J Supercomput (2008) 45: 88–104
DOI 10.1007/s11227-008-0202-4

U-multimedia framework: a secure and intelligent multimedia service framework based on context information in U-home

Deok Gyu Lee · Jong Hyuk Park · Tai-Hoon Kim · Laurence T. Yang

Published online: 5 April 2008

Abstract In the last few years, intelligent secured multimedia services play a vital role along with ubiquitous home environment (Park et al. in Lecture Notes in Computer Science, vol. 4097, pp. 660–670, 2006; Lecture Notes in Computer Science, vol. 4159, pp. 893–901, 2006; IEICE Trans. Inf. Syst. E89-D(12):2831–2837, 2006; Lecture Notes in Artificial Intelligence, vol. 4252, pp. 777–784, 2006; Lecture Notes in Artificial Intelligence, vol. 3801, pp. 313–320, 2005). There are certain constrains and limitations in providing effective and efficient services in U-home. The mechanism and applications are integrated to realize such services. Three different kinds of ubiquitous multimedia services are proposed in the framework. Based on the temporal and spatial context information, the surrounding situations are recognized. The contexts are collected and well analyzed with the preconditions to provide the final services. The proposed framework provides efficient services in the multimedia based deices based on the current context information.

D.G. Lee
S/W Content Research Laboratory, Information Security Research Division, Electronics and Telecommunications Research Institute, Daejeon, Korea
e-mail: deokgyulee@etri.re.kr

J.H. Park (✉)
Department of Computer Science and Engineering, Kyungnam University, Masan-si, Kyungnam, Korea
e-mail: jhpark1@kyungnam.ac.kr

T.-H. Kim
Division of Multimedia, Hannam University, Daejeon, Korea
e-mail: taihoonn@hnu.kr

L.T. Yang
Department of Computer Science, St. Francis Xavier University, Antigonish, Canada
e-mail: ltyang@stfx.ca

Keywords U-home · Ubiquitous multimedia service · Context information · DRM · WSN agent

1 Introduction

The approach to the modern civilization was achieved by industrialization from an agrarian society through the industrial revolution and the realization of informational revolution by the progress of computer and electric communication. After that, owing to the rapid growth of computing power and network, the convergence era where broadcasting, communication, technology, and devices are compatible with each other were introduced. Recently, the new computing paradigm—the era of ubiquitous computing is just around the corner for us.

Mark Weiser at Xerox PARC proposed the concept of "Ubiquitous Computing" in 1991. It is a user-centric environment where various kinds of computers are embodied into person, object, and the environment which are connected each other and the seamless services are provided to users anytime and anywhere with any device [6, 7]. We expect that the fundamental components (person, object, environment, etc.) comprising the world are going to be more intelligent in the era of ubiquitous computing.

To realize the ubiquitous computing society, we should make smart environments such as home or office. That means the implementation of smart home network services is the first step to realize ubiquitous computing society; especially, home network services such as home automation, security, and multimedia entertainment are going to attract users.

In this paper, a multimedia service framework based on context information in U-home (U-Multimedia Framework) is proposed. This proposed frame work provides better results than the existing home network environment. To provide ubiquitous multimedia services in U-home, we should solve at least the basic infrastructure and security issues to provide user-centric services. In addition, the security, flexibility, and expandability for multimedia services in a dynamic environment applying context information from all elements in U-home is achieved well in this work. The goal of this research work is to provide intelligence and security of the multimedia service in U-home applying elements of dynamic environment. In addition, some parts of this paper were presented in [8].

In this paper, our assumptions are as follows: One is providing infrastructure such as Wired LAN, Wireless LAN, and Wireless Sensor Network in U-home. The other is providing real-time communication among person, object, and device in U-home.

This paper is organized as follows. In Sect. 2, we describe our proposed framework—U-Multimedia Framework including definition and expression of context, architecture, design, and service process. In Sect. 3, we discuss prototype implementation and analysis of U-Multimedia Framework. Conclusions and future work will be given in Sect. 4.

2 U-multimedia framework

2.1 Definition and expression of context

In this subsection, we define context which is the core element in this paper. To have a better understanding, we describe the formal definition of context and its expression. Context information to show device status and context information to recognize user's location are mainly used for the context used in this paper. Device context information is the current specification and situation information of the device to provide multimedia service optimized to multimedia playing device. And user location context is the situation information used for dynamic access control hereafter.

The formal definition of context used in U-Multimedia Framework and related expressions based on [9–12]—context type, context based access control, access control policy, and resource access are discussed.

Definition 1 (Context type) A Context Type (CT) is defined as a property related to every participant in an application when it is running. The context type may be a definite property such as temporal or spatial information. In addition, context type can be used to describe an abstract concept.

