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ホームネットワークにおける柔軟な機器利用を考慮した機器接続構成アルゴリズム

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近年、ホームネットワーク分野ではECHONETやUPnP, DLNA, OSGiなどのプロトコルが規格化され、機器間の相互接続を容易に行なえる環境となりつつある。一方、宅内にはレガシーなインタフェースしかもたない家電が多く存在する。このようなホームネットワークに対してサービスを提供する会社は、レガシーな家電とネットワークインタフェースを持つような情報家電を柔軟に組み合わせてサービスを提供することが求められている。我々は新旧の家電が混在するホームネットワーク環境で最適なサービス環境を提供するために、柔軟な機器利用を可能とする機器接続構成アルゴリズムを提案する。これにより機器の構成が異なる家庭環境でも柔軟に機器を利用した統合型ホームネットワークサービスを提供することが可能であると考える。

A Composition algorithm of Appliances for flexible Home Netwoking

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In recent year, many fields of industry, which include the ECHONET, UPnP, DLNA and OSGi, evolved to create interworking solution for ubiquitous home networking. Accordingly, service provider becomes to be needed to composite devices through these solutions including legacy appliances. In this paper, we proposed a composition algorithm of appliances that can provide a suitable service for home network environment. It is expected that will be able to provide an integrate service flexibly even if each homes have different environment.

1. Introduction

For more than a decade, an appliance in the networked home environment has developed as various fields by industry and academic researchers. Especially, providing integrated services to end-user with briefly establishment of the appliances has been considered for actualizing ubiquitous home networked environment.[1)] However, there are several challenges which need to be considered that interoperability between these appliances and difficulties associated with the integration of combined functionality.[3)]

Currently, in the challenges of above, number of industry have tried to give solution as their own field such as Universal Plug and Play(UPnP)[2)], Digital Living Network Alliance(DLNA)[4)], the Open Services Gateway Initiative(OSGi)[5)] and the Energy Conservation and Home care Network(ECHONET).[6)] Despite the list of solution they provide, we still have a problem that these solutions do not provide any capability for composing services between connected appliances include a legacy appliances.

In this paper, we proposed a composition algorithm of appliances that can provide a suitable service for home network environment. We believe that will be able to provide an integrate service flexibly even if each homes have different environment. Section 2 gives an overview of the background of issue and it's requirement. Section 3 discusses our proposed system model and describes how we address composition of appliance. Section 4 describe our experimentation. Section 5 discusses our conclusions and future work

2. Background

Generally, infrastructure of the appliances in the home network environment is composited by diver-

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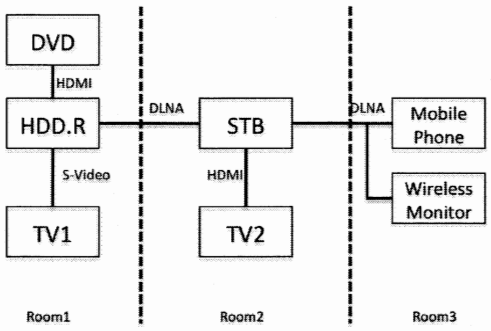

図 1 Example of networked home environment

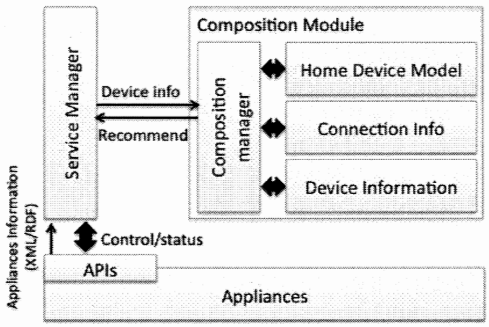

図 2 Structure of the Composition system

sification of an agreement from different kind of industry. For example, there exist Audio and Video electronics, not only a brand new DVD player which can provide a functionality of DLNA and capability of HDMI but also the past generation of TV only have a terminal of S-video.

Figure 1 is shown the example of networked home environment. The appliances, can provide a multimedia service with DLNA between each room, are composited with legacy AV such as TV1, DVD player and TV2. In this case, a centralized service manager might not provide an integrated service since the service manager could not be looked up the composition between the appliances. For example, when user located on front of TV2 in the room2, want to watch a movie using DVD player located in Room1, service manager has to establish the composition of the appliance such as DVD, HDD.R, STB and TV2. Moreover, a capability of the appliances need to be considered the Quality of Service(QoS). In the below, we have defined a number of the requirement for flexible composition between the variety of appliances.

