Device Coordination

1. Introduction

This document is intended to be an initial base document on which further device coordination is developed.

1.1 Concept

Recent advances in computing technologies and network infrastructure have enabled to provide rich services either local or remote to users through a variety of mobile devices such as digital cameras, handheld computers, PDAs, and smart phones. A wide range of services including home/office networking, location-based services, and intelligent traffic management services are becoming more available than ever, technically practical and financially affordable. In particular, Web-related technologies have contributed to enhance the realization of ubiquitous applications by means of their rich interoperable and extensible mechanisms that have been widely accepted in many domains.

In spite of the rapid growth of Ubiquitous Web Applications (UWA), they impose several important challenges to provide useful services to relevant users through suitable devices. Specifically, services that are either local or remote, explicit or implicit, and individual user-targeted or a group of user-oriented can have diverse characteristics. Therefore, how to unambiguously describe services to discover them in a ubiquitous environment needs to be addressed. Especially, for providing such services, it is also necessary to establish solid relationships between devices and services that they provide.

In a ubiquitous environment, devices may play as clients, servers, or a combination of both. Depending on their roles, devices need to efficiently be accessed and effectively utilized to provide useful services to users. To meet these requirements, how to clearly identify devices and bind them to services needs to be addressed. Furthermore, more often than not, capabilities of devices in providing services or performing computational tasks vary ranging from a simple sensory capability to high decision making performance. Therefore, their capabilities and their usage states corresponding to service provision are to also be specified in an unambiguous way.

In addition to services and devices, special care needs to be taken to consider users preferences. Therefore, discovering devices and biding them to a certain set of services involve a process of describing user's needs and searching for a matching resource. In this process, users can be asked to specify their preferences interactively, or other third-party can be assigned to manage the user preference. Both the two cases, however, require well-defined specification of user preference that can be supported by CC/PP that has already been accepted as a recommendation of W3C.

For Ubiquitous Web Applications, services, devices, resources, and user preference need to be harmonized. More specifically, web applications providing services through devices need to be able to access proper resources in accordance with their capabilities and user preference through well-defined interfaces without the need to consider internal implementation or network-specific aspects. To this end, it is necessary to develop a mechanism for devices to find available resources, bind to them, and adapt their capabilities to provide specific services or exchange information concerning the states of service provision processes. This procedure is closely related to coordination among heterogeneous devices within a system.

Device coordination plays a crucial role in deal with these challenges listed above. It covers the means for discovering and binding of resources into application sessions in consideration of user preference. This involves consideration of how to describe user preferences, device capabilities,

and services as a basis for discovery. Moreover, device coordination is responsible with handling interdependencies among devices, resources, and user preference in providing seamless services to users.

1.2 Formal Definition of Device Coordination

Device coordination is considered a mechanism that aid to managing interdependencies among devices that have different types or levels of capabilities to provide services in such a way that users can enjoy the benefits of the services [1], [2]. Although there are several facets in interdependencies, this document considers interdependencies from a resources' perspective. How to describe resources and how access control mechanisms to be applied to resources of individual device are among the important issues in device coordination.

Device coordination is broadly defined as a mechanism to eliminate or at least mitigate the interdependencies among devices to achieve a mutually agreed goal service by means of facilitating purposeful communication between devices and adjusting their resource usages.

Formally, it is represented by the following expression: Device coordination (γ) can mathematically be represented as a function such that

$\gamma : D_C^{req} \times D_R^{resp} \rightarrow S_U$, where D_C^{req} is a set of service-requesting devices with a capability set C, D_R^{resp} is a set of service-providing devices with a resource set R, and S_U is a set of services that are provided to a user set U .

Device coordination takes two device sets as input parameters in order to coordinate them $\left(s_u = \gamma\left(d_p \times d_q\right), s_u \subseteq S_U, d_p \subseteq D_C^{req}, \text{and } d_q \subseteq D_R^{resp}\right)$. It bridges gaps between capability and resource of devices to provide services to users.