Based on context type, every application has its own Context Set (CS), which is defined as a set of context types:

$$CS = \{CT_1, CT_2, \ldots, CT_n\}, \quad 1 \leq i \leq n$$

In order to make this abstract concept of context type usable when decisions of access control need to be made, it is necessary to have each context type evaluated by some context implementation. A context implementation (CI) of context type is defined as a function with n context types that return an object of CT.

$$CI : CT_1 \times CT_2 \times \cdots \times CT_n \rightarrow CT, \quad n \geq 0.$$

Definition 2 (Context based access control) The definition of a context based access control (CAC) is a regular expression. Based on this format, our access control is able to specify any complex context related constraint to describe all kinds of security requirements.

$$CAC = \bigcup_{j=1}^{i} Cond_j, \qquad Cond = \bigcap_{i=1}^{j} SubCond_i$$

$$SubCond := \langle CT \rangle \langle OP \rangle \langle VALUE \rangle,$$

where $CT \in CS$; OP is a logical operator in the set $\{>, \geq, <, \leq, \neq, =\}$ and $VALUE$ is a specific value of CT. Suppose we have a context set $CS = \{Time, Location, Security\ Class\}$, and we have a partial security rule such as "adult content can be accessed at living room between 21:00 and 24:00 with a security class of a password, otherwise, a higher security class is required." If "in" is a user-centric logical operator

and "living room" is a valid value of context type as location, then this rule could be expressed as

$$Context\ Constraint := (Time \geq 21{:}00 \cap Time < 24{:}00 \cap$$
$$Location\ in\ Home \cap SecClass \geq H(PW)) \cup (SecClass > H(PW))$$

Definition 3 (Access control policy) The definition of an access control policy (ACP) as a triplet, $ACP = (S, P, CC)$. Where

"S" is the subject in this policy, which could be a user or a role
"P" is the target permission in this policy, which is defined as a pair $\langle K, O \rangle$
"K" is an operation kind defined in $\{PLAY, COPY, DELETE\}$ and
"O" is a resource object such as adult content, teenager content, and so on

CC is a context constraint in this policy. If CC is empty, then this policy returns to simple Role based Access Control (RBAC).

Definition 4 (Resource access) The definition of resource access as a triplet, $RA = (U, P, RC)$. Where

"U" is a user who issues this resource access in user set.
"P" is the permission that this user wants to acquire.
"RC" is Runtime Context which is a set of values for every Context Type in the Context Set. That is, $RC = \{V_1 \text{ of } CT_1, V_2 \text{ of } CT_2, \ldots, V_n \text{ of } CT_n\}$, where $= \{CT_1, CT_2, \ldots, CT_n\}$ is the context set of the application.

A resource access $RA(U, P, RC)$ is granted only if there exists an access control policy $ACP(S, P', CC)$, such that $U \in S$, $P = P'$, and CC evaluates to true under RC.

Definition 5 (Formal definition of the CAC and its architecture) CAC executes context constraint process by using context information such as temporal and spatial information when permission—role assignment (PA) is established. CAC model includes basic characteristics of RBAC like Least Privilege, Role Hierarchy, SoD, and Cardinalities concepts.

2.2 U-multimedia framework architecture

U-Multimedia Framework has applied authentication and DRM Digital Right Management (DRM) technology to provide security for each service. User authentication and device authentication should be performed for a user to get service from U-Multimedia Framework, and ubiquitous multimedia services which are capable of one source and multiusage is supported according to the result of user authentication and device authentication. U-Multimedia Framework consists of U-home Multimedia Streaming Service (UMSS) to support streaming and U-home Intelligent Multimedia Service (UIMS) to provide optimized contents to specific devices, and U-home Universal Multimedia Service (UUMS) to share and distribute multimedia file at any time. The architecture for service of U-Multimedia Framework is shown in Fig. 1.

Table 1 Formal definition of the *CAC*

U, R, P, S, C represent the finite set of users, roles, permissions, sessions, and context information respectively within the system.
$PA \subseteq P \times R$ represents the finite set of permission to role assignments. This is a many-to-many relationship.
$UA \subseteq U \times R$ represents the finite set of user to role assignments. This is a many-to-many relationship.
user: $S \rightarrow U$, a function that maps a session s_i to a user.
$RH \subseteq R \times R$ is a partial order on R, called the role hierarchy or role dominance relation, also written as $\geq$, where $r1 > r2$, only if all permissions of $r2$ are also permission of $r1$ are user of $r2$.
For RBAC0:$S \rightarrow 2^R$, a function that maps a session s_i to a set of roles, where $roles(s_i) \subseteq \{r \mid (user(s_i), r) \in UA\}$, and each session si has the permissions $\bigcup r \in roles(s_i)\{p \mid (p, r) \in PA\}$.
For RBAC1, $roles$:$S \rightarrow 2^R$, is modified from RBAC0 to require $roles(s_i) \subseteq \{r \mid (\exists r' \geq r)\ [(user(s_i), r') \in UA]\}$ and each session s_i has the permissions $\bigcup r \in roles(s_i)\{p \mid (\exists r' \leq r)[(p, r') \in PA]\}$.
For Context based Access Control (CAC), CAC adds context constraints in the form of restrictive functions that operate on basic RBAC components to meet the specific needs of the protection policies of an organization and factor of dynamic environments. Constraints in CAC include SoD (Separation of Duties) and Cardinalities including concepts of the RBAC2. In addition, It includes context such as environments, time, location, etc.
$CCA \subseteq CC \times R$ represents the finite set of CC to role assignments. This is a many-to-many relationship.

