Open Language Grid
- Towards a Global Language Service Infrastructure -

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Abstract

To facilitate intercultural collaboration, we designed the language service infrastructure called *the Language Grid,* which allows users to create language services from existing language resources and combine them to develop multilingual environments adapted to their problem domains. Based on seven years experience in operating the language service infrastructure, this paper proposes *the Open Language Grid*, which is intended to realize a self-organizing infrastructure, where user groups can easily start their own server to accumulate language services, and to connect their server to other servers in a peer-to-peer fashion. By integrating various language services provided by both academia and industry, users can easily develop a multilingual environment on their mobile devices.

Keywords: Language service; Language resource; Machine translation; Intercultural collaboration; Intercultural communication; Services computing.

1. Introduction

Though machine translation services are available on the Internet, they are often not usable in real problem domains. Though various multilingual tools have been created, we often observe that the success of a tool in one situation does not guarantee its success in another. To design a multilingual environment that is usable in a specific problem domain, we have to deal with the following problems. First, language resources, which include dictionaries, parallel texts, part-of-speech taggers, machine translators and so on, are often not accessible for end users because of intellectual property rights. Second, even if they are accessible, language resources are often not easy to use because of nonstandard interfaces and quality glitches. Third, language resources are seldom customizable, i.e., machine translators do not allow users to modify them; it is often not possible to add new words to their dictionaries.

Since machine translators adopt general algorithms, customization is crucial to create a multilingual environment for a specific domain. The obvious customization step is to combine domain-specific dictionaries with machine translators. However, the creator of those dictionaries does not have to be a professional in research institutes or universities. End users often have to create their own dictionaries (e.g., a multilingual dictionary for their jargon) when available dictionaries are not sufficient for their activities. Therefore, the role of the language service infrastructure is to allow users to improve the quality of translation by themselves. For example, when translating sentences, users should first be able to access their own parallel texts. When a user enters a sentence to be translated, the parallel texts provide similar sentences. If the user is unable to find the intended expression in the provided sentences, machine translation is then executed. In the process of translation, a dictionary registered by the user is combined with the machine translator to improve its translation quality. If the quality of translation is still not enough, members of the user community may manually correct the translation result. This correction is possible, when the community members share the context. The corrected parallel texts are accumulated for future translations. In this way, machine translation mediated communication can work better in high context communities, such as international NGOs.

Our goal, then, is to develop an infrastructure where language resources can be easily shared and customized as Web services. Those language services are composed to realize the multilingual environment. However, barriers hinder the utilization of existing language resources. For example, part-of-speech taggers developed in research institutes or universities, are often provided only for research purposes. Their Web sites do not state the taggers can be used by non-profit organizations. If members of such an organization want to use them, they need to ask providers for permission by a letter or e-mail. Since this often becomes a complex procedure, users may give up accessing those language resources. Therefore, an important role of the language service infrastructure is to reduce the negotiation costs related to intellectual property rights, so that users can easily access existing language resources.

Though we have successfully operated the language service infrastructure called *the Language Grid* for seven years [7] [9], we encountered difficulties in concluding contracts among service providers, service users, and grid operators. Legal issues have become one of the biggest problems for the language service infrastructure. To cope with the legal problem, this paper proposes *the Open Language Grid*. It is designed to realize a self-organizing language service infrastructure, where user groups can easily start their own server to accumulate language services, and to connect their server to other servers in a peer-to-peer fashion. Furthermore, the open policy allows the infrastructure to adapt to a highly distributed computing environment. Since commercial machine translation services are often free for personal use, users can combine language services provided by academia, industry and other users on their own mobile devices.

