Language Grid Revisited: An Infrastructure for Intercultural Collaboration

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Abstract. Since various communities withmultiple languagesinteract in daily life, tools are needed to support intercultural communication. However, we often observe that the success of a multi-language tool in one situation does not guarantee its success in another. To develop multi-language environments that can handle various situations in various communities, existing language resources should be easy to share and customize. Therefore, we designed the Language Grid as service-oriented collective intelligence; it allows users to freely create language services from existing language resources and combine them to develop new services to meet their own requirements. This paper explains the design concept and service architecture of the Language Grid, and our approach to user involvement in collective intelligence activities.An institutional design is also essential forcollective intelligence. We create a federated operation model to bridgedifferentstakeholders including service providers, service users, and service grid operators.

1 Introduction

After 9.11 in 2001, we started research on *intercultural collaboration*[1].While the Internet allows people to be linked together regardless of location, language remains

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[1] There was no such concept at that time. We created the concept of *intercultural collaboration* by adding *goals*to*intercultural communication*, so that we can advance methodologies and technologies to support the multi-language and multi-culture communities. *ACM International Conference on Intercultural Collaboration*now exists to discuss research issues.

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the biggest barrier: only 35% of the Internet population speaks English[16]. The remainder is divided between other European languages and Asian languages. In fact, it is not possible for anyone to learn the languages needed to access all possible information on the Internet.In particular, Asian people are nottaught neighboring languages. Few Japanese understand Chinese or Korean and vice versa. Peoplelearn English to collaborate, but often cannot think in English:serious barriers to intercultural collaboration exist,because the collaboration often requires elaboratingnew ideas in the native language.As there is no simple way to solve this problem, it is necessary to combine different approaches. Teaching English is one way, but learning other languages and respecting differentcultures are also important. Since one cannot master all languages, the use of machine translation systems and other existing language resources on the Internet is a viablesolution.

To increase the accessibility and usability oflanguage resources(dictionaries, parallel texts, part-of-speech taggers, machine translators, etc.), we proposed the *Language Grid*, whichwraps existing language resources as atomicservices and enables users to compose new services by combining atomic services. We believe that *fragmentation and recombination* is the key to creating various customized language environments for different types of user communities. Our slogan is "from language resources to language services."The concept was presented in a keynote speech ofSAINT 2006 [9]. In this paper, we revisit it after six years'experience indeveloping, sharing, and utilizing language services worldwide.

Let us call the infrastructure that supports the formation of service-oriented collective intelligence the *service grid*[2]. The service grid has three stakeholders: *service providers*, *service users,* and *service grid operators*. For institutional design, we should consider the following issues of the stakeholders:

- How to protect the intellectual property rights of service providers and to motivate them to provide services to the service grid. To this end, service providers should be allowed to define for what purposes their services can be used and to define usage rights accordingly.
- How to encourage a wide variety of activities of service users to increase their satisfaction. To this end, service users should be allowed to run application systems that employ the services permitted for such use.
- How to reduce the load on service grid operators while allowing them to globally extend their service grids. To this end, *federated operation* should be facilitated, where several operators collaboratively operate their service grids by connecting them in a peer-to-peer fashion.

We organized this project based on collaboration between researchers in various universities and research institutes and potential users in non-profit and non-governmental organizations (NPO/NGOs). Participatory design and action research methodologies have been employed during the project. Software development, applications in real communities,and institutional design for federated operation are all related, and thus performed in parallel.

[2] Service grid is a generic term meaning a framework where "services arecomposed to meet the requirements of a user community within constraintsspecified by the resource provider[5, 12]."

As a result, wetook only two years to start its operation. Around 30 organizations joined in December 2007to share language resources. It has become one of the most advanced service infrastructures for intercultural collaboration. The remaining parts of this paper are organized as follows. First, we explain the reasons why we should shift our focus from language resources to language services. We thenintroduce the design concept, service layers, stakeholders, user involvement,and federated operation.

