used a small number of beacons in the trial study. Depending on the structure and the size of home, a greater number of beacons may be required. However, as more devices are equipped with Bluetooth technology [10], it may be possible to detect a sufficient number of signals to calculate the viewers' location accurately without installing additional beacons.

Conclusion & Future Work

The system we proposed can detect TV viewing behavior more robustly and accurately than previous systems. However, further research is needed on the usage of the collected information. For example, real-time analysis of each audience's TV viewing behavior information can be used to create an important database for the development of a TV contents recommendation system. Moreover, studies can also be conducted on the situation where a smart TV functions as a hub system in a future home.

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