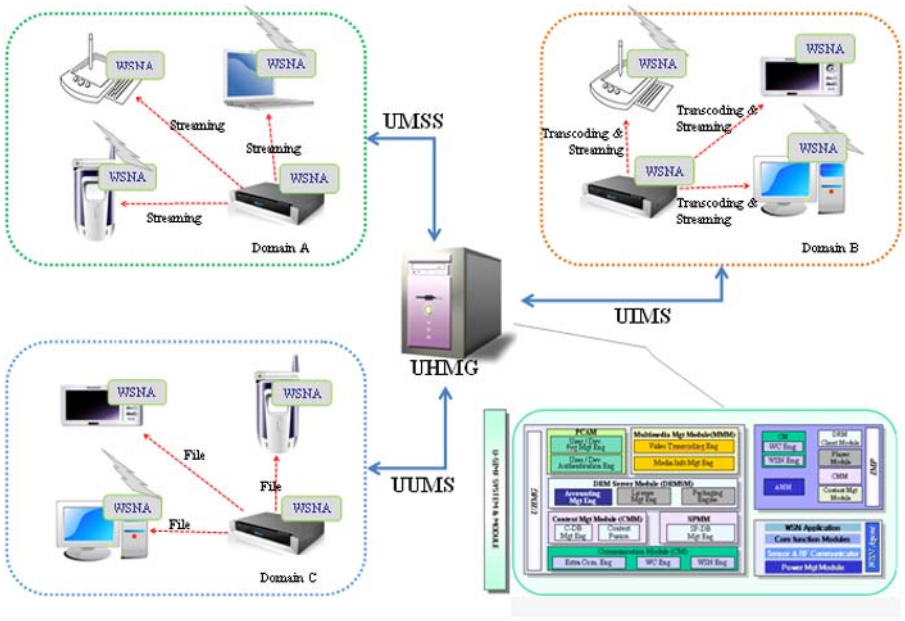


Fig. 1 U-multimedia framework architecture

UHMG is the core device of U-Multimedia Framework and gateway to manage and control all objects (user, device, communication, and database) related to the service of U-home. Moreover, it plays a major role in providing streaming service to storage, management of the contents, and multimedia playing devices located in each room of U-home.

In other words, it is a type of management server which provides UMSS, UIMS, and UUMS, the core services of U-Multimedia Framework.

Furthermore, each device sends and receives context information of user through Wireless Sensor Network (WSN) agent and provides optimized ubiquitous multimedia services to the relevant device. Access control algorithm for device authentication and license management is proposed and applied for the ubiquitous multimedia services to make one source multi usages through WSN agent possible. This algorithm makes analysis of profile and access control information of devices in U-home. And devices included in the relevant domain are available only for the already approved contents.

2.3 U-multimedia framework design

U-Multimedia Framework largely consists of three layers of database and network: U-Multimedia Framework system and module and U-Multimedia Framework services (refer to Fig. 2).

Database and network layer is the basic infrastructure consisted of communication and database. In case of communication, the existing wire LAN and wireless LAN and wireless sensor network are used for context information communication in U-home. Database consists of multimedia database such as multimedia content and relevant metadata, and security policy database in which security rule in U-home is set, and context database to support intelligent service.