2 Why Language Service

Language resources should be easily shared to support various intercultural collaboration activities.To allow users to create their own language resources that can be combined with other resources, we taketheservice-oriented approach, where each language resource is wrapped as a language service. Fig. 1 shows how to create atomic language services from language resources. Data like multilingual dictionaries and parallel texts can be wrapped to form atomic language services that cantranslate words or sentences. However, those atomic services do not have to be a simple retrieval function: a parallel text service can return the translation of a sentence that is similar to the input sentence. Wrapping software like machine translators is straightforward, but even human interpreters can be wrapped as translation services. Users do not have to distinguish machine from human translation services other than by their quality of services: machine translators can provide faster services while human interpreters return higherquality translations.

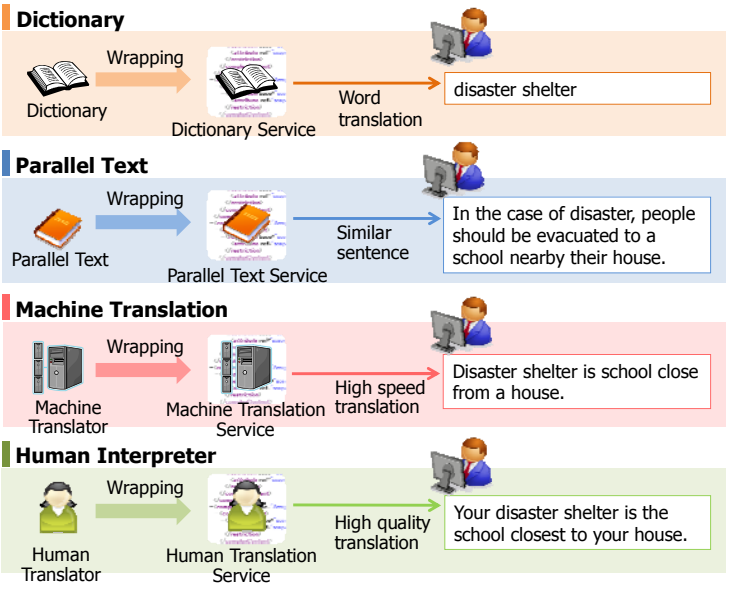

Fig. 1 Languageservice (atomic)

The next step is to combine atomic language services to create new services. Fig. 2 illustrates the process of combininga variety of atomic services for Japanese teachers to translate their announcements for Brazilian parents. To translate Japanese sentences into Portuguese, we first need to cascade Japanese-English and English-Portuguese translators, because there is no direct translatorhandling Japanese to Portuguese. To replace words output by machine translators with the words in multilingual dictionariesspecific to schools, part-of-speech taggers are necessary to divide the input sentences into parts. We can train *example-based machine translators* with Japanese-Portuguese parallel texts. We then have different types of translators including example-based machine translators and will face the problem ofdetermining which one is the best: example-based machine translators can create high quality translation only when they trained with similar sentences. We may use back-translation, say Japanese-Portuguese-Japanese translation, to compare original and back-translated Japanese sentences, and select the translator that can produce back-translated sentences most similar to the original ones. In spite of all these efforts, the quality of translation is stillinsufficient and the Japanese teachers may use human translation services.

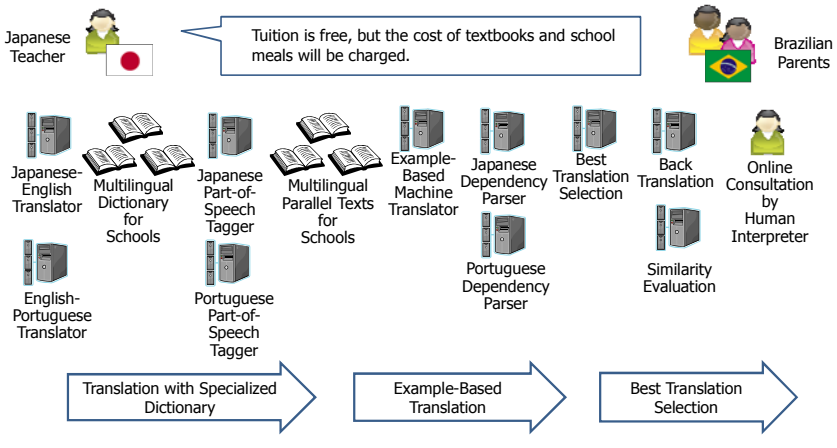

Fig. 2 Languageservice (composite)

