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P2P とグリッド技術の統合とその携帯電話アプリケーションへの適用に関する検討

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あらまし　近年、移動体通信において，トラフィック量の増加に伴い，自由且つ対等で自律的なネットワークを構築できる Peer-to-Peer(P2P)技術が注目されている．我々は携帯端末を用いた P2P プラットフォームを構築し，その上で数々のアプリケーションを開発してきた．しかし，一般的に P2P 通信のアプリケーションは，１対１での通信形態が多く，グループで協調しながら行うアプリケーションは限られたものとなっている．一方，計算機技術において，普及型 PC ををを有機的につなぎ合わせることにより，大型コンピューターと同等の性能を発揮するグリッド技術への期待が高まっている．グリッド技術のアプリケーションは分散したリソースを協調して用いることにより，現在，あらゆる分野に適応したサービスの提供が行われている．このコンセプトを P2P 通信へ適用し，両者の融合技術として P2P グリッド技術を提案する．また，P2P グリッド技術のアプリケーションとして Ring-tone Orchectra(RTO)を実装を考え，本技術の有効性を検証する．　RTO は複数の携帯端末間で音楽ファイルを共有し，また一の指揮者端末，それ以外を演奏者端末と決め，指揮者端末の制御に基づいて演奏者端末が一斉に音楽を演奏するというアプリケーションである．本稿では，P2P グリッド技術及び RTO アプリケーションの概要について述べる．

キーワード　P2P, グリッド技術，　モバイルネットワーク

Consideration on the Integration of P2P and Grid Technologies and its application to mobile phones

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Abstract By combining two separate technologies, it is possible to create a novel system which leverages the advantages of both. Peer-to-Peer (P2P) technology has received widespread attention as a framework for file sharing. However, it is really a generic system for local communication, and could be used to control resource access in distributed computing systems. On the other hand, Grid technology has been receiving attention as a framework for the distribution of computational tasks among computers. Our work has combined these two into one single system, leveraging a generic P2P platform to distribute computations and resource access. We have developed a conceptual demonstration system, the "Ring-tone orchestra (RTO)", which coordinates the ringing tones among closely located mobile phones into the same melody.　This paper describes the P2P technology, the Grid technology, and the ring-tone orchestra application.

Keyword P2P, Grid technology, Mobile network

1 Introduction

The term “the Grid” was coined in the mid1990s to denote a proposed distributed computing infrastructure for advanced science and engineering. Grids are persistent environments that enable software applications to integrate instruments, displays, computational and information resources that are managed by diverse organizations in widespread locations [1] [2]. In earlier times, Grids are regarded as only Computational Grid that is hardware and software infrastructure that provides dependable, consistent, pervasive, and inexpensive access to high-end computational capabilities. Recently research area of Grids is becoming wider, and various kinds of Grids, besides Computational Grid, has been focused on. To date, Data Grids, Access Grids, Sensor Grids and other kinds of Grid technologies are studied actively [3][4][5]. These technologies that bring “nontrivial qualities of service” by having efficient distributed system, could eventually produce the future infrastructures in the Ubiquitous world.

Meanwhile, the market of mobile Internet services is very successful, and has been growing very quickly since the services were started in 1999. We had developed a mobile P2P platform [7][8] and some service applications on it, e.g. P2P instant messaging application [6]. Such conventional applications do not utilize dispersed peers’ resource, however, in order to supply more various and valuable mobile Internet services, coordinated usage of them should be promoted. Therefore, we propose and try to evolve a new technology applied Grid technology to the P2P network.

As a reference case of P2P Grid, we propose Ring-tone Orchestra (RTO) application. The feature of this application is that dispersed mobile terminals ring an orchestra tune in a harmonized manner by cooperating, using the functions characterized by Grid technology on the P2P network.

This paper describes the P2P technology, the Grid technology, and the ring-tone orchestra application.

2 Existing Technologies

2.1 P2P Platform

This section abstracts the features of the mobile P2P Platform, in terms of its protocols, messages, communication types and node identifier. The more detailed information is given in [7][8].