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2. The Language Grid

2.1 Design Concept

Nowadays, there are many machine translators (Google translate, Bing translator, etc.) available on the Internet. However, translation quality seldom fully satisfies the various unique requirements. It appears that we need to customize machine translators with local dictionaries for different situations. For schoolteachers, it is necessary to compile a multilingual dictionary of words frequently used in the schools. Suppose the available multilingual dictionaries are adequate. To combine those local resources and machine translators, however, we need to negotiate with the companies or the research institutes that provide the machine translators, and make contracts with them. Let's assume all contracts are signed successfully. It is still not easy to combine machine translators and dictionaries, because the APIs and data formats are not standardized. To combine the language services provided by several organizations that have different specifications, standardization of language services is essential [1]. The service-oriented approach allows users to create and share standardized services while protecting the intellectual property rights of language resources.

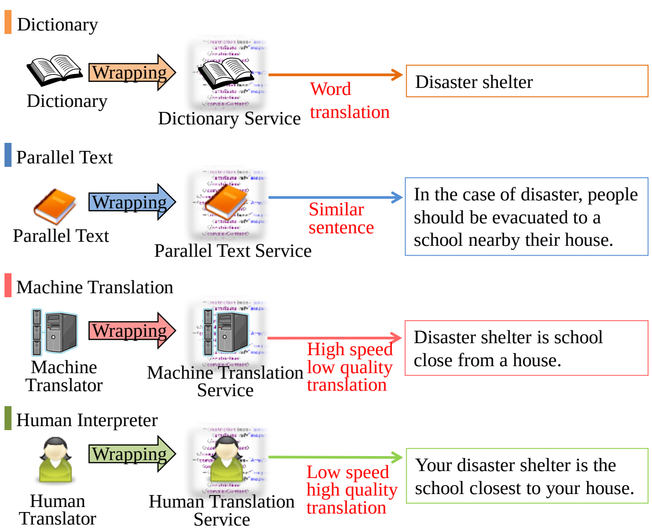

Figure 1. Wrapping language resources into language services

Figure 1 shows how to create atomic language services from disparate language resources. Data like multilingual dictionaries and parallel texts can be wrapped to create atomic language services for the translation of words or sentences. Wrapping software like machine translators is straightforward because the software already has own interfaces to access their functions and the responsibility of wrappers is to establish standardized interfaces. 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 higher quality translations.

To deal with the unique requirements of various multilingual activities, it is thus necessary to compose atomic language services to create a new service, which we call the composite language service. Figure 2 illustrates the process of composing a variety of atomic language services for Japanese agricultural experts to translate their knowledge for Vietnamese farmers. We first need to cascade Japanese-English and English-Vietnamese translators, because there is no available direct translator handling Japanese to Vietnamese with assured translation quality. To replace the words output by machine translators with the words in multilingual dictionaries for agriculture, part-of-speech taggers are necessary to divide the input sentences into parts. We can train example-based machine translators with Japanese-Vietnamese parallel texts. We then have different types of translators including example-based machine translators and will face the problem of determining which one is best: example-based machine translators can create high quality translation only when they trained with similar sentences. We may use back-translation, say Japanese-Vietnamese-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. If the quality of translation is still not enough for the Vietnamese farmers to understand, however, Japanese experts may use human translation services.

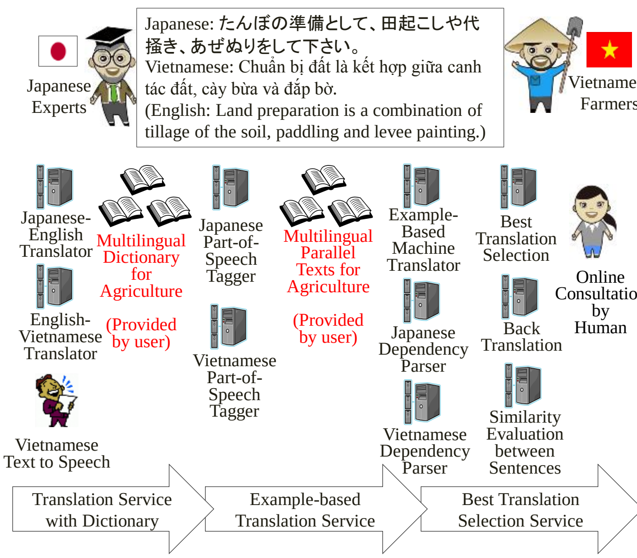

Figure 2. Example of composite language service

2.2 Architecture

The Language Grid is a service-oriented platform to share language services [8]. In this platform, end users can combine existing language services provided by others to create new composite language services for their own purpose. Users can develop applications for supporting multilingual activities by using the composite language services.