3 Design Concept

As evident fromthe previous sections, a variety of language resources already exist online. However, difficulties often arise when people try to use those language resourcesin their intercultural activities; the confusing web of complex contracts, intellectual property rights, and non-standard application interfaces make it difficult for users to create customized language services that support intercultural activities. Since many language resources have usage restrictions, it is difficult for users to negotiate with every language resource provider when combining several resources for their purpose.To improve the accessibility and usability of existing

language resources,the Language Grid reduces the negotiation costs related to intellectual property rights.

We then need to allow users to easily create new language services by combining existing ones.The word *grid* is defined as "a system or structure for combining distributed resources; an openstandard protocol is generally used to create high quality services[3]."

Fig. 3 illustrates the design concept of the Language Grid. The platform allows users to register services and share them. Major stakeholders fall into three categories:*service providers*, *service users,*and *service grid operators*. Service providers provide language services such as machinetranslators, part-of-speech taggers, dependency parsers, dictionaries, andparallel texts. Service users invokeregistered language services for their intercultural activities.Service gridoperators manage and control language resources andservices. Note that stakeholders are not individuals but organizations like research units in universities, and that a single organizationcan act as three different stakeholders: a service provider, a service use, and a service grid operator of other service grids. We will discuss how to coordinate different stakeholders in more detail in Section 5.

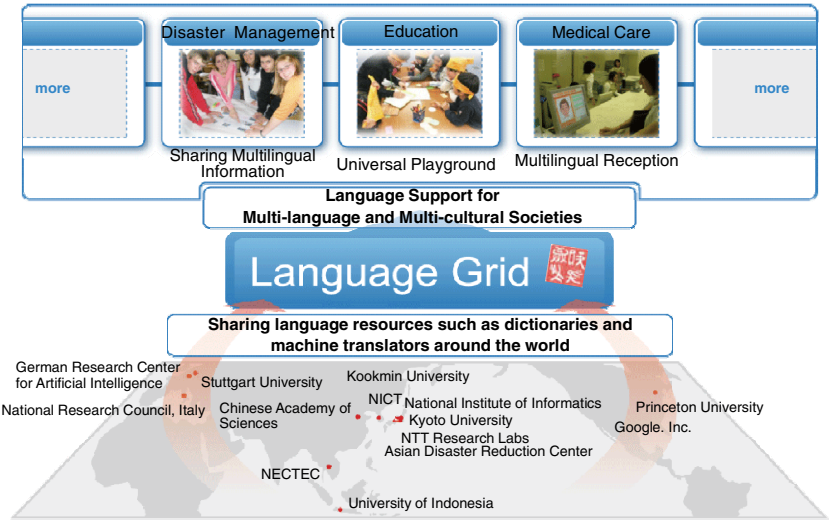

Fig. 3 Design concept

To combine language services provided by stakeholders that have different incentives, standardization of language services is quite important [3].There also exist several efforts to pipeline language processing programs: *Heart of Gold*[2] and *UIMA*[4]. Their aim is topipeline various language processing programs efficiently, while we are more user-oriented and focus on managing the intellectual

[3] Our approach, applying the grid concept to ensure the collaboration of language services, has not been tried before.

property rights associated with language resources. Since the motivations are orthogonal, we have bridged Heart of Gold and the Language Grid [1], and will apply the results to UIMA.