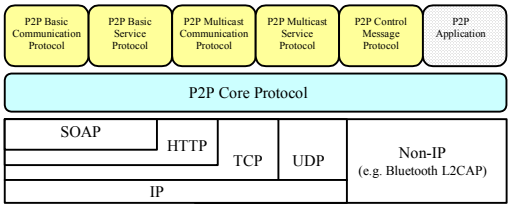

Figure 1 Platform protocol stack

Protocols: As shown in Figure 1, the platform is composed of both P2P Core protocol and five upper layer and forwarding the messages. The upper layer protocols on the top of P2P Core protocol provide additional services such as searching resources, joining multicast groups protocols. P2P Core protocol, which is independent of a particular transport mechanism such as SOAP/HTTP, TCP/IP or Bluetooth, takes fundamental roles such as sending, receiving or reporting errors. At the same level of the five protocols, users can define new applications.

Messages: All messages over a P2P network are represented in XML. A Core element identifies a protocol message and its one-level-deep children represent core protocol parameters needed for routing messages over the P2P network.

Communication types: There are three types of unicast, multicast and broadcast communications available. Especially in the multicast communication, bi-directional spanning tree method is used to construct a multicast distribution tree and all multicast group members share one spanning tree [7].

Node identifier: In the P2P network, all communications are based on node identifiers used to identify nodes and to specify routing paths to destinations. They are static and assigned by the nodes themselves in a decentralized manner. Our current naming system is based on UUID[11] that guarantees global uniqueness.

2.2 Grid Technology

Large computing ability by controlling distributed nodes’ resource can be provided by the tools that had been already released by e.g. computer vendors [9][10]. The environment build by Globus Alliance [12] is referred in this paper, where they have several versions of the executable tools with fundamental four functions described as follow.

Information Service: This function provides information about resource/service. It can manage two types of information; one is available service information that all nodes can contribute on the network, and the other is resource information that all nodes have. The resource information can be regarded as complementary information of the service information. It should contain both static one (e.g. device name, storage size, file, data) and dynamic one (e.g. status of use of the resource). The device as well as the model, the version and other attributes of it would determine the type of resource.

Resource Management: In executing a service "Job" is created. This function manages job allocation, job release and job monitoring, where the job can be performed using own and/or other nodes' resources on the network.

Data Management: This function should support a secure, high-performance and reliable data transfer among nodes. Also, it can provide interfaces for controlling and monitoring 3rd party file transfers, and records the locations of data copies and allows discovery of replicas.

Security: This function should be based on the above three functions, and enable secure and enhanced services with them.

3 Integration of P2P and Grid Technologies

By combining two separate technologies, it is possible to create a novel system which leverages the advantages of both. In this paper, we propose an integration of P2P and Grid technologies (say, "P2P Grid"), which can provide valuable service by sharing or managing dispersed resources that are heterogeneous and dynamic. Concretely we construct Grid technology oriented functions on the P2P platform. It should be noted that Grid technology treated in this paper can provide rather less ability so that it is assumed that intended devices are mobile devices that could be connected via ac-hoc mobile network using i.e. Bluetooth, WLAN ad-hoc mode.

We create a P2P Grid platform where, the workflow can be divided into six processes; Device Discovery, Resource Exchange, Authentication, Service Discovery, Confirmation, and Job Process, see Figure 2.

It is assumed that all nodes can be separated into two types of nodes; one is a service consumer node and the other is a service provider node, when executing a job. Firstly, distributed nodes can enter mobile P2P network in the Device discovery process, then the node P2P Grid platform implemented can make a group in Resource exchange process. These processes can leverage the existing P2P platform. The Authentication process ensures relationship between a service provider node and a service consumer node, and the Service discovery process follows after it to find resource/service information. Finally after the Confirmation process in order to confirm condition change, the Job execution process can be performed.

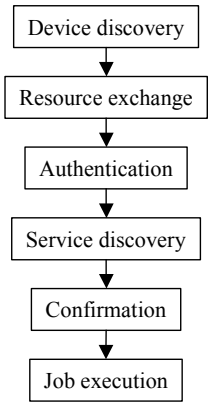

Figure 2 P2P Grid Workflow

These will be explained in detail as follows, however, detail message formats for each process are omitted in this paper for simplicity purpose.

3.1 "Ring-tone Orchestra" application

We also propose "Ring-tone Orchestra (RTO)" application to confirm the validity of the proposed technology. RTO is a single task that performs an orchestra tune with a group of mobile phones initiated by a "conductor" (one of mobile phones) utilizing resources of "players" (available mobile phones nearby a conductor, i.e. ringers or music players. A conductor searches available resources, allocates fragmented jobs to players, distributes necessary files or indicates where to download files, and requests to play them in a harmonized manner. All activities shall be coordinated based on Grid concepts, i.e. information service, resource allocation, data management, and secure transaction.