- Possibility of the composition: Service manager has to define all of the possibility of composition on existing appliance in the home.
- Capability of service: The composition has to be considered the QoS of an appliances which is composited by service manager.
- Observation of a state of device: The devices have to be watched on the state carefully since their could provide other service on a concurrent operations.

These challenges form the basis of our approach and in the following sections we discuss how they have been addressed within our system.

3. Proposed system

The system we have designed ensures the integration of the appliances composition, which mean that the system is covered a vast range of an agreement from various industry, include the legacy appliances. In our system, we preponderantly considered a methodology, how to discover the all of possibility of composition between thus appliances. As same time, the system determine the best possible of QoS on the discovered list of the composition.

3.1 Structure

Figure 2 is shown the structure of the composition system. The Service Manager handles the appliances through the API within providing the Integrated service according to a service scenarios.

The Information of the appliances such as Model name, number and functions are registered to the service manager using the XML or RDF(Resource Description Framework). When the service is required with the compositing of the appliances, the Service Manager request it to the Composition Module with providing the information of the Device and the status of the appliances. The Composition Manager discover all of the composition list and transmit the recommendation which is determined on these lists as more appropriate composition.

3.1.1 Device Information

The Composition Manager storages the Device Information received from the Service Manger, such as a device type, model name and a connecter type. It is used to discover the possible composition of appliances by the Home Device Model. In the follow, we have define the contents of data in the Device Information.

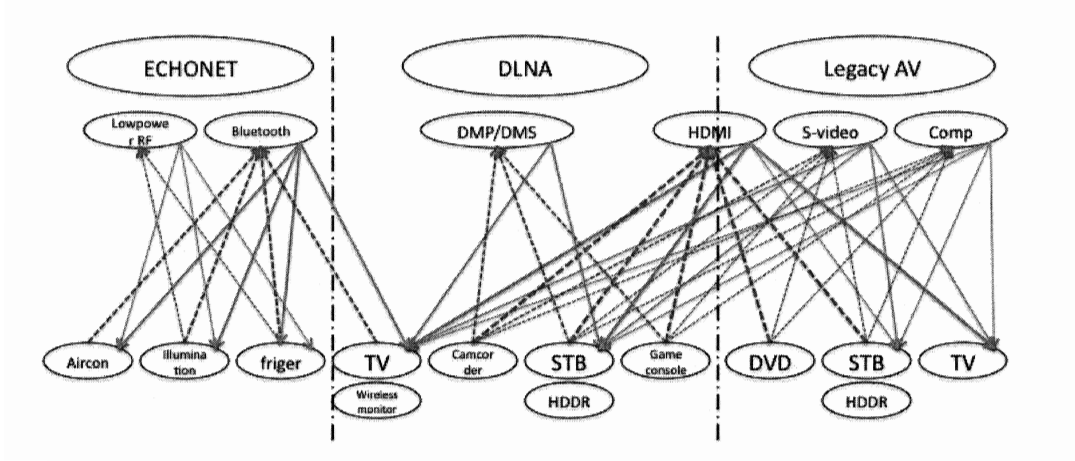

図 3 Description of the Home Device Model

- Index: index of the Model Name
- Device Type: TV, DVD, STB
- Model Name: a proper name from a manufactory
- Connecter Type: HDMI, S-video,DLNA
- Direction: input/output

3.1.2 Connection Information

The possible composition list obtained from the Home Device Model are needed to compare with the existing connection of the appliances which is in the real home environment. Also Connection Information module provides the state informations of the device since an appliance might be in the working as concurrent operation. In this case, the composition manager has to discover other possible composition.

- Connection: BOOL(True/False)
- Operation: BOOL(True/False)

If the appliance is working on other service, the service manager announce the state to the composition manager and these information are renewed to the 'False' on the connection information module.

3.1.3 Home Device Model

The Home Device Model provides a brief of a structure for the composition modeling of devices, the existing devices in the home environment are referred on this model, which is contained an information of the capability of the appliances. Figure 3 is shown the description of the home device model, which is covered three different agreement of device.

The model is considered as relation between the device and efficiency of the connection instrument their own. In the describing the composition model, the classification might be three divisions as follow.