A narrow definition of device coordination in terms of UWA is given as follows:

Device coordination involves a means to describe capabilities of devices and required resources to provide services and relationship between such devices and services, establish a scheme to discover services and bind devices to them, and provide a protocol-independent mechanism to enable event exchanges between them for the purpose of providing users with useful services fitting to user preference.

Fig.1. shows a schematic representation of the narrow definition of device coordination.

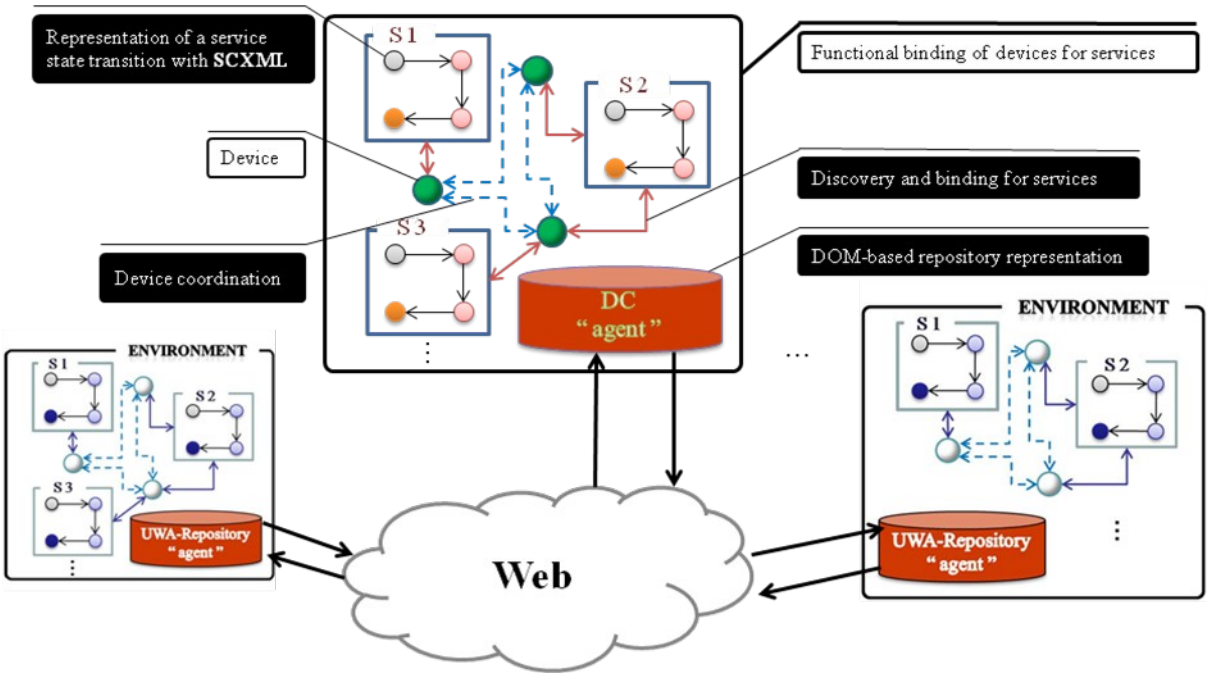


Fig. 1. A Schematic Representation of the Narrow Definition of Device Coordination

To realize the device coordination as the above narrow definition, there are several issues to be addressed. These are related to services,

Device coordination consists of several major steps. The first is related to services (SCXML for a Service). It is obvious that device coordination may not be required during all service lifecycles (sessions). Put other words, device coordination can be dependent of states of a service. For example, when a phone rings, other devices related to sound volume need to change their volume level for conversation over the phone. This volume change of other devices is, however, required only after a user pick up the phone to start conversation. This shows a situation that device coordination is invoked depending on states of a service. Therefore, it may need to describe service state transitions by means of possibly SCXML concerning device coordination.

The second is to identify and describe the relationship between services and devices (DSDL). Similar to WSDL (Web Service Description Language), it is necessary for device coordination to have a specification to describe what service is available for a device and how the service can be provided by accessing certain resource of the device. For this reason, resource binding plays an important role in device coordination, and it needs to be considered in the relationship between services and devices. Available resources can be exposed via well-established web technologies such as markup and scripting.