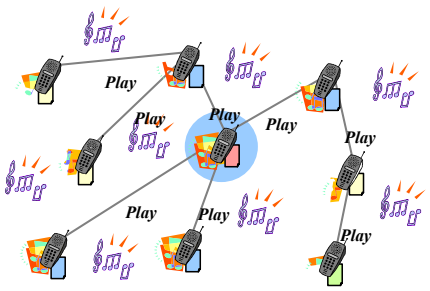

Figure 3 RTO application image

RTO shall be created based on the P2P platform as shown in Figure 4. For simplicity purpose, there is not independent P2P Grid platform layer here, but assumes the RTO application layer includes it. Portion of the P2P protocol are applied in accordance with the message transaction type used in RTO.

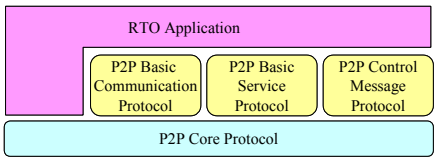

Figure 4 RTO protocol stack

3.2 P2P Grid function and RTO work flow

This sub-section describes serial P2P Grid processes that work using P2P platform plus Grid oriented functions. RTO workflow in term of message transaction is shown along with each process. Hereinafter a service consumer node and a service provider node are called SC-node and SP-node respectively. Correspondingly a conductor and a player in RTO become SC-node and SP-node.

1) Device discovery

This process is provided by the P2P platform [7][8]. A node (to be SC-node) attempts to initiate route by broadcasting *Lookfor* message to nearby the node(s) (to be SP-node(s)).

Route in underlying transport is known by which the SC-node receives *LookforResponse* message. SC-node that has route information of nearby nodes can enter a network by Hello method. For simplicity, there assume to be one SC-node and two SP-nodes in the following example figures.

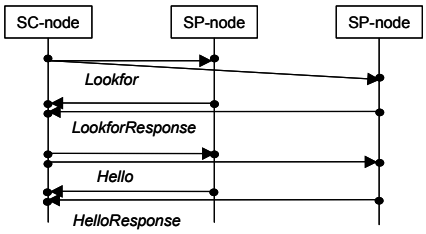

Figure 5 Sequence in Device discovery

2) Resource exchange (P2PGrid Platform Discovery)

SC-node searches the nodes with P2P Grid platform by this process. SC-node sends *ResourceInformationRequest* message to SC-node(s), where it comprises URI that corresponds to P2P Grid platform. SP-node replys *ResourceInformationResponse* message that shall indicate Yes or No, then P2P Grid nodes are grouped.

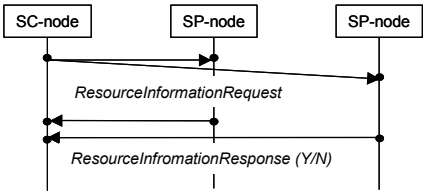

Figure 6 Sequence of Resource exchange

3) Authentication

Authentication process is performed for the purpose that SC-node gets permission for using SP-nodes' resources, and realizes secure system. The process supports three types due to their purpose and security levels; a private class, a group class and a public class. Service discovery that is a next process will be performed in accordance with the class applied.

- Private class

  This is used when SC-node having some prior information intends to use the specific SP-node(s)' resources without taking Service discovery process in advance.

  SC-node sends *AuthenticationRequest* message to SP-node in unicast for authorization. Then SP-node returns *AuthenticationResponse* message in unicast as certification, if it authorizes. Relationship is valid for specific SC-node and SP-node(s).

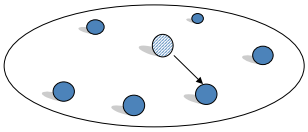

Figure 7 Private class Authentication

- Group class

  This is used when available resources are to be shared the nodes that a group labeled.

  SC-node sends *AuthenticationRequest* message to group member SP-nodes in multi-destination unicast. Similar to Private class SP nodes returns certification, if they authorize as the same group member.

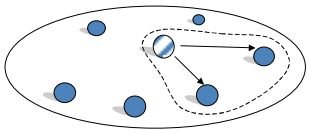

Figure 8 Group class Authentication

- Public class

  All nodes use initially this since in general they have no information of others.

  SC-node sends *AuthenticationRequest* message in broadcast. All SP-nodes that receive the request should reply certification since this establishes relationship more freely.

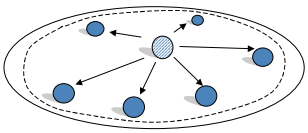

Figure 9 Public class Authentication

In RTO, it is assumed there is no prior information SC-node has, so that Group class or Public class Authentication should be applied.