- Devices
- Connection instrument
- Interrelation

Each device has several connection instrument and the direction of input/output, it is expressed by the lines between class of the devices and class of the connection instrument. A same device type which has different connection instrument may exist same agreement area by indexing the each device from the model name.

The interrelation between the device and connection instrument is represented by a weight of the lines, it is determined according to the Quality of capability.

3.2 Algorithm

The algorithm of device composition are divided to number of a procedure. First of all, searching the whole composition route on the device model. Second, determining the best recommendation on the composition list as the QoS and efficiency of operation.

3.2.1 Route searching

To search the whole route on the device model, we need to consider the possibility of infinity loop between the device. In this case, need to define several precondition such as follow.

- The searching must not be visited same device within the process.
- A number of hope has to be smaller then number of the device in the home.

In this algorithm, we referenced the DFS(Depth first Search) that is an uninformed search that progresses by expanding the first child node of the search tree that appears and thus going deeper and

```
def fun_Composition(start_index,reach_index):
  DeviceOut=fun_capable_output(start_index)

  for i in range(0,len(DeviceOut)):


            Possible_dev=fun_capable_input(DeviceOut[i])

            for j in range(0,len(Possible_dev)):

              fun_disp(DeviceOut[i])

              if DeviceInfo[possible_dev[j]][DeviceType] !=
DeviceInfo[reach_index][DeviceType]:

                fun_disp(Possible_dev[j])

                resch=DeviceInfo[possible_dev[j]][Index]
                fun_Composition(resch,reach_index)
              else:

                fun_disp(Possible_dev [j])
```

図 4 The Composition Algorithm

deeper until a goal node is found, or until it hits a node that has no children.

The figure 4 is shown the brief of the composition algorithm. In depending on this figure, `fun_composition` receive an devices index of start and object as a factor. The function of `fun_capable_output` is searching the list that is possible output instrument on the start device. `fun_capable_input` receive the factor of each index searched by `fun_capable_output`, looking up the possible input as same variety of instrument. If a result of the index which is input instrument searched by `fun_capable_input` is matched with the index of the object, the output instrument is being next list. In negative case, `fun_composition` is called out as a recurrence with renewing the index of start device.

3.2.2 Determination of the composition

For determining the best composition, need to preponderantly considered how to define the relation between two items as follow .

- Quality of Service
- Efficiency of operation

Tho QoS is determined by the capability of the connection instrument. composition manager storage the worst weight of the connection instrument on the result which as each possible composition

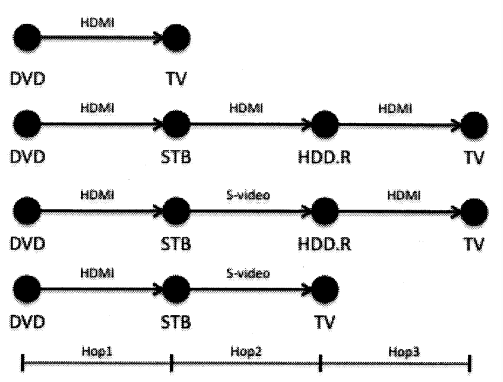

図 5 Relation between the Quality and Efficiency

since the quality of the connection is depended on a consistency. For example as figure 5, the quality of third line just has the value of S-video.

The service manager prevents to ignore the accidently increasing the scale of the composition considering number of the hop between the appliance For the efficiency of the operation.

$$Q = Cw/Ct * 100 \quad (1)$$

The Cw is the worst weight, Ct is number of instrument.

$$E = Hn/Hm * 100 \quad (2)$$

The Hn is the number of hop, Hm is maximum number of hop.

Above the quality Q and efficiency E are used to determine the flexible composition depending on the user preference by the service manager.

As you can see the figure 5, the best composition might be the first line on the list . Hence, in case of the ambiguous such as second and fourth line, service manager is needed a standard of valuation.

4. Experiments

In order to implement the system, we constructed using four home appliance informations of which has virtually distributed in the world, Panasonic TV: PZR900, DVD: BW930, Set-top-box: TZ-DCH and Sony TV: KDE-P3 as the Table 1, is that described the connection instrument of each device.

