Roles of Smart TV in IoT-environments: a Survey

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Abstract

In this paper we analyze the applicability of Smart TV in Internet of Things (IoT) environments. First, we list possible roles of TV in IoT-infrastructure and features that a platform should possess in order to act in the respective role. Then we evaluate existing Smart TV platforms according to presented requirements to figure out suitability of various platforms for usage in IoT.

Index Terms: Smart TV, Internet of Things, IoT roles.

I. Introduction

As stated in [1], the central idea of Internet of Things is the ubiquitous presence of diverse things, such as smartphones, Radio-Frequency IDentification (RFID) tags, sensors, etc., which are able to communicate with each other to achieve common goals. Internet of Things will have high impact on several aspects of everyday life, particularly on domestic field. Key requirements for IoT devices include being uniquely addressable, sustainable and enhanceable.

Smart TV device is a television set or a set-top box for the television which provides more computing and connectivity capabilities than a basic television set. Smart TV devices in the current state are rather focused on online services, such as on-demand streaming media, over-the-top content and interactive media. Such TVs have an Ethernet port or a Wi-Fi module and can run applications, thus they are uniquely addressable and enhanceable. So, it is possible to use technologies of existing Smart TV platforms in an IoT-environment.

The paper is structured as following. In Section II we consider feasible roles for Smart TVs and features necessary to fulfill the respective role. In Section III we use the list of requirements obtained earlier to evaluate applicability of existing platforms in IoT-infrastructure. Section IV concludes the paper.

II. Use of Smart TV in IoT

In this section, we present most expected roles that Smart TV can play in IoT-environment and requirements for using Smart TV in the according role. We analyzed hardware and software capabilities of modern Smart TVs and considered their possible roles in abstraction from the TV itself. We figured out core requirements for each role. The resulting list acts as a core for Section III where we compare the applicability of different Smart TV platforms in IoT.

1) Information storage: is a role in which TV acts as the storage for data from user and sensors. In [2] authors describe an example in which DVD player holds user's movies. In IoT context it is appropriate to use Smart TV in similar, but enhanced way: the user keeps their collection of movies and music on TV, freeing disk space on the laptop. Another benefit is the possibility to access this data from any device connected to home network: laptops, desktops, smartphones, tablets, other TVs. For example, usually user watches their favorite

series on the big TV in bedroom, but they dinner in kitchen and wants to watch them on the small kitchen TV. User just turns on the small TV and plays files located on the big TV without the need to do any extra activities like bringing a laptop to kitchen or downloading series on a USB flash drive.

Furthermore, in IoT-environment there are a lot of other machines with the limited data storage capacity, particularly sensors. Some applications that process data from sensors need access to log of that data, for example, time intervals which user spends in bedroom. This data is used to automatically adjust room temperature when user is in bedroom and save energy when they are not. Smart TV stores data from all units in same local network, thus resolving problem of small amounts of memory in these devices.

In IoT-environment there are other devices able to store large amounts of information, such as laptops and desktops. The main difference between Smart TV and them is uptime. Users tend to power off their personal computers when they do not use them, especially at night. If user turns TV off with remote, he deactivates only its screen, without affecting ability to store and share data.

In order to successfully fulfil this role TV requires presence of internal mass storage drive or ability to connect removable media devices (external hard drive, flash drive, memory card).

2) Visualization device: is a role in which Smart TV acts as the device for displaying content from external sources. Due to its big screen TV is suitable for the representation of various graphical information. IoT-environment produces a large amount of displayable data, such as rooms temperature and lighting levels, contents of the refrigerator, etc. Smart TV serves as a hub that shows all information about the home in a comfortable way. A corresponding example of creation of interface to visualize similar data is studied in [3].

The other way to utilize advantages of the TV's big screen is to use it to visualize content from local devices with smaller screens, such as smartphones and tablets. For example, user opens TV menu and browses through devices with available media, such as "User's laptop", "User's tablet", etc. Usage of DVD player for same purpose is mentioned in [2]. Furthermore, user gadgets are not the only ones which can use TV as the external video display. Smart TV is the easy way for guests of the home to share various video content from their devices, the only requirement is connection to the same Wi-Fi network. For example, guest presses "Share to TV" button on smartphone and TV shows dialog, which alerts about incoming file and allows to accept or decline it. TV distinguishes user devices from guest by white list and offers them additional privileges, such as ability to broadcast to TV without confirmation or other user-defined rules.