Information about why and how device coordination is invoked may need to be shared among devices (DCC). In this case, indeterminacy of communication or conversation among devices should be considered in coordinating devices. For example, current resource usage/availability or adjusting capability of a device needs to be transparent to other devices that possibly are interconnected via different protocols. Therefore, how to exchange events and the context of device coordination should be considered an important facet. DOM-based representation of conversation between devices and services can be a potentially effective candidate to support this aspect, and it is necessary to devise a specification for device coordination context to support the coordination mechanism. The device coordination context can be a data structure used to mark messages belonging to the relevant web application involved in device coordination, and it may contain elements that identify a service type and uniquely describe the instances of that service type.

1.3 Relationships with Other Technologies

To achieve seamless device coordination, it is necessary to share information among devices involved in providing useful services to users.

1.3.1 CC/PP(Composite Capability and Preference Profile)

A CC/PP profile is a description of device capabilities and user preferences. Devices which join in coordination may have different capability and preference according to the types of devices and the status of users. The device capabilities and user preferences may be considered in device coordination and they can be referred in the description of CC/PP.

1.3.2 Delivery Context: Client Interfaces (DCCI)

DCCI provides a framework for client-side access to a hierarchy of device properties together with a means to set event handlers for notifications of changes to property values. In some cases, device coordination should recognize the properties of individual devices to provide data or information in proper manners (e.g. display, CPU, speaker, etc.).

1.3.3 DIAL(Device Independent Authoring Language)

DIAL provides the filtering and presentation of Web page content available across different delivery contexts. It enables to accomplish device-neutral data and information transmission in the course of device coordination.

1.3.4 RDF(Resource Description Framework)

RDF provides a general method of representing information in the Web. It enables to coordinate devices in consideration for data semantics of Web resources which can be accessed on the Web and be utilized by devices for the purpose of effective coordination.

1.3.5 SCXML (State Chart XML)

SCXML specified a state-machine based execution model based on Harel State Tables. The state transitions described in devices can be referenced to recognize current or potential states of each device for the optimized device coordination.

1.4 Scope and out-of-scope

1.4.1 Scope

There are a variety of ubiquitous devices access to the Web, such as mobile phones, smart phones, personal digital assistants, interactive television systems, voice response systems, kiosks and even certain domestic appliances. Unfortunately, any common and generic way to help them communicate on the Web has not been provided so far. This work addresses the challenges of offering the standardized mechanism of enabling the device coordination. This work aims to design the following components.

- Communication protocol: There are several communication protocols, such as Web services, UPnP, Bluetooth, etc. In the other hand, although the ubiquitous devices are accessible to Web, they have often a great difficulty in timely communicating with others in heterogeneous environments. A simple and generic standardized way to Web-based device communication is required in order to support dynamic and nomadic coordination of

Ubiquitous Web Applications. To achieve the goal, it can be seamlessly interoperated with the existing communication protocols commented above.

- Device description: The Ubiquitous Web Applications Working Group has proposed suitable standards of describing the properties of ubiquitous devices and users. To realize device coordination, it should be possible to recognize the properties of devices which can be considered to coordinate in users' preferences and needs. The issue includes what properties to describe for the devices, how to describe the properties, and how to bind them with other related technologies.

- Coordination mechanism: To bind the services in Ubiquitous Web Applications and manage the dependencies of services, the light and concrete mechanism of device coordination is necessary. It may contain a variety of issues, such as device discovery, service registration, conflict resolution, event handling, etc.

- Security and privacy: Considering a situation where a user uses multiple services through devices that can be shared among other users, security and privacy are also important issues in device coordination.

1.4.2 Out-of-scope

Intuitively, device coordination involves a variety of aspects such as how to represent common goals of multiple devices, how to group certain sets of devices together, how to assign services to specific devices, how to allocate resources among different devices, how to determine priority among services provided by different devices, and how to share information such as user context and environmental factors among devices. Even though these aspects impose great challenges on device coordination, it is considered beyond the scope of this document. However, these can be implemented to specific application domains by means of the framework and mechanisms proposed in this document.