We described the relations between a devices and a connection instruments based on the information which is from the Table 1 as the Figure 6, according to the Home Device Model . In this implement, Each connection has the weight of capability, we chose the precedence of the minimum and, all of the connection instruments were established in the

表 1 Device Information

Index	Device Type	Mode name	Manufacturer	HDMI		DLNA		D4		S-video		Comp	
1	TV	PZR900	Panasonic	In	X	In	X	In	X	In	X	in	X
2	DVD	BW930	Panasonic	X	Out	X	Out	X	Out	In	Out	X	Out
3	STB	TZ-DCH	Panasonic	In	Out	In	Out	In	Out	In	Out	in	Out
4	TV	KDE-P32	SONY	X	X	X	X	In	X	In	X	In	X

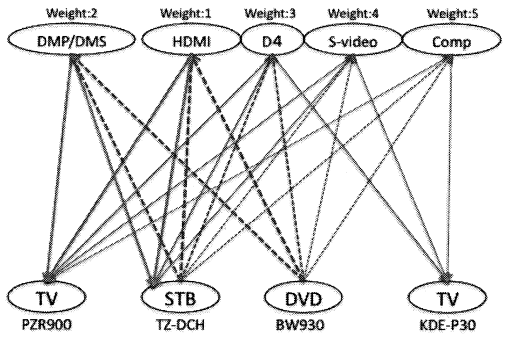

図 6 Modeling the Device

```
Index   Type    Capability      Direction       weight  manufacturer    state
2       'DVD'   'HDMI'          'Output'        1       'BW930'         1
1       'TV'    'HDMI'          'Input'         1       'PZR900'        1
succes----------------------------
2       'DVD'   'HDMI'          'Output'        1       'BW930'         1
3       'STB'   'HDMI'          'Input'         1       'TZ-DCH'        1
3       'STB'   'HDMI'          'Output'        1       'TZ-DCH'        1
1       'TV'    'HDMI'          'Input'         1       'PZR900'        1
succes----------------------------
3       'STB'   'Svdo'          'Output'        4       'TZ-DCH'        1
1       'TV'    'Svdo'          'Input'         4       'PZR900'        1
succes----------------------------
3       'STB'   'Svdo'          'Output'        4       'TZ-DCH'        1
4       'TV'    'Svdo'          'Input'         4       'KDE-P32'       1
Dead-end<-------------
3       'STB'   'COMP'          'Output'        5       'TZ-DCH'        1
1       'TV'    'COMP'          'Input'         5       'PZR900'        1
succes----------------------------
3       'STB'   'COMP'          'Output'        5       'TZ-DCH'        1
4       'TV'    'COMP'          'Input'         5       'KDE-P32'       1
Dead-end<-------------
2       'DVD'   'DLNA'          'Output'        2       'BW930'         1
1       'TV'    'DLNA'          'Input'         2       'PZR900'        1
succes----------------------------
2       'DVD'   'DLNA'          'Output'        2       'BW930'         1
3       'STB'   'DLNA'          'Input'         2       'TZ-DCH'        1
3       'STB'   'HDMI'          'Output'        1       'TZ-DCH'        1
1       'TV'    'HDMI'          'Input'         1       'PZR900'        1
succes----------------------------
3       'STB'   'Svdo'          'Output'        4       'TZ-DCH'        1
1       'TV'    'Svdo'          'Input'         4       'PZR900'        1
succes----------------------------
```

図 7 The Part of the composition result

enable of a state which mean that the system might search whole possibility to composite the device.

A value of the weight is decided depend on quality of the connection instrument, HDMI provided the resolution of maximum 1080i(Interace scan), D4 is 1080i, S-video is maximum 720p(Progressive scan) and Comp is maximum 480i.

The Figure 7 is illustrated the result of the composition list obtained from the device model, the searching condition is that find the all possible composition list from DVD BW930 to TV PZR900. The possible compositions are indicated as 'success', if an appliance is end-node which mean the possible node to connect is not existing more, marking it as 'dead-end'.

5. Conclusion

In this paper, we proposed a framework to flexibly composite the appliances on the networked home environment for providing integrate service. Our system make two novel contribution 1) The device model provides representing the relation of the connection instruments on the device, and 2) the composition algorithm search the possible composition in the device model.

We strongly expect that our system will provides to recommend the methodology how to select the best composite to an integrate service manager in various home environment. Also, we believe it could be worked on an assistance to build an appliance into the home. However, we still have several challenge as an embodiment of the methodology such as the considering on QoS, efficient and context aware service for the understandable centralization computer.[7)]

In the future work, we will carefully develop the system according to the integrate service application on considering what we mentioned above.

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