To achieve the possibility of playing this role, Smart TV needs a way to access content from devices in same local network. Another important feature is ability for the external device to initiate transmission of information to TV.

3) Interaction point: is a role in which Smart TV acts as means for the user to interact with the IoT infrastructure. In [4] authors suggested to use TV as controller for room lighting, but there is no obstacles to manage other home switches and controllers, such as temperature regulators, from TV. For example, user watches TV and gets cold, so they simply use TV's remote to enter the home management menu or even gives a voice or gesture command to adjust the temperature. Smart TV processes this instruction and sends it further to temperature regulator which in turn heats the room.

Advantage of such system towards modern regulators with individual remote is that control is unified, i.e, user does not have to use a certain remote for each controller. They control any aspect of comfort from any suitable device, including their TV.

To act in this role, it is necessary for Smart TV to have at least one of various control options, such as remote, gestures, voice input or other devices and ability to integrate with other devices.

4) Data processor: role supposes using Smart TV as the external computation unit for other devices. Due to its large dimensions, it is easy to incorporate a powerful processing unit into one. Also, as stated in [5], TV is almost always plugged into the power network. Therefore, with the use of certain applications designed to use this possibility TV can act as external data processor for other devices to quicken computations and save their battery charge.

Another way to use Smart TV in this role is to make it manage various routines. For example, usually the user comes to the home from the work at 18:00 and makes himself a coffee. TV gathers this information from the coffee machine and is now able to send a command to start preparing the coffee at 17:55, thus freeing user from the routine.

Requirements to use Smart TV platform in the data processing role are the possibility to develop applications and sufficient processing capabilities.

5) Data source: is role in which Smart TV acts as source of sensor data. In [6] authors describe a router that monitors a set of three sensors: water, smoke and temperature and transfers collected data to home server. User can request current status of any sensor or check textual database that the server maintains. It is not hard to transfer such functionality to TV, which also may possess video and sound sensors.

An example of the successful usage of Smart TV in this role is home security system. Video feed from the camera of the TV is always available in the home network, thus it is possible to view recorded video stream from any user's device connected to Internet. Smart TV processes this stream and recognizes faces. If TV finds an unidentified face, there are two cases. If there are no adult residents in the house, Smart TV triggers the alarm, otherwise, it sends notification to user. They can choose whether recognized face is intruder or guest.

Another possible application of Smart TV is monitoring children. Parents often spend most of their day at work and have no or little possibilities to check on their children. Kids spend a lot of time in front of TV watching cartoons or playing, also they do their homework near the TV. Therefore, TV camera almost always sees them, thus allowing parents to look after their children.

In order to play this role, TV needs ability to gather sensor data. Sensors which provide that data can be external or embedded into TV.

III. Overview of platforms and middleware

Smart TV concept is currently represented by Smart TV platforms and Smart TV middleware. Platforms are high-level product with API that differs from vendor to vendor. Middleware is API that provides basic functions to control TV which application developers use to focus on high-level programming instead of low-level. So, middleware acts as layer between hardware and software. All platforms base on some middleware, which can be proprietary or not. In this section we analyze possibilities of using existing Smart TV platforms and middleware in various roles, given in the previous Section. Table I contains overall information on our opinion about applicability of these platforms in each role. Good means that it is possible for platform to act in all use cases we provided for according role. Average means that platform has strictly limited use in particular role, i.e., is not suitable for some use cases. Bad means that platform has no or little possibility of acting in this role, i.e., is not usable in any given use cases.

TABLE I
COMPARISON OF PLATFORMS AND MIDDLEWARE

	Storage	Visualization	Interaction	Processing	Source of data
Samsung	Good	Good	Good	Average	Good
Panasonic	Good	Good	Good	Average	Good
LG	Good	Good	Good	Average	Good
Mediaroom	Average	Bad	Good	Average	Good
Google TV	Good	Good	Good	Good	Good

A. Smart TV platforms

1) Samsung Smart TV: In 2007, Samsung introduced the Internet TV, enabling viewer to receive information from the Internet while at the same time watching conventional television programming. This development was later renamed to ”Smart LED TV” and then to ”Samsung Smart TV”, which additionally supports downloading and installing applications.

Samsung Smart TV supports external hard drives and usb-flash [7] that reveal role of *Information storage*, such as digital video recording and playing different media files. Internal memory is used as a buffer for streaming content and for installed application files.