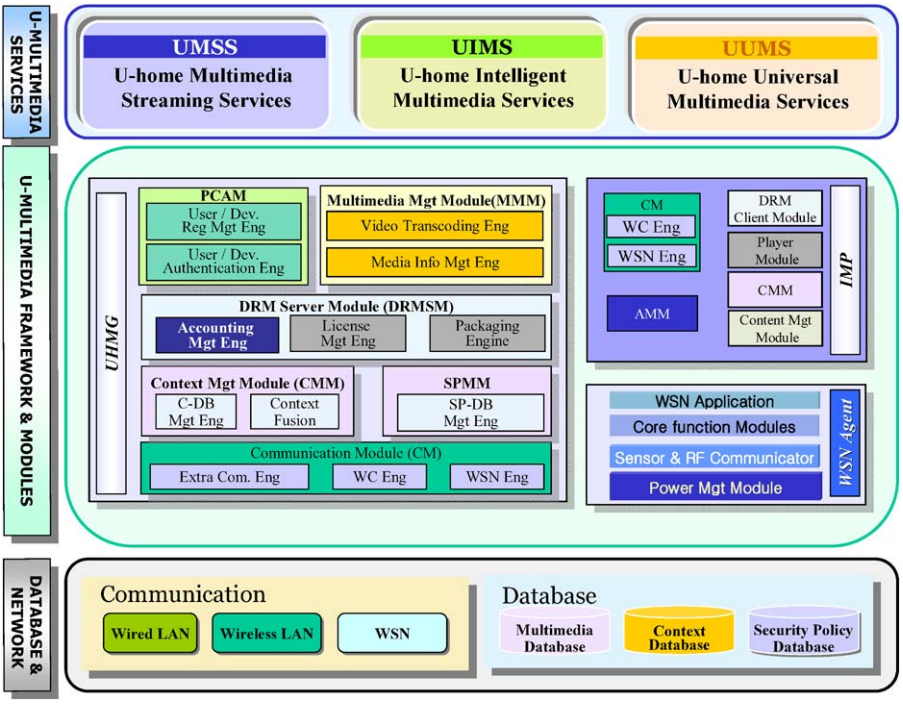


Fig. 2 U-Multimedia framework three layers and block diagram

Table 2 Notation in U-multimedia framework service process

Notation	Description
Content_ID/*Device_ID*	Unique value of content/device
Con_Req()	Requesting relevant contents by a user
UHMG/*WSNA*/*Usr*	U-home multimedia gateway/WSN agent/User
A_B	Module B of system A
UHMG_X	X module of UHMG
Device_Profile	Specific information of IMP (OS type, CPU type, memory size, media support format, MAC address)
Auth_Info	authentication information (ID/PWD, Certificate, PKI Key Information) on User or device
Device_Auth_Req()	Requesting device authentication
Device_Auth	Process of device authentication
Device_Auth_Res()	Sending the result of device authentication
Enc()/*Dec*()/*Play*()	Encryption, decryption, and play of contents
License(*Conid*)	Creating license for Content id
Device_Profile_Parsing	Analysis and processing of device information received from devices
Con_List	Contents list
StreamingService()/*Dwon_Service*()/ *Push_Service*()	Streaming, download, push service of multimedia contents
Con_Transcoding	Content transcoding

U-Multimedia Framework system and module layer consists of UHMG which control and manage all services in U-home, IMP, and WSN agent. In addition, it is a core part to provide intelligent multimedia services.

The intelligent multimedia player (IMP) is a device such as a PDA, PC, or DTV which has been equipped with the ability to intelligently display media contents in U-home, and transmits the context information about IMP to the UHMG through the WSN Agent.

The private certificate authority module (PCAM) authenticates user and the IMP by acting as a private certificate authority that has been previously authenticated by a public certificate authority. The DRM Server Module (DRMSM) is responsible for the security function of downloaded multimedia contents to the multimedia management module (MMM) through an external line. It provides security of multimedia in U-home such as user rights settings, authorization, and management in order to ensure the transparency of use for the user.

U-Multimedia Framework service layer consists of UMSS, UIMS, and UUMS and it will be described in detail in Sect. 2.4.

2.4 Service process for U-multimedia framework

Table 2 is the notation to describe service process.

This service process goes on based on the following assumptions;

1. Device profile and ID are provided through general wire and wireless network and wireless sensor network.
2. Authentication information can also be used for certificate such as X and 509v3 besides authentication information based on ID and password.

A. U-home multimedia streaming service (UMSS)

UMSS provides streaming service to multiusers and devices. A user acquires user authentication through the WSN agent, and UHMG supports multimedia streaming service with IMP located in each room of U-home.

The following are the steps taken to provide the UMSS:

1. When a user selects the desired contents out of a content list, a WSN agent transfers the device profile and authentication information to the DRM server module of UHMG.

$$Usr: Con\_Req(Content\_ID),$$

$$WSNA \rightarrow UHMG\_DRMSM: Device\_Profile, Auth\_Info$$

2. DRM server module of UHMG requests authentication to private certificate authority module of UHMG for streaming service of the content.

$$UHMG\_DRMSM \rightarrow UHMG\_PCAM: Device\_Auth\_Req(Device\_ID, Auth\_Info)$$

3. Private certificate authority module of UHMG transfer result of authentication to DRM server module of UHMG after completion of authentication procedure.

$$UHMG\_PCAM: Device\_Auth,$$

$$UHMG\_PCAM \rightarrow UHMG\_DRMSM: Device\_Auth\_Res(OK)$$

4. After normal completion of authentication, DRM server module of UHMG commands multimedia management module of UHMG to do streaming service of the contents requested by the user.

$$UHMG\_DRMSM \rightarrow UHMG\_MMM: Content\_ID$$

5. Multimedia management module of UHMG starts streaming service.

$$UHMG\_MMM \rightarrow UHMG\_CM: Streaming\_Service()$$

6. The content from communication module of IMP is decrypted through DRM client module of IMP and the user can play the content.

$$IMP\_DRMCM: Dec(Cont), Play(Cont)$$

B. U-home intelligent multimedia service (UIMS)

UIMS executes transcoding in real time on the basis of device profile and provides intelligent multimedia services to serve optimized contents to user's device which wants multimedia services.