4 Service Layer

As shown in Fig. 4, the Language Grid consists of the followingfour service layers.The bottom layer, called *P2P Service Grid Layer,*aims at connecting core nodes to enable them to share registered information of language services. Core nodes manage all requests to language services, while service nodes actually invoke the atomic services. If the requested service is a composite one, core nodes invoke the corresponding Web service workflow that includes one or more atomic services.Registered information of language services is shared among all core nodes. The same services are provided, regardless of which core node receives the request. The core nodes also control access to services to fulfillthe usage conditions set by the service providers. Service providers can access the usage statistics of the services they provide.

The second layer is called the *Atomic Service Layer*. In this layer, any user can add new language resources.A Web service that corresponds to a language resource is called an *atomic service*. The third layer is the *Composite Service Layer*. Atomic language services can be combinedby a Web service workflow. A service described by a workflow is called a *composite service*. Various composite services have already been constructed, including specialized translationsinvolving several atomic services, such as machine translators, part-of-speech taggers, and domain-specific dictionaries. WS-BPEL and Java-based scenarios are used to describe workflows.Currently, more than 130 atomic and composite language services are being shared with standard interfaces. Table 1 lists all of the language servicetypes currently available.

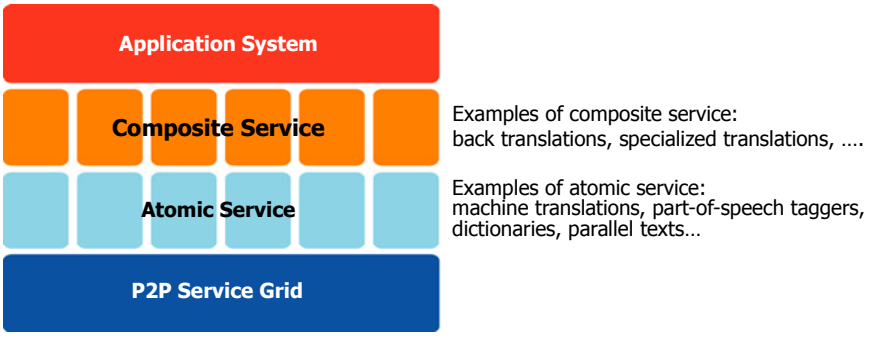

Fig. 4 Service layer

To realize the second and third layers, Web service technologies including *language service ontology*, *horizontal service composition*and *service supervision* have

been developed to enable the collaboration needed among language services.Language service ontology is a technology to define standardlanguage service APIs in a hierarchical way so that end users are provided with simple interfaces while professionals can access more complex interfaces[8]. For horizontal service composition, we apply constraint optimization algorithms to select the appropriate services and thus satisfy QoS requirements [7]. To combine machine translators working on the same document or conversation, *context-awareservice composition* is proposed: multiple translations are coordinated to determine the meanings of words consistently [14, 21]. Service supervision, on the other hand, is a runtime technology to monitor and modify the process of composite services [18, 19].

Table 1 Language service list

Service Category	Service Type	Number of Services
Translation	Translation Service	23
	Domain-Specific Translation Service	2
	Multilingual Mixed Document Translation Service*	0
	Back Translation Service	1
	Multi-hop Translation Service	2
Paraphrase	Paraphrasing Service*	0
	Transliteration Service*	0
Dictionary	Multilingual Dictionary Service	9
	Multilingual Dictionary Service withLongest Match	24
	Concept Dictionary Service	19
	Pictogram Dictionary Service	1
	Multimedia Dictionary Service*	0
	MultilingualGlossary Service*	0
	Dictionary Creation Support Service*	0
Corpus	Parallel Corpus Service	31
	Dialog Parallel Corpus Service	1
	Template Parallel Corpus Service	5
Analysis	Morphological Analysis Service	11
	Dependency Parsing Service	2
	Similarity Calculation Service	1
	Language Identification Service	1
Speech	Text To Speech Service	3
	Speech Recognition Service	1
Other	Structural Alignment Creation Service*	0
Meta Service	Service Management Service	1

(Service types marked * are currently under development.)