Samsung Smart TV supports DLNA protocol that enables displaying different content simultaneously on laptop, smartphone and tablet and streaming media from devices to TV. This feature allows to play *Visualization device* role.

Samsung’s platform supports Smart Interaction features required for *Interaction* role that provides launch and use of applications through Motion Control and Voice Control [8]. Motion Control allows to use hands to control TV functions by swiping to navigate and grabbing to select movies, games and applications. Voice Control allows navigate menus and launch any applications through voice commands.

Samsung’s platform only supports web-based apps (JS, CSS, HTML, FLASH) [9]. For developing application Samsung offers Smart TV SDK, which is available for all platforms: Windows, Linux, Mac. This reveals role of *Data processing*. Samsung Smart TV supports push-notifications [10]. It allows to show popup-message on screen with ability to launch application.

To represent the Samsung Smart TV as the *Source of data*, latest TV models besides sensors for voice control have internal cameras, that provide Face Recognition [8] for instant access to personal apps and Skype’s contact list.

2) Panasonic Viera Connect: Viera Cast is Smart TV platform by Panasonic that makes it possible to stream multimedia content from the Internet directly into TVs. Viera Cast was announced on Consumer Electronics Show in January 2008, but in 2011 the platform has been updated. Now it is called Viera Connect and allows to develop and install third-party applications.

Devices from Panasonic support connection of USB external hard drives [11] to store media files: music, video, photos and TV recordings, thus uncovering role of *Information storage*

Viera Connect has a possibility to connect DLNA-compatible AV equipment to home network [12] that required for the *Visualization* role.

Interaction role is present with following features: ability to connect keyboard that does not require any drivers and Viera Remote application that offers usage of an iOS or Android device as a remote, which allows you to turn smartphone or tablet into a remote control.

Panasonic's platform supports HTML, Java Script (AJAX) for developing application with VIERA Connect SDK [13]. This reveals role of *Data processing*.

Viera Connect devices have no internal sensors, but support external USB cameras [14] that represent role of *Source of data*.

3) LG Smart TV: LG Electronics introduced their first Internet TV in 2007, branded as "NetCast Entertainment Access" devices. In 2011 they renamed it to "LG Smart TV" and added more interactive TV features that enable user to receive information from the Internet while watching conventional TV programming at the same time.

Role of *Information storage* presented by support for connecting external USB drives to store and play media contents.

Platform has the Smart Share feature [15] required for *Visualization* role. This feature provides synchronization of devices in a single Smart TV system - from Blu-Ray player, Hi-Fi systems, smartphones and laptops.

LG Smart TV offers the Magic Motion Remote Control (MMRC) that operates like a computer mouse. With MMRC TV devices can track the movement of remote control in space. This feature is required for *Interaction* role.

Role of *Data processing* represented by support for popular development environment: HTML 5.0, Java Script, ActionScript 3.0 (Flash) and gaming platforms (Unity 3D and Marmalade).

TVs on this platform do not have internal cameras and microphone but these devices can be connected separately. This discloses role of *Source of data*.

B. Smart TV middleware

1) Microsoft Mediaroom: Microsoft Mediaroom is proprietary middleware that many pay-TV providers use to deliver their services to end users [16]. Hardware and its features differ between providers and they do not post specifications of their set-top boxes.

Microsoft Mediaroom has no support for USB, thus no support for external USB drives, but YouView Humax DTR-T1000 [17] has a 500GB hard drive, allowing to use it in *Information storage* role. This middleware has no way to show content from any source except service provider, making it not suitable for *Visualization* role. Possibility to connect to X-Box and thus to Kinect makes Mediaroom useful in *Interaction with user* and *Source of data* roles. Mediaroom Presentation Framework (MPF) allows creation of rich and functional applications, but only service providers are able to give a license to develop and publish an application to provider-specific store. It hardens using Mediaroom in *Data processing* role.

Microsoft Mediaroom was created only to deliver pay-TV services and is not suitable for usage in IoT-infrastructure.

2) Google TV: Google TV is currently available only through Sony NSZ-GS7 Internet Player [18], [19], which comes in single modification. It has 8GB of internal memory and support for external USB flash and hard drives, enabling this middleware in *Information storage* role. Presence of DLNA allows usage of device in *Visualization* role. Various convenient ways to control TV, such as phone or tablet and universal remote with touchpad and QWERTY keyboard make Google TV suitable for *Interaction with user* role. *Data processing* role requires applications and Google Play, available on TV, has tons of them. Also, Google TV operates on Android 3.0 operating system, which is able to run applications in background. Fulfillment the role of *Source of data* is made possible by ability to connect external USB video camera.