The Language Grid consists of four service layers [15]. The bottom layer, called P2P service grid, aims at connecting two kinds of servers (core nodes and service nodes). Core nodes manage all requests to language services and combine multiple atomic services according to workflows, while service nodes actually invoke atomic services. The second layer is called Language Resources. In this layer, any user can add new language resources to the Language Grid. A Web service that corresponds to a language resource is called an atomic language service. The interfaces of atomic language services are standardized according to service type. Each language resource is wrapped with the corresponding standardized interface. The third layer is Language Services. Atomic language services can be composed by Web service workflows. A service described by a workflow is called a composite language service. WS-BPEL and Java-based scenarios are used to describe the workflows and bind atomic language services to activities in the workflows at runtime [10]. Web service technologies including language service ontology [5], horizontal service composition [4], context-aware service composition [13] [20] and service supervision [19] [20] have been developed to enable the collaboration needed among language services. Different types of Application Systems including collaboration tools have been developed on the top layer. For instance, popular collaboration tools including LiquidThreads, an extension for MediaWiki that implements a threaded discussion system.

The Language Grid is built based on Service Grid, which has been released as open source software and is being used by other initiatives as a service infrastructure [6]. Figure 3 shows details of the service grid architecture [16]. The service grid architecture consists of five parts: *Service Manager*, *Service Supervisor*, *Grid Composer*, *Service Database*, and *Composite Service Container*.

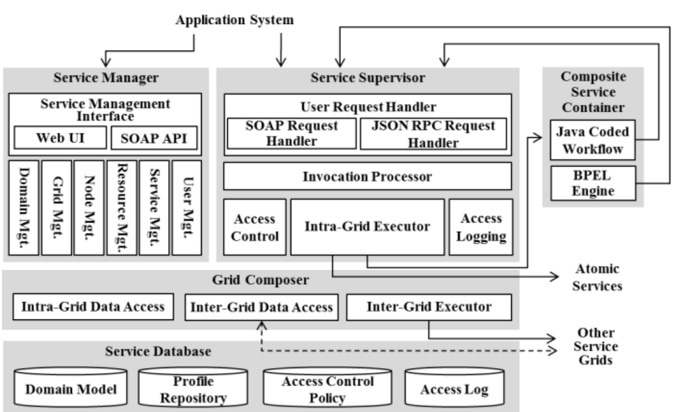

Figure 3. Service grid architecture

The *Service Manager* manages domain definition, grid information, node information, user information, service information and resource information registered in the service grid. Since the information is registered through the *Service Manager*, it plays a front-end role for any functions other than service invocation. The *Service Supervisor* controls service invocations according to the requirements of the service providers. Before invoking the services on the *Composite Service Container*, it validates whether the request satisfies providers' policies. The *Grid Composer* connects its service grid to other service grids to realize service grid composition for operators. The *Service Database* is a repository to store various types of information registered through the *Service Manager* and service invocation logs. The *Composite Service Container* provides composite service deployment, composite service execution, and dynamic service binding so that service users can customize services. The *Composite Service Container* deploys composite services whose abstract workflows are implemented by Java or WS-BPEL. In invoking a component service of a composite service, Java coded workflow or BPEL Engine can select a concrete service, based on binding information included in the service request.

2.3 Federated Operation

To globally disseminate the service grid, which is centered on non-profit organizations like universities and research institutes, multiple operator organizations need to create/join an affiliation. We call this the federated operation [17]. The reasons driving 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 a lot of 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. This type of operation promotes the formation of peer-to-peer networks by the operators. The type of affiliation is defined by reuse of agreements, but the formation of the peer-to-peer network by the operators is flexible and no maintenance cost is incurred. In the following section, we further discuss decentralized affiliation since it suits non-profit organizations like universities and research institutes.