1.5 Definition of Terms

Capability

An attribute of a sender or receiver (often the receiver) which indicates an ability to generate or process a particular type of message content.

This term was taken verbatim from Composite Capability/Preference Profiles (CC/PP): Structure and Vocabularies 2.0.

Coordination

A mechanism of binding separated activities of multiple actors, agents, or computing devices in order to achieve the proper goal. See also the Device Coordination.

Device

An apparatus through which a user can perceive and interact with the Web.

This term was taken verbatim from Glossary of Terms for Device Independence.

Delivery Context

A set of attributes that characterizes the capabilities of the access mechanism, the preferences of the user and other aspects of the context into which a web page is to be delivered.

This term was taken verbatim from Glossary of Terms for Device Independence.

Device coordination

A mechanism to eliminate or at least mitigate the interdependencies among devices to achieve a mutually agreed goal service by means of facilitating purposeful communication between devices and adjusting their resource usages.

Preference

An attribute of a sender or receiver (often the receiver) which indicates a preference to generate or process one particular type of message content over another, even if both are possible.

This term was taken verbatim from Composite Capability/Preference Profiles (CC/PP): Structure and Vocabularies 2.0.

Resource

A network data object or service that can be identified by a URI. Resources may be available in multiple representations (e.g. multiple languages, data formats, size, resolutions) or vary in other ways.

This term was taken verbatim from Glossary of Terms for Device Independence.

Service

An abstract resource that represents a capability of performing tasks that form a coherent functionality from the point of view of providers entities and requesters entities. To be used, a service must be realized by a concrete provider agent.

This term was taken verbatim from Web Services Glossary.

User

An individual or group of individuals acting as a single entity. The user is further qualified as an entity who uses a device to request content and/or resource from a server.

This term was taken verbatim from Composite Capability/Preference Profiles (CC/PP): Structure and Vocabularies 2.0.

2. Use Cases

This document presents major uses cases that device coordination can contribute for effective service provision. Each case highlights the need for Device Coordination in realizing Ubiquitous Web applications.

2.1 Home Networking

2.1.1 Automatic volume control

If a person receives a phone call, automated volume control systems, such as audio components and digital television, will lower their volumes to avoid interference automatically.

1.5.1 Home -theater system

A user can watch video on PDP in the living room, which was recorded on his or her cellular phone.

The video files which were recorded on his or her cellular phone can be played on the HDTV in the living room.

1.5.2 Home appliance

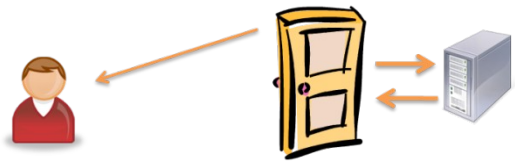
If a user turns on the radio in the kitchen, PDP will lower the volume in the living room.

1.5.3 Risk detection

If any fire risk is detected (e.g., gas leakage), it will be alerted the fire station to.

1.5.4 Door opening

A home security system needs to automatically identify a resident and unlock the door.



2.2 Location-based Service

2.2.1 Location-based Restaurant Recommendation

If a user search for a restaurant on PDA, it will recommend restaurants close to his/her location.

2.2.2 Location-based Direction Providing Service

If a user searches for a destination on his/her cellular phone, it will provide the shortest path from a standing point to the location.

2.3 Personalized Service

2.3.1 Intelligent Music Playing Service

An MP3 player will recognize a user's current mood, it plays a piece of music in an appropriate genre.

2.3.2 Movie Information Service

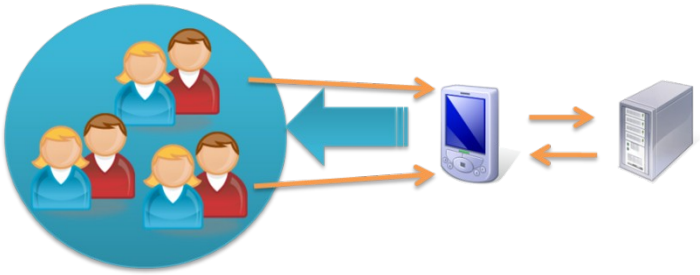
A user can search for newly released movies, and make a reservation for the ticket right on the spot.