The following are the steps taken to provide the UIMS:

1. When a user selects the desired contents out-of- contents list, WSN agent transfer device profile and authentication information to DRM server module of UHMG.

$$User: Con\_Req(Content\_ID),$$

$$WSNA \rightarrow UHMG\_DRMSM: Device\_Profile, Auth\_Info$$

2. DRM server module of UHMG request authentication to private certificate authority module of UHMG for the streaming service of the content.

$$UHMG\_DRMSM \rightarrow UHMG\_PCAM: Device\_Auth\_Req(Device\_ID, Auth\_Info)$$

3. Private certificate authority module of UHMG completes authentication procedure and transfers the result of authentication to DRM server module of UHMG.

$$UHMG\_PCAM: Device\_Auth,$$

$$UHMG\_PCAM \rightarrow UHMG\_DRMSM: Device\_Auth\_Res(OK)$$

4. After completion of authentication, IMP transfers the device profile to UHMG context management module from IMP.

$$UHMG\_DRMSM \rightarrow UHMG\_CMM: Device\_Profile$$

5. Context management module of UHMG makes an analysis of the device profile and then delivers device information for transcoding to multimedia management module of UHMG.

$$UHMG\_CMM: Device\_Profile\_Parsing,$$

$$UHMG\_CMM \rightarrow UHMG\_MMM: Device\_Profile\_Info(OS\_type, CPU\_type,$$

$$MemorySize, Content\_format, IP\_address)$$

6. Multimedia management module of UHMG conduct transcoding and encryption for the contents requested by user on the basis of analysis information on IMP profile and then provide streaming services.

$$UHMG\_MMM: Con\_Transcoding$$

$$UHMG\_MMM \rightarrow IMP\_CM: Streaming\_Service(Enc(Content))$$

7. The content from communication module of IMP is decrypted through DRM client module of IMP and the user can play the relevant content.

$$IMP\_DRMCM: Dec(Cont), Play(Cont)$$

C. U-home universal multimedia service (UUMS)

UUMS provides multimedia contents sharing function at any time among devices and UHMG. Interactive multimedia services; download service for contents saved in the UHMG from IMP and push service to send contents from UHMG to IMP.

The following are the steps taken to provide the UUMS:

C-1. Contents download service from UHMG to IMP

1. IMP receives contents list of UHMG through communication module.

$$UHMG\_CM \rightarrow IMP\_CM : Con\_List$$

2. A user selects desired contents to be downloaded out of the contents list through communication module of IMP, and WSN agent transfers device profile and authentication information to DRM server module of UHMG.

$$User : Con\_Req(Content\_ID),$$

$$WSNA \rightarrow UHMG\_DRMSM : Device\_Profile, Auth\_Info$$

3. DRM server module of UHMG receives content id requested from communication module of IMP and creates license for relevant content id.

$$UHMG\_DRMSM : License(Contid)$$

4. Process after this is same with the process of 3∼7 in UIMS.

C-2. Contents push service from UHMG to IMP

When a user wants to conduct contents push service to his own IMP while watching the contents on DTV through UHMG, service will be executed as follows;

1. A user selects the currently watching desired contents at UHMG, and device profile and authentication information collected through WSN agent is transferred to DRM server module of UHMG.

$$User : Con\_Req(Content\_ID),$$

$$WSNA \rightarrow UHMG\_DRMSM : Device\_Profile, Auth\_Info$$

2. DRM server module of UHMG receives content id requested by communication module of IMP and creates license for relevant content id.

$$UHMG\_DRMSM : License(Contid)$$

3. Process after this is same with process of 4 in C-1.

Fig. 3 Internal components of UHMG

3 U-multimedia framework prototype implementation and analysis

3.1 Prototype implementation

3.1.1 UHMG and IMP

The UHMG uses B/C Company's BCM7038 chip as a HD decoder and BCM3125 is used as a MAC chip of DOCSIS. The BCM3125 consists of module and demodule transceiver having Physical (PHY) Layer transmission function that is MCNS Compliant and 1-Chip device that Media Access Controller MAC) has been added based on DOCSIS standard. Those devices provide the functions which are needed to transmit HD video in home using network and data transmission and receiving of the high speed. In addition, the single chip device has those functions as following; analog-to-digital conversion, downstream QAM demodulation, adaptive equalization, MPEG termination, forward error correction (FEC), upstream FEC encoding, upstream QPSK/16-QAM modulation, digital to analog conversion for RF output, upstream, and downstream MAC control. The downstream physical layer supports 64/256 QAM transfer rate and channel decoding is executed through ITU-T J.83 ANNEX A and B [13].

Furthermore, the optimized VideoLan server and VideoLan player as multimedia server and player for multimedia streaming services are used. The specification of each IMP is described below:

Mobile Centrino 1.20 GHz, Windows XP Professional, 512 MB RAM, Video Memory 64 MB. To play multimedia contents, GOM player [14] is used for both IMPs. In addition, both IMPs are installed with Wireless LAN, Wired LAN and WSN agent. Figure 3 shows the internal structure of UHMG.