5 Stakeholder

To coordinate the different stakeholders,we discuss institutional design in terms of the contracts among service providers, service users, and service grid

operators.From the service provider's standpoint, to protect their intellectual property,the provider should be able to know the purpose to use their services.In fact, many research institutes and public organizations clearly specify that their services are for *non-profit or research use only*. To reflect such service providers' concerns, we classify the purpose of service use into the following three categories and allow each service provider to permit one or more of the categories:

> *Non-profit use* means use by public institutions and non-profit organizations for their main activities, or use by companies and organizations other than public institutions and non-profit organizations for their *corporate social responsibility* activities.
> *Research use* means use for research that does not directly contribute to commercial profit.
> *Commercial use* means the use for purposes intended to directly or indirectly contribute to commercial profit.

When service providers register their services on the grid, they are required to provide information on copyright and other intellectual property rights of the resources included in their services. In the event that the service provider has been granted a license to the resource by a third party, such information shall also be included.

For the service provider, it is desirable that there be flexibility in setting out the terms of use of their services. Possible conditions are as follows: restrictions on the service users who may be licensed to use the service, restrictions on the purpose for which the service may be used, restrictions on the application systems that use the service,and restrictions on the number of times that the service may be accessed and the amount of data that may be downloaded from the service.In general, when the service grid allows the terms of use to be set in detail, it will increase the service provider's satisfaction, while imposing greater overhead on the service users to comply with the detailed terms of use. Moreover, when the service users use a composite service, they need to satisfy all terms of use of every atomic service in the composite service. Therefore, we must trade the service provider's flexibility off against the service user's convenience and the operator's cost.

When service users use the service grid for purposes other than personal use, many of them provide an *application system*that offers services to other users. Here *application system* means, as shown in Fig. 5, a system that is provided by a service user and that allows users of the system to indirectly access the service grid without being personally authorized by the service grid. A service user may operate different types of application systems; for example, one provides an application system to the general public through the Web, and another provides an application system through a particular terminal in a certain location like a reception counter.

Where is the service provider's incentive for providing their services? When the service providers provide their services for free, the service grid operator is required to provide statistical information on the use of the services to the service providers. The statistical information shows who used or is using which service and to what extent. Such information stimulates the interaction between the

service providers and the service users. When service providers provide their services for profit, they will receive fees from the service users by concluding a contract for the payment of such fees.

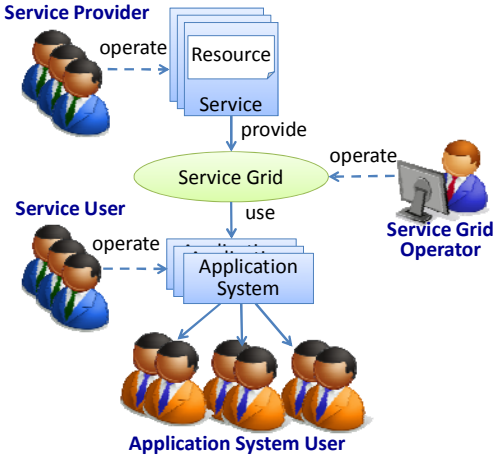

Fig. 5 Service use through application system

6 User Involvement

The*service grid server software* has been developed and released as open source software. Using this source code, universities and research institutes can operate any kind of service grid. As of January 2012, 145 groups in 17 countries had joined: research institutes include Chinese Academy of Sciences, the National Research Council, German Research Center for Artificial Intelligence, and National Institute of Informatics, universities include Stuttgart University, Princeton University, Tsinghua University and a number of Japanese universities, NPO/NGOs and public sector bodies. Companies have also joined: Nippon Telegraph and Telephone Corporation, Toshiba, Oki, and Google are providing their services.

We first expected that NPO, NGO and public sectors would become the major users, but universities are using the Language Grid more intensively at this moment; researchers and students who are working on services computing, Web analyses, CSCW, and multicultural issues are using language services for attaining their research goals [13, 20, 22, 23]. This trend is natural in the early stage of introducing a new Internet technology. Fig. 6 shows the statistics of member organizations[4].