Let an affiliated operator be a service grid user that 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 such a case, the affiliated user can use the original service grid, in which 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 cases, service providers still have the right to choose whether to allow the affiliated user to use their services or not.

Two service grids in equal partnership are likely to establish a bidirectional affiliation, where both operators become users of the other 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 service grid.

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.

2.4 Lessons Learned

We designed an institutional framework for a public service grid operated by non-profit organizations such as universities and research institutes. From a consideration of the different standpoints of service providers, service users and service grid operators, which constitute the service grid, we proposed and experienced the following framework:

- To protect the intellectual property rights of service providers, the purposes of service use are classified into non-profit use, research use, and commercial use. The service providers can set the terms of service use for each purpose.
- The type of control employed by application systems are classified into client control and server control. This flexibility allows service users to employ different types of application systems to support their activities.
- 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 is realized in a peer-to-peer fashion by introducing the concepts of affiliated operators and affiliated users.

To promote language service provision from a range of providers, the Language Grid employs strict agreements to protect the intellectual properties of their providers, which requires the conclusion with not individuals but organizations, and prohibits commercial use of the language services. However, these limitations resulted in the participation of only a few users, such as universities and non-profit organizations. The agreement excluded companies who were interested in commercial use of the language services, and individuals who wanted to use them for their personal use.

Moreover, the current operation model of the Language Grid assumes that language grid operators reach agreement with each other for the federated operation, and language grid users register their language services into the servers so that the third parties can use them. The server software was implemented to realize this operation model. The software based on this operation model interfered with access to free commercial language services for personal use. This is because the access from the Language Grid is regarded as invocations for not personal use but third parties' use. Also, this operation model demands that service providers operate their services stably.

3. Open Language Grid

3.1 Open Architecture

To remove the limitations pointed out in the previous section and involve more potential users like individuals and companies, we introduce a different language grid and propose its coordination with the existing one: Open Language Grid allows individuals to participate, to use language services for commercial purpose, to easily start operation of grid servers, and to freely connect their servers to other servers. Hereafter, to explicitly distinguish it from the existing one, we call the existing one a *contractual grid*, and the Open Language Grid an *open grid*.

These changes affect the legal agreement, system architecture, and the registered language services. In terms of agreement, this new policy is not compliant with the existing agreement. It is not allowed to access language services on the contractual grid from open grid but the converse is allowed. This asymmetry is caused by the less strict terms of use of open grid than the existing agreement.

In terms of available language resources, the open grid permits users to register only the language resources that can be freely provided to the other users as services, such as open-source language resources. Accordingly, we have registered open-source language resources into the Open Language Grid, such as Stanford POS Tagger for English, SVMTool for Spanish, and MeCab, ChaSen, and Juman for Japanese. These freely available language resources are published by academic communities. They are easily found using LRE Map [2], which provides the possibility of search based on a fixed set of metadata and to view the details of found resources.