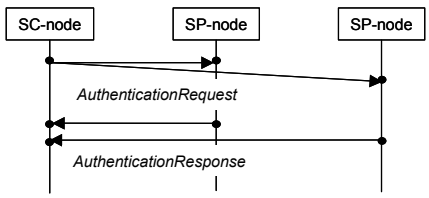

Figure 10 Sequence of Authentication

4) Service discovery

SC-node queries service information to SP-node on the authentication class basis by *ServiceDiscovery* message. SP-nodes show own service/resource information by returning *ServiceDiscoveryResponse* message. Here, SC-node needs to decide what service/resource will be used for the intended application. Hence, negotiation between SC-node and SP-node is performed for condition setting.

In RTO, SC-node would like to know the resource information includes a ringer type and music files. After SC-node receives *ServiceDiscoveryResponse* message, SC-node offers conditions and/or requirements that meet the demand by *RTORequest* message. In the other words, SC-node assigns part of an orchestra tune. SP-node returns *RTOresponse* message being one of Acceptance (meets the requirements), Rejection (not meet the requirements), and Conditional acceptance (in this case, also send with the condition such as time restriction). In case of Conditional acceptance, negotiation will be continued till agreement achievement.

If they achieve an agreement, though this is optional, music file can be transferred from SC-node to SP-node.

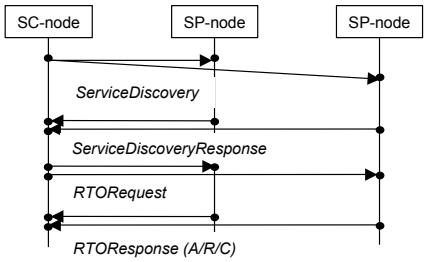

Figure 11 Sequence of Service discovery

5) Confirmation

Confirmation process is performed for ensuring available resources just before Job execution process. SC-node can grasp actual number of performers. Therefore, what can be confirmed should be connection between SC-node and SP-node(s), and condition changes.

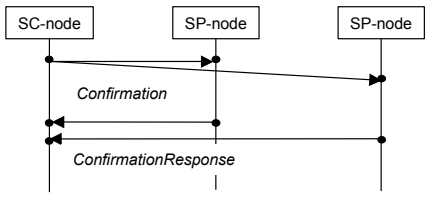

Figure 12 Sequence of Confirmation

6) Job execution

After the above process, SC-node can start the intended job with a command to SP-nodes. Appropriate execution types could be considered according to nature of a job. We show possible execution types as described below.

- No time-constrained execution
  This is general type execution.
  One job could be achieved by unicast, multi-unicast, or chain type execution.

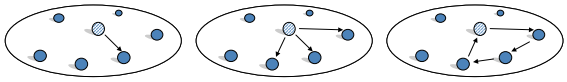

Figure 13 No time-constrained execution

- Time synchronous execution
  On the contrary, this type execution is strict for time requirement. It will be applied, for example, to a job where all SP-nodes should provide their resource/service at the same time.

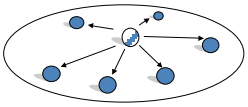

Figure 14 Time synchronous execution

- Efficient job execution for multi-task assignment
  Besides the above types, there is a case that some jobs are assigned to a specific SP-node. Efficient procedure should be taken according to e.g. policies and rules.

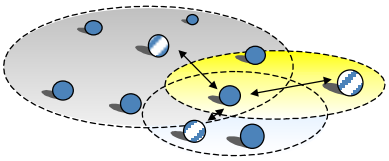

Figure 15 Execution in multi-task assignment

In RTO, time synchronous execution should be applied. SC-node sends *JobStartRequest* message. SP-nodes ring simultaneously assigned part in harmonized manner. Synchronous starting is available for example using the Bluetooth piconet and the nodes share a common clock.

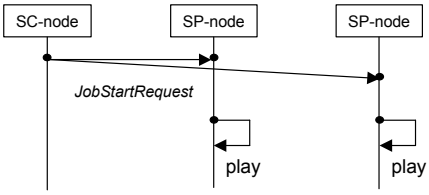

Figure 16 Sequence of Job execution

4 Conclusion

We propose an integration of P2P and Grid technologies and describe core functions. The P2P Grid can provide enhanced services on the P2P network by sharing distributed resources. In addition, we propose Ring-tone orchestra application to confirm the validity. Implementation work will be a future study.

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