[4] As shown in Fig. 6, the number of member organizations increased steadily during the three years of operation, but temporarily decreased in April 2011 when member organizations were required to reconclude the agreement due to the start of federated operation.

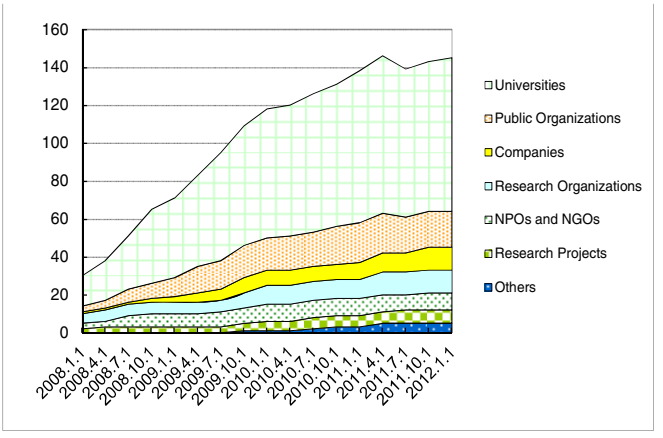

Fig. 6 Number of participant organizations

In the collective intelligence, the platform can grow only through the voluntary efforts of users. As more users provide more services, the more fully they can utilize the benefits of the services. Thus we took a participatory design approach from the beginning of the project: we always work with potential users including NPOs. Those potential users established the Language Grid Association and started using language services for intercultural collaboration. Unlike conventional machine translation systems, the Language Grid combines users' dictionaries andparallel texts, and machine translators to produce better quality translations. NPO/NGOs, schools and other non-profit sectors have appreciated this benefit in a broad range of fields, including disaster management, education, and medical care. A few examples are described below.

Japan now has an increasing number of school students who are non-native Japanese speakers, and most teachers are unable to communicate with the foreign students and their parents. Therefore, we developeda service in which users can chat in a multilingual environment.The supportsite, called the shared screen multilingual chat system,was designed specifically for this situation; students and teachers can chat while looking at the same display. They can input text in their mother tongue, translate the sentence, check the back translation, and post it to the log area on top of the page. In addition, users can register terms used inthe school into the user dictionary, which makes the translation result more correct. This service provides auto-completion using a glossary for school life provided by localcity government.This site was developed in two weeks by three graduate students in Kyoto University. Thisexample shows how quickly peoplecan create customized multilingual environment by using the Language Grid.

When foreigners, who are not fluent in Japanese, fall ill in Japan, they may be unable to receive adequate medical attention because of their inability to communicate with Japanese medical doctors. In Kyoto, volunteer interpreters are being dispatched up 1700 times per year. Interpreters are also stationed in several affiliated hospitals. A support system has been developedfor communication between

foreign outpatients and medical staff at hospital reception desks. Outpatients who cannot speak Japanese can receive information and communicate with hospital staff in their mother tongue. After the outpatient answers some questions posed by the system, it replies with the appropriate consultation procedure. In the case of medical interpretation, however, machine translations are not useful due to their quality. Therefore, the system refers to multilingual parallel texts of medical sentences.The parallel-text-collection system was developed toshare highly accurate parallel text among volunteer interpreters. Fig.7 illustrates the multilingual reception system currently being used at the reception desks of Kyoto City Hospital and Kyoto University Hospital [15].