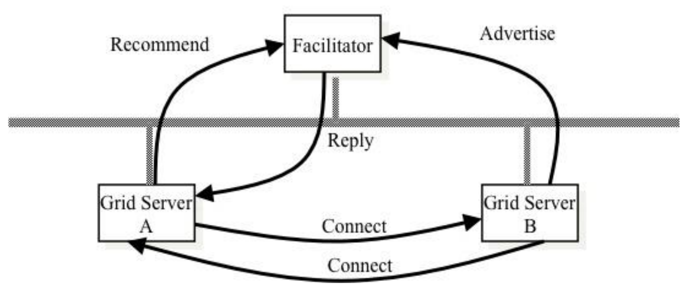

Figure 4. Facilitation of grid connection

Finally, in terms of system architecture, every grid server connects each other in full mesh topology to permit mutual usage of language services. To this end, we need a communication facilitator that mediates the connection among them because servers do not know each other at first. There are three facilitation approaches: broker, recruit, and recommend [3]. The broker and recruit styles are not suitable for this purpose because they cannot tell who join the open grid network. Only the recommend style responds to the name of another server in the open grid. Figure 4 shows how to facilitate the connection between two grid servers. First, server A asks a facilitator to recommend a grid server to whom it would be appropriate to connect. Grid server A receives the response holding the name of grid server B. Grid server A, then, requests grid server B for a connection. When grid server B approves the request, it also sends the request to grid server A. After establishing the connection, grid server A is free to initiate communication with grid server B to share registered language service information. To embed this facilitation mechanism, we had to extend the grid composer component that connects with other grids.

3.2 Mobile Mashup

The operation models of both the contractual grid and open grid assume that users register their language services with servers so that the third parties can use them. The software based on this operation model prevented access to free commercial language services; only personal use was permitted. This is because the access from both grids is regarded as invocations for not personal use but third parties' use. To solve this problem, we have introduced Language Mashup. The rest of this section details mashup, and how to coordinate both grids and mashup in each case. The purpose of Language Mashup is to combine useful commercial language resources that are open to the public but limited to just personal use. There are many such language resources on the Web, for example, Bing Translator, Google Translate, Baidu Translation, and SYSTRANet. They often provide high-quality services if users pay for them. However, even if the users pay for them by themselves, they cannot register the services with the existing Language Grid and Open Language Grid unless permission is explicitly given by the providers. To solve this intellectual property right problem, we normally need to spend a long time in negotiations, and implement some special functionality to control access in a more secure manner. It is not realistic to deal with each case by working with this type of language resource.

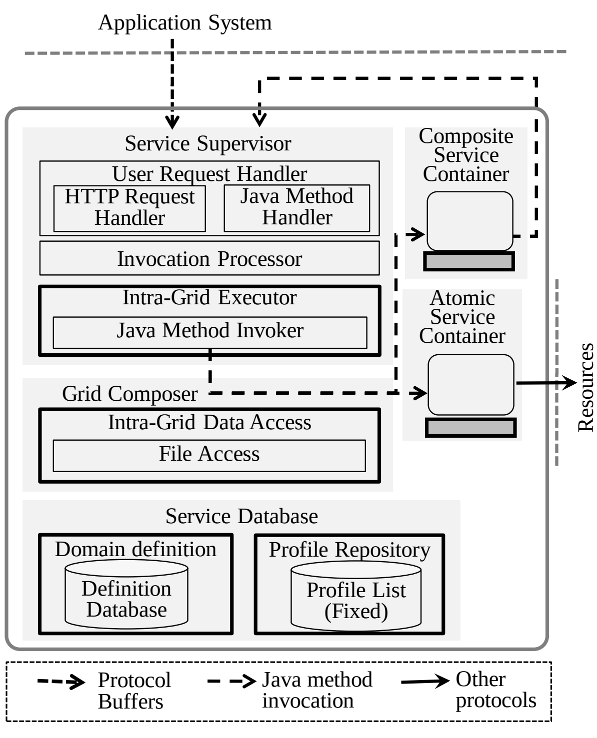

Figure 5. System architecture for language mashup

The design philosophy of Language Mashup is to operate a grid server on the user's smart device(s) for his/her personal use and register language resources necessary to implement his/her application by himself/herself. By invoking mashup on user's smart devices, the user invokes each atomic language service directly to form a composite language service. This is regarded as personal use of those atomic language services and is accepted by the service providers.

To realize this concept, we have designed a system architecture for Language Mashup (Figure 5). This architecture has three main differences from the existing one:

- It has no peer-to-peer mechanism to connect with other grids because it cannot provide the registered services due to licenses of the registered language resources.
- It has no service manager to manage registered information such as a list of users and computation resources, or to provide service management functionalities with users, such as service monitoring and access control. This is because a single user takes both roles of service user and provider.
- It employs Java method invocation between Service Supervisor and Composite/Atomic Service Container, not HTTP-based communication protocol such as SOAP and Protocol Buffers, because every wrapper is deployed on the user's local smart device(s).