2.3.3 Product Information Service

A PDA provides all the information for hot items that are daily advertized and suitable shops as well.

2.3.4 Multi-user Preference matching Service

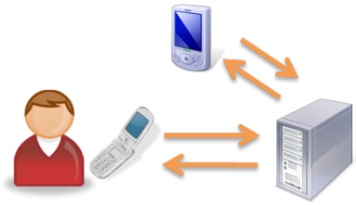
A device needs to provide services that can satisfy multiple users' preference in consideration of their device capabilities.



2.4 Device dependent service

2.4.1 Device selection

A user's schedule will be transmitted from a remote device to whatever device the user is currently using.



2.4.2 Device modality adaptation

If a PDA is not equipped with a sound system, it will automatically transfer sound to a desk top computer.

2.5 Intelligent Traffic Systems

2.5.1 Traffic congestion

A navigation system constantly receives traffic information from devices installed on roads and traffic light systems, and provides the best possible route for the driver.

2.5.2 Weather forecasting / monitoring

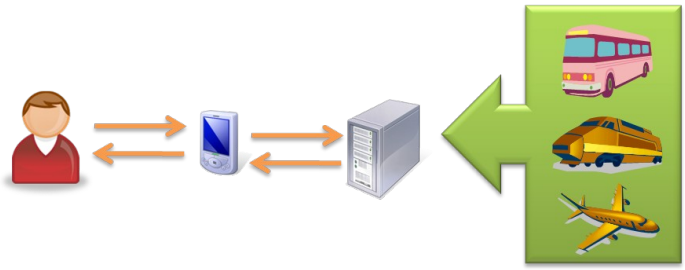
If a user queries for weather information via his or her PDA, it will provide weather information in consideration of the user's schedule and location.

2.5.3 Subway path

If a user searches for the shortest path to the destination, his or her PDA will provide a route in consideration of the location of the closest subway from the standing point.

2.5.4 Transportation Information Providing Service

If a user searches for a direction for a specific location in front of a kiosk, it will provide the best possible transportation method to the destination.



2.5.5 Bus Arrival Information Providing Service

A PDA provides arrival time of the bus at the nearest bus stop.

2.6 Mobile Banking Service

2.6.1 Electronic payment

A user can use a wire transfer or purchase goods with his or her cellular phone.

2.6.2 Amusement Park Payment System

A user can purchase a family ticket with PDA, and each of family member's cellular phone be used as a means to show tickets for the rides.

2.6.3 Banking

A user can use a banking service in front of an ATM by connecting his or her PDA that stores the user's PIN information.

2.6.4 Shopping mall

Current shopping information will be transferred from the user's desktop to his or her PDA, so the user can continue shopping on the road.

2.7 Education

2.7.1 Online Lecture

If a user answers a question wrong on his or her PDA, a lecture will be provided specific to the question that the user answered wrong.

2.7.2 Level Based Education

If an instructor records student's cores, the proper study materials will be sent to each student's PDA

3. Requirements

R01. Device and service must have its own universally unique identifier, respectively.

R02. Device and service description must specify a profile about it, respectively.

R03. Each device must provide at least one or more than one service.

R04. Each device must communicate with only one coordinator at a time.

R05. Relationships between a device and a service must clearly be specified.

R06. Device capabilities of device specified in device description must be available at the time when a service needs to be provided by the device.

R07. Device description must describe the operational request and response messages between devices.

R08. A service may have relationship with at least one or more than one other service.

R09. A service description must be able to express composition of one or more than on service.

R10. A service must express its own state.

R11. Relationship among services must have extensibility.

R12. Metadata of device and service must be able to be specified in description.

R13. A coordinator must be able to recognize device messages independent of protocol type.

R14. A coordinator must be able to discover devices and services managed by other coordinators.

A. References

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