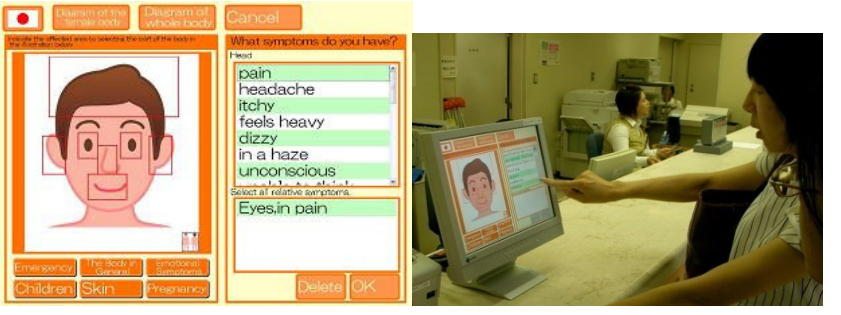

Fig. 7 Multilingual reception system

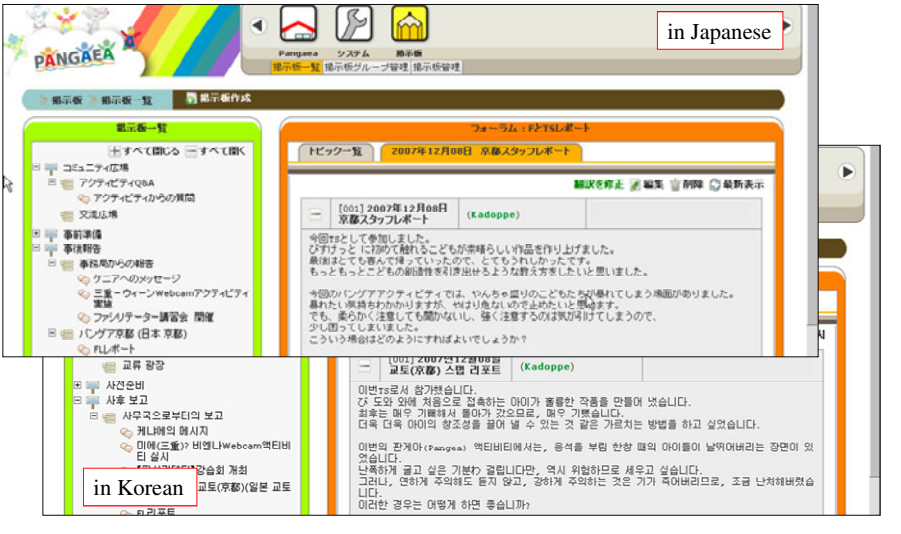

Fig. 8 Multilingual community site (NPO Pangaea)

International NPOs often have their branches overseas. Language barriers exist among volunteer staffs, making it difficult to maintainthe community. In such circumstances,toolsenable volunteer staffs to communicatein their mother tongue and reduce the stress involvedin discussions. These tools are used even inface-to-face meetings by bridgingthe languagegap by displaying multilingual communication via a projector. Local staff can input their questions oropinions in their mother tongue.Collaboration tools using the Language Grid providecost effective communication opportunities.In one case, users created their own languageenvironment. NPO Pangaea developed a communitysite (see Fig.8) and maintains their multi-cultural community by employinga multilingual BBS. In fact, this tool triggered the development of the Language Grid Toolbox that is now provided to NPO Pangaea. The participatory design approach realized not only collaboration between developers and users, but also the development of multilingual environments in a spiralfashion.

7 Federated Operation

The operation model we designed reflects the intentions of user groups around the world like research institutes and non-profit organizations [11]. Design of the operation model was conducted in parallel with the development of the service grid server software. It took more than six months to achieve consensus on the model. It is probably fair to say that the software was written to realize the operation model.

From our operation experience over three years, we have gained many insights.Because the operation center in Kyoto cannot reach local organizations in other countries, over 70 percent of participating organizations are in Japan. Since we need global collaboration even for solving language issues in local communities, this imbalance should be overcome: the operators need to be dispersed into different organizations globally and to collaborate with each other.The *federated operation* model was invented to realize such collaboration. Reasons to drive federated operation include not only the limited number of users that a single operator can handle, but also the locality caused by geographical conditions and application domains.