By removing the above components, we have downsized the software to 1 MB. This size is small enough to run on smart devices such as smart phones and tablets.

Table 1 compares the features of each grid server including mashup. This shows they can complement each other to deal with various situations. In particular, the ranges of available language resources differ with grid server type. The contractual grid can make various language resources available if their providers reach agreement. The open grid can provide only open-source language resources to avoid complex legal negotiations. Mashup can combine free commercial language resources with academic language resources for the user's personal usage.

Table 1. Comparing three kinds of grid servers

	Agreement	Operator/ User	Purpose	Language Resources (LRs)
Contractual grid	Strict one	Organization/ Organization	Non-profit, Research	LRs provided under the agreement
Open Grid	Relaxed one	Organization/ Individuals	Non-profit, Research, Profit	Open-source LRs (e.g. MeCab, Stanford POS Tagger)
Mashup	None	Individual/ Individual (same)	Only personal use	LRs permitted for personal use (e.g. Bing Trans.)

By coordinating the three kinds of grid servers, we can create multilingual environment to suit various situations. Figure 6 indicates how to coordinate them. The arrow represents the direction of service invocation. Users of the contractual grid can combine language services on both grids. On the other hand, mashup users can combine commercial language services on the mashup and academic language services on open grid by registering the former services into the mashup server.

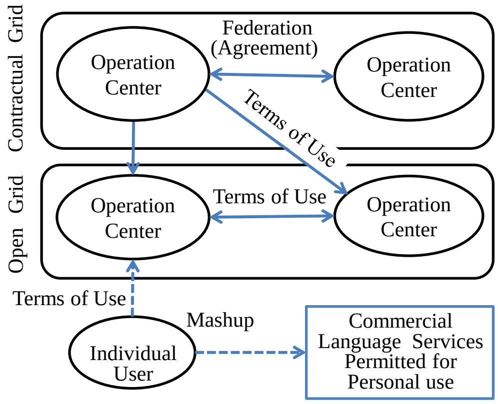

Figure 6. Coordination among contractual and open grids

4. Impact on Multilingual Communities

We discuss three case studies in multilingual communities that use the Language Grid for their activities. We introduce the current status of the three multilingual activities and show how Open Language Grid can help each multilingual activity from the perspectives of sharing community-based language services, utilizing open source language resources, and enhancing personal use.

4.1 YMC-Viet Project

The first case study is an intercultural agricultural support project named YMC-Viet (Youth Mediated Communication – Vietnam) [14], which aims at designing new services for multi-language knowledge communication via the Internet. The goal is to transfer agriculture knowledge from Japanese experts to Vietnamese farmers in rural areas with low literacy rate, to increase rice productivity and to decrease the environmental burdens caused by excess use of agrichemicals. Four seasons of experiments were conducted over the 2011 to 2014 period in Thien My and Dong Thanh communes of Vinh Long province, Vietnam. Since educated children (youth) have higher literacy than their parents (farmers) in rural areas of Vietnam, the Japanese experts send the expertise agricultural knowledge to the Vietnamese farmers via their children as shown in Figure 7.

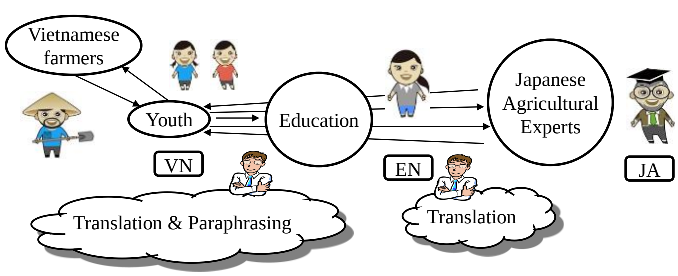

Figure 7. Youth mediated communication model [14]

Figure 8 shows the communication between Japanese experts and Vietnamese children via a multilingual tool. The Language Grid provides machine translation services for the project. To ensure the translation quality, it is also necessary to consider combining machine translation services with human activities, including pre-editing, post-editing, and human translation. Since the quality of machine translation and human services is difficult to estimate, a participatory service design approach was proposed for testing multi-language communication models, considering the balance between translation quality and translation cost [11] [12].