3.1.2 Flexible license mechanism in U-multimedia framework

License management mechanism applied role and domain concept, not the existing discretionary or mandatory access control, is proposed and applied to grant right for content in U-Multimedia Framework. Even though one device or one user get the right for access for the desired contents, use and super-distribution of the content is allowed only when not only users belong to other device or domain, but also role is granted for an acquired license. Table 3 shows some part of the proposed mechanism.

Table 3 Flexible license mechanism in U-multimedia framework

```
<AccessControl>
    <domain_id>Family</domain_id> // setting domain and group object
    <u_id>Jone</u_id> // setting user ID
    <device_id>Samsung KK Model</device_id> // information of IMP
    <license_id>1234567890</license_id> // license ID of content
    <role>overwrite</role> // permission for user, device, and group
</AccessControl>
```

3.1.3 WSN agent

WSN agent has a function that collects context information on each individual by connecting to UHMG and user, and controls the network communication among WSN agents. It consists of four layers. The first layer is a low power manager which is a device managing low electric power consumption. The second layer consists of sensor parts such as motion, voice, brightness, and device status check sensor, and so on. The third layer consists of operation system, module for wireless packet transmission and context information processing, protocol module supporting the network construction among sensor nodes, and middleware part for the determination of user preferences and inputting command on the object devices using transmitted metadata of the multimedia. The last application layer is an application program that providing a required service to the device equipped with WSN agent [5].

3.1.4 Intelligent transcoding algorithm

In [1], we have proposed the Video Transcoding Decision based on IMP Context (VTDIC) algorithm which decides the intelligent video transcoding level (SD/HD) for intelligent multimedia service in U-home. The VTDIC algorithm decides the level of video transcoding based on the current status context of IMP collected to the UHMG through the WSN agent. Input values including device kind, OS type, CPU clock speed, video and main memory are the critical elements that decide level of the video transcoding. In this algorithm, empirical average values were set as the critical value to provide customized service to IMP.

We process real time transcoding using VTDIC algorithm for user location context acquired by WSN agent to provide optimized multimedia service.

3.2 Analysis U-multimedia framework

In this section, the comparison and analysis among the existing methods for security and efficiency of U-Multimedia Framework are discussed. For the case of security, we make comparison and analysis among the proposed context based access control model and extended RBACs (RBAC and GTRABC).

In addition, from the aspect of the efficiency of consuming system resources, we verify efficiency of consuming resource at U-Multimedia Framework by comparing case of general contents playing with case of contents playing at the IMP with using VTDIC algorithm.

Table 4 Comparison between proposed model and existing models

Characteristics	RBAC [15]	GTRBAC [16]	CAC
Consideration of role and rights	○	○	○
Inheritance of role considering domain concept	X	○	○
User to User/device delegation considering domain	X	X	○
Delegation according to the user location information	X	∗	○

○: Satisfied

∗: Partially satisfied

X: Unsatisfied

Moreover, CACs mechanism controls access by an entity even though it has been successfully authenticated already and restricts a privilege and access right. When some authenticated user wants to use U-home service, CACs mechanism receives identity-related information from corresponding authentication and informs the result to the entity.

Corresponding device authentication When a device is offered in UMSS, UIMS, and UUMS, corresponding device authentication is provided to verify that devices are identical devices. This authentication method implements device authentication through the device of the user when multiple devices are connected to one communication. This authentication can provide different levels of protection. Even when a smart device is moved, the authentication can be done using that result value is stored in the databases.

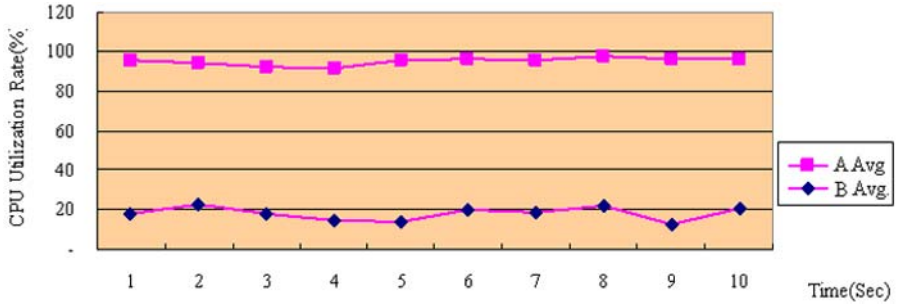
Connection/non-connection confidentiality Device in domain must provide confidentiality for user data in both communication and database. Domain receives information from database and receives the final authentication from the UHMG. Nonconnection confidentiality must provide data confidentiality before the device connects to a specific domain.