There are two types of federated operation. One is *centralized affiliation*, where the operators form a federal association to control the terms of affiliation based on mutual agreement. This yields flexibility in deciding affiliation style, but incurs high cost in maintaining the federal association. The other is *decentralized affiliation*, which allows a service grid user to create and become the operator of a new service grid that reuses the agreements set by the first service grid[5].This type of

[5] Sometimes it is impossible for different service grids to use exactly the same agreements. A typical problem is the governing law. For international affiliation, a possible idea is to adopt a common law like New York State law, but operators may wish to adopt the governing law of their own locations. In such a case, operators will use the same agreements except for the governing law. In that case, the service providers would need to accept the use of the different governing law to handle the affiliated users in that location.

operation promotes forming peer-to-peer networks by the operators. Since the formation of the peer-to-peer network by the operators is flexible and maintenance costs are avoided, we adopteddecentralized affiliationsince it suits non-profit organizations like universities and research institutes.

Let an*affiliated operator*be a service grid user who operates its own service grid that reuses the agreements of the original service grid.Let an*affiliated user* be a user who is licensed to use the affiliated operator's service grid. In sucha case, as shown in Fig. 9,the affiliated user can use the original service grid, where the affiliated operator takes the role of a service grid user. That is the key idea of the peer-to-peer federated operation. Even in such case, service providers still have the right to choosewhether to allow the affiliated user to use their services or not.

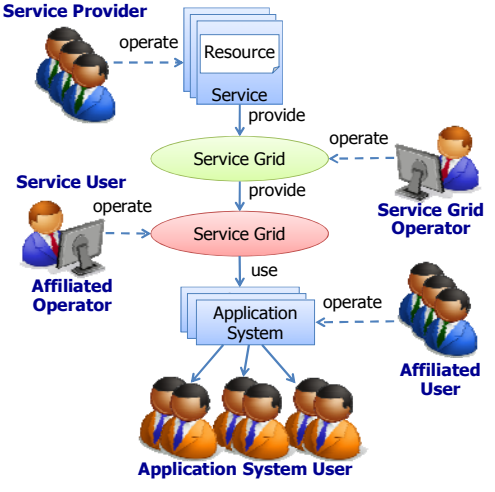

Fig. 9 Federated operation of service grid

Two service grids in equal partnership are likely to establish a *bidirectional affiliation,* where the operators become users of the other's service grid.*Unidirectional affiliation* is also possible. For example, if one service grid provides only basic services and the other provides only applied services, the latter can be a user of the former.

We are now in the process of creating a network of operation centers to cover Asian languages. In fact, the Bangkok operation center[6] in Thailand opened in October 2010. Bangkok has a plan to provide a collection of atomic services including a Thai-English dictionary and machine translator, Thai text-to-speech tagger, and morphological analysis utilities. Those services can be accessed by users of the Kyoto operation center.Moreover, in 2012, Jakarta operation center will start at the University of Indonesia.

[6] National Electronics and Computer Technology Center (NECTEC) established the Bangkok operation center.

So far, we have described the federated operation of the same kind of service grids. In fact, we were able to realize the collaboration of different kinds of service grids. The joint research conducted with Tsinghua University's smart classroom is a typical achievement [17].We rebuilt the smart classroom as a collection of pervasive computing services. That allowed easier connection between the smart classroom and the Language Grid to quickly create the*open smart classroom*, which connects classrooms in different countries.

8 Conclusion

The Language Gridwasproposed six years ago. The system was designed as an infrastructure that allows users to create new language services for their intercultural collaboration activities. We designedan institutional framework for a public service grid operated by non-profit organizations such as universities and research institutes.To decrease the cost of service grid operators and extend service grid operation globally, the framework allows service grid operators to conduct federated operation. The collaboration of operation centers in Asian countries has beenrealized in a peer-to-peer fashion by introducing the concepts of affiliated operators and affiliated users.Using this infrastructure, various kinds of intercultural activities have begun at hospital receptions, local schools, shopping streets,and so on [6, 10].

Each multi-cultural community needs its own multi-language environment. To cope with this diversity, we have been taking the participatory design approach, where collaboration among researchers and users is the key for creating customized multi-language environments. For example, tools for intercultural collaboration that use the Language Grid have been built by user communities, and then generalized by researchers for wide distribution. In other words, we could develop customized language environments for intercultural collaboration by mirroring the approach taken by humans in creating and diffusing domain specific words and dictionaries.

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