Figure 8. Communication between Japanese experts and Vietnamese youths

The most important language resources in this project are dictionaries and parallel texts in the agricultural domain. For the YMC-Viet project, a multilingual dictionary for agriculture and multilingual parallel texts for agriculture were created with 3,099 and 2,485 entries respectively. These resources are embedded in the systems and combined with the translation services on the current Language Grid. However, it is difficult to share and reuse those resources without registering them under the current contractual grid. Since Open Language Grid provides an open infrastructure for any user to start their own language service infrastructure, it will become easier for the multilingual communities to provide their services freely and share resources among the communities.

4.2 Kyoto University Translation

The *Kyoto University Translation* project enables public users to translate documents related to Kyoto University. This service is available on the website of Kyoto University Coop for public access as shown in Figure 9. This system uses machine translation services on the Language Grid and the Kyoto University dictionary service, which includes approximately 15,000 entries of words in Japanese, English, Chinese and Korean extracted from various multilingual documents and Web contents created for Kyoto University. The system also enables the users to create their private dictionaries and merge them into the public dictionary. One important feature is that it uses KyotoEBMT [18], an example-based machine translation service, as a function of reusing the language resources by learning the 2,000 parallel texts extracted from documents related to Kyoto University.

To provide a variety of translation services for such types of domains and locations, it is also important to use statistical machine translation by training the collected corpus. However, it is difficult to use major open source statistical machine translators and analyzers on the current Language Grid with contractual grid. Open Language Grid makes it possible for users to use and combine various open source language resources, and therefore provides more alternative solutions for multilingual communities to meet the various requirements of specific translation demands.

Figure 9. Kyoto University Translation

4.3 Y's Men International Convention

The Language Grid will be used for supporting Y's Men International 26th Asia Area Convention which will be held in 2015 and have approximately 1,000 participants from around the world. Major Asian languages will be supported in addition to English in this convention, i.e., Japanese, Chinese, and Korean. In the presentation sessions, the conference room will be separated into four areas (Japanese, English, Chinese, and Korean); a screen is placed at the front of each area. The presenters give their presentations in English on the front screen, and the speeches are transcribed by a note-talker in real time. The audiences are able to see the transcribed speeches translated into their own languages on their screens during the presentation.

To enable the participants to understand the presentations more easily, the translated texts are shown on not only the front screen of each language group but also on user mobile devices such as smartphones, laptop, or tablet PCs. Since many commercial machine translation services are not available on the current contractual grid, it is difficult to provide optimal translation services for those personal users from different countries with different languages. However, Open Language Grid makes it possible for personal users to mashup commercial services that are only available for personal use, and so participants can compose various machine translation services on their mobile devices for better translation quality during the convention.

5. Conclusion

This paper proposed the Open Language Grid to resolve the problems uncovered during in our seven year experience of operating the Language Grid by providing the following attributes.

- Allow users to start operation of language service servers, and to freely connect their servers to other servers in a peer-to-peer fashion. In that sense, server federation will be built in a bottom-up manner.
- Use a simple open source Terms of Use, instead of concluding legal agreements among providers, users and operators. By avoiding legal negotiations, usability of language services is significantly improved.
- Allow users to mashup commercial language services and services registered with the open grid. Since commercial services are often free for personal use, users can compose various language services on their mobile devices.

There are more than seven thousand living languages in the world. To make potential language resources available to human society, we hope our proposal can contribute to design a global language service infrastructure.

Acknowledgments

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