3.2.1 Comparison among CAC in U-multimedia framework and the existing extended RBACs

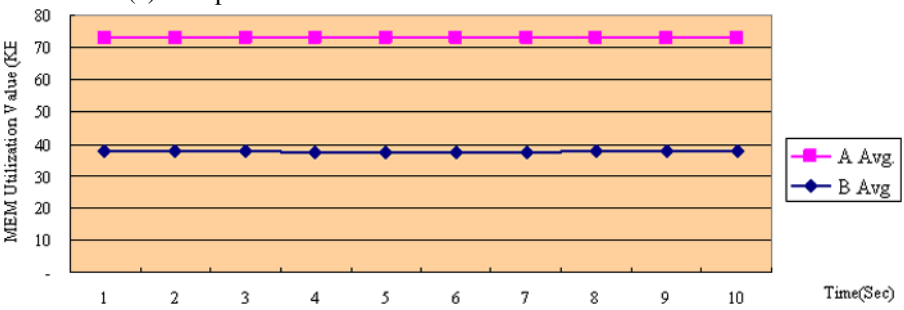
CAC in U-Multimedia Framework considers role and authority of the existing extended RBAC models [15, 16] and supports role constraints according to information of user location, In addition, it supports delegation/multilevel delegation between user and device, considering domains. Furthermore, it supports flexibility based on context information and supports access control considering the properties of home service under a ubiquitous environment, Finally,it supports user location access control using WSN agent (refer to Table 4).

3.2.2 The efficiency of consuming system resources

In this paper, the efficiency of consuming system resources in IMP, which is a component of the proposed system, is discussed. We experimented two cases; (A) case



(a) Comparison on the CPU use ratio in case A and B of IMP



(b) Comparison on the memory use amount in case A and B of IMP

Fig. 4 Comparison on the use of CPU and memory in case A and B of IMP

where multimedia contents are generally played in IMP and (B) case where multimedia contents are transcoded to fit the specification of IMP using VTDIC algorithm described in Sect. 3.1, sent, and played in IMP. The efficiency of consuming system resources is measured by observing the CPU use ratio and memory use amount.

In the first experiment, the CPU use ratio was observed. Given that the same multimedia contents were played in IMP for cases A and B, the CPU use ratio for 10 seconds was measured. The same experiment was repeated three times. The results have shown as an average CPU use ratio of 18.4 and 94.6% each. Thus, compared to the ordinary method of playing multimedia contents, CPU use ratio is reduced by 76.2% when playing the contents with the proposed U-Multimedia Framework.

In the second experiment, the memory use amount was observed. Given that the same multimedia contents were played in IMP for cases A and B, the memory use amount for 10 seconds was measured. The same experiment was repeated three times. The results have shown as an average memory use amount of 37.6 and 72.9 KB each. Thus, compared to the general method of playing multimedia contents, memory use amount is reduced by 35.3 KB when playing the contents in U-Multimedia Framework.

In conclusion, as shown in Fig. 4, the proposed U-Multimedia Framework model has a significantly improved efficiency of consuming system resources when playing multimedia contents compared to the ordinary playing method.

4 Conclusion and future work

Ubiquitous computing grants intelligence to the elements of the world and provides user-oriented services. In addition, it will be provide human with comfortable and easy life. However, without resolving the security issue, the services will be hard to serve to users.

This paper presented a framework which can provide secure and intelligent multimedia services based on context information in U-home. Furthermore, the framework provides security, expandability, and flexibility in U-home environment which has advanced a step further than the existing home network environment. Moreover, CAC, which is the core of the framework, uses temporal and spatial context information to reflect dynamic environmental elements. In other words, the merit of CAC is that it can dynamically decide access control according to the context information. Finally, the framework improves the efficiency of consuming resources by applying the current context information of devices.

Context based services will be very useful to human in the future. Considering, however, the problem of infringement of privacy by this kind of leakage of context, we must make use of them with care. Accordingly, we plan to expand and develop models to apply protection of context privacy in the future.

Acknowledgements The research work is supported by Kyungnam University. In addition, we appreciate G. Kousalya for providing the proof reading of this paper.

References

1. Park JH, Lee S, Hong SH (2006) C-iUMS: Context based smart and secure multimedia service in intelligent ubiquitous home. In: TRUST'06 (EUC 2006). Lecture notes in computer science, vol. 4097. Springer, Berlin, pp. 660–670
2. Park JH, Park J-S, Lee S, Koh B-S (2006) A DRBAC model based on context for smart and secure services in intelligent ubiquitous home. In: UIC-06. Lecture notes in computer science, vol. 4159. Springer, Berlin, pp. 893–901
3. Park JH, Lee S, Hong I-H (2006) DRBAC model using a WSNM for Services in i-Home. IEICE Trans Inf Syst E89-D(12) 2831–2837
4. Park JH, Lee S, Koh B-S, Jang J-H (2006) uiH-PMAC model suitable for Ubi-Home gateway in ubiquitous intelligent environment. In: KES 2006. Lecture notes in artificial intelligence, vol. 4252. Springer, Berlin, pp. 777–784
5. Park JH, Lee J-CS, Park HU, Lee DG (2005) User-oriented multimedia service using smart sensor agent module in the intelligent home. In: CIS 2005. Lecture notes in artificial intelligence, vol. 3801. Springer, Berlin, pp. 313–320
6. Weiser M (1991) The computer for the 21st century. Sci Am 265(3), 94–104
7. Weiser M (1993) Some computer science problems in ubiquitous computing
8. Park JH, Lee DG (2007) PIS-CC RBAC: Patient information service based on CC-RBAC in next generation hospital considering ubiquitous intelligent environment. In: MUE2007. IEEE Comput Soc, Los Alamitos, pp. 196–200
9. Ferraiolo DF, Sandhu R, Gavrila S, Kuhn DR, Chandramouli R (2001) Proposed NIST standard for role-based access control. ACM Trans Inf Syst Secur (TISSEC), pp. 224–274
10. Covington MJ, Fogla P, Zhan Z, Ahamad M (2002) A context-aware security architecture for emerging applications. ACSAC'02, USA
11. Hu J, Weaver AC (2004) A dynamic, context-aware security infrastructure for distributed healthcare applications. In: Pervasive security, privacy and trust (PSPT2004), Boston, MA