Overall Google TV has biggest amount of premises to be used in IoT-environment. Its main advantage towards previous platforms is its operating system. None of other platforms are able to run applications in background, while Google's Android OS can. Such ability is necessary to show notifications and process consistent flow of data which sensors and other devices transfer to TV. It makes Google TV Good in *Data processing* role, and lack of such functionality makes other platforms Average.

IV. Conclusion

We surveyed most expected roles Smart TV can play in IoT-environments and anticipate that Smart TV has great potential in world of IoT, furthermore, Google TV is already highly suitable for incorporating in IoT-infrastructure. Samsung, Panasonic and LG platforms are less suitable due to their strictly limited API, which does not allow to run applications in background, thus reducing capabilities of using these platforms in very important role of *Data processing*. Adding functionality of running background applications will enable usage of these platforms in this role.

Smart TV vendors currently dedicate a lot of resources for interaction features. Each Smart TV platform has its own interaction technology. It is possible to adapt these technologies for usage in other domains of Internet of Things, such as transportation or healthcare.

References

[1] L. Atzori, A. Iera, and G. Morabito, "The internet of things: A survey," *Computer Networks*, vol. 54, no. 15, 2010.
[2] C.-F. Lai, Y.-M. Huang, and H.-C. Chao, "Dlna-based multimedia sharing system for osgi framework with extension to p2p network," *IEEE SYSTEMS JOURNAL*, vol. 4, no. 2, 2010.
[3] M. Carnesecchi, A. Rizzo, A. Alessandrini, M. Caporali, and M. Milani, "Designing ilook: An integrated, zoomable interface to support users' interaction with networked home appliances," *PsychNology Journal*, vol. 9, no. 3, 2011.
[4] T. Koskela and K. Väänänen-Vainio-Mattila, "Evolution towards smart home environments: empirical evaluation of three user interfaces," *Personal and Ubiquitous Computing*, vol. 8, no. 3, 2004.
[5] M. Z. Bjelica and N. Teslic, "A concept and implementation of the embeddable home controller," in *MIPRO, 2010 Proceedings of the 33rd International Convention*. IEEE, 2010.
[6] J. K. Omwoyo *et al.*, "Embedded monitoring server," 2007.
[7] "Slim led es7500 features." [Online]. Available: http://www.samsung.com/nz/consumer/tv-audio-video/television/led-tv/UA55ES7500MXRD-features/
[8] "The future of smart tv, now." [Online]. Available: http://www.samsung.com/sg/smarttv/
[9] "Samsung smart tv sdk faq." [Online]. Available: http://www.samsungdforum.com/Support/FaqList?faqCateID=2/
[10] "Flow of sap," 2012. [Online]. Available: http://samsungdforum.com/Guide/art00080/index.html/
[11] "Th-l55et5a overview." [Online]. Available: http://www.panasonic.com.au/Products/VIERA+televisions/LCD+TVs/TH-L55ET5A/Overview/
[12] "Home network convenience." [Online]. Available: http://www.panasonic.ae/viera/pages/intelligent_DLNA_Wi-Fi.html/
[13] "Development guide, technology overview." [Online]. Available: http://developer.vieraconnect.com/intro/development-guide/technology-overview/
[14] "Viera connect apps navigator, optional accessories." [Online]. Available: http://panasonic.net/avc/viera/global/connect_apps/optional_accessories/
[15] "Lg smart share." [Online]. Available: http://www.lg.com/us/support/smart-share/
[16] J. Beach, "Microsoft leads two global iptv segments," 2012. [Online]. Available: http://www.iptv-news.com/2012/11/exclusive-microsoft-named-as-leader-of-two-global-iptv-segments/
[17] "Youview review." [Online]. Available: http://reviews.cnet.co.uk/tv-recorders-and-receivers/youview-review-50008506/
[18] "Nsz-gs7." [Online]. Available: http://www.sony.co.uk/product/google-tv/nsz-gs7
[19] B. Drawbaugh, "Sony nsz-gs7 google tv review," 2012. [Online]. Available: http://www.engadget.com/2012/06/26/sony-nsz-gs7-google-tv-review/