12. Zhang G, Parashar M (2004) Context-aware dynamic access control for pervasive applications. In: Proc. of the communication networks and distributed systems modeling and simulation conference (CNDS 2004), Western Multi-Conference (WMC), San Diego, CA, US
13. Park JH, Song J, Koh B-S, Lee D-G, Park B-H (2006) A hybrid intelligent multimedia service framework in next generation home network environment. In: ICHIT 2006 proceeding
14. Gom Player website: http://www.gomplayer.com
15. Sandhu RS, Coyne EJ, Feinstein HL, Youman CE (1996) Role based access control models. IEEE Comput 29(2), 38–47
16. Joshi JBD, Bertino E, Latif U, Ghafoor A (2005) A generalized temporal role-based access control model. IEEE Trans Knowl Data Eng 17(1), 4–23

Deok Gyu Lee received his Ph.D. degree in the Graduate School of Computer Science from Soonchunhyang University, Korea. He is now a post-doc of R&D Institute, ETRI Electronics and Telecommunication Research Institute (ETRI), Korea. Dr. Lee has published many research papers in international journals and conferences. Dr. Lee has served as Chairs, program committee for many international conferences, and workshops; Chair of ISA'08, DMUC'07, and PC member of IS'07, TRUST'07, ASWAN'07 and so on. Dr. Lee's research interests include Key Management, signature schemes, Broadcast Encryption, Contents Security, Wireless Security, Ubiquitous Computing, Home Network, etc. He is a member of the KICS, KIISC, KMS, and IEICE.

Jong Hyuk Park received his Ph.D. degree in the Graduate School of Information Security from Korea University, Korea. He is now a professor at the Department of Computer Science and Engineering, Kyungnam University, Korea. Dr. Park has published many research papers in international journals and conferences. Dr. Park has been served as chairs, program committee, or organizing committee chair for many international conferences and workshops. Dr. Park is the founder of the International Conference on Multimedia and Ubiquitous Engineering (MUE), International Conference on Intelligent Pervasive Computing (IPC), and the International Symposium on Smart Home (SH). Dr. Park is editor-in-chief of the International Journal of Multimedia and Ubiquitous Engineering (IJMUE), the managing editor of the International Journal of Smart Home (IJSH). In addition, he has been served as a guest editor for international journals by some publishers: Oxford, Emerald, Hindawi, Springer, Elsevier, Interscience, and SERSC. Dr. Park' s research interests include Digital Forensics, Security, Ubiquitous and Pervasive Computing, Context Awareness, Multimedia Services, etc.

Tai-Hoon Kim received his M.S. degrees and Ph.D. in Electrics and Electronics & Computer Engineering from the Sungkyunkwan University, Korea. Now, he is currently a professor of Hannam University. He wrote 16 books about the software development, OS such as Linux and Windows 2000, and computer hacking & security. And he published about 100 papers by 2006. He was a chair and program committee of international conferences and workshops. He was a guest editor of AJIT and FGCS Journal, and now he is an editor-in-chief of JSE and IJSIA Journal. He researched security engineering, the evaluation of information security products or systems with Common Criteria and the process improvement for security enhancement. In these days, he researches also some approaches and methods making IT systems more secure.

Laurence T. Yang'**s** research includes high performance computing and networking, embedded systems, ubiquitous/pervasive computing, and intelligence. He has published around 280 papers in refereed journals, conference proceedings, and book chapters in these areas. He has been involved in more than 100 conferences and workshops as a program/general conference chair and more than 200 conference and workshops as a program committee member. He served as the vice-chair of IEEE Technical Committee of Supercomputing Applications (TCSA) until 2004, currently is the chair of IEEE Technical Committee of Scalable Computing (TCSC). In addition, he is the editors-in-chief of 10 international journals and few book series. He is serving as an editor for around 20 international journals. He has been acting as an author/coauthor or an editor/coeditor of 30 books from Kluwer, Springer, Nova Science, American Scientific Publishers, and John Wiley & Sons.