

Composing Human and Machine Translation Services: Language Grid for Improving Localization Processes

Donghui Lin[†], Yoshiaki Murakami^{*}, Toru Ishida^{†‡}, Yohei Murakami[†], Masahiro Tanaka[†]

[†]National Institute of Information and Communications Technology (NICT),
3-5 Hikaridai, Seika-Cho, Soraku-Gun, Kyoto, 619-0289, Japan
{lindh,yohei,mtnk}@nict.go.jp

^{*}Navix Co., Ltd.,
8-3-6 Nishi-Gotanda, Shinagawa-Ku, Tokyo, 141-0031, Japan
murakmy@navix.jp

[‡]Department of Social Informatics, Kyoto University,
Yoshida-Honmachi, Sakyo-Ku, Kyoto, 606-8501, Japan
ishida@i.kyoto-u.ac.jp

Abstract

With the development of the Internet environments, more and more language services become accessible for common people. However, the gap between human translators and machine translators remains huge especially for the domain of localization processes that requires high translation quality. Although efforts of combining human and machine translators for supporting multilingual communication have been reported in previous research, how to apply such approaches for improving localization processes are rarely discussed. In this paper, we aim at improving localization processes by composing human and machine translation services based on the Language Grid, which is a language service platform that we have developed. Further, we conduct experiments to compare the translation quality and translation cost using several translation processes, including absolute machine translation processes, absolute human translation processes and translation processes by human and machine translation services. The experiment results show that composing monolingual roles and dictionary services improves the translation quality of machine translators, and that collaboration of human and machine translators is possible to reduce the cost comparing with the absolute bilingual human translation. We also discuss the generality of the experimental results and further challenging issues of the proposed localization processes.

1. Introduction

Machine translation has been an important research topic for several decades in the area of artificial intelligence. With the expansion of the Internet environments, more and more machine translation services have been provided by companies like Google¹, Yahoo², Microsoft³ and so on. However, the gap between human and machine translators remains huge. On the one hand, machine translators always have limitations in translation qualities and therefore are seldom used for translating documents with high requirement of qualities. On the other hand, bilingual human translators are not available everywhere for any purpose at any time in the real world, and the cost of translations of highly-trained bilingual individuals are always high in both labor and time. In previous research, approaches of collaborative translation by human and machine translators have been studied (Hu, 2009; Morita and Ishida, 2009). Although most of the previous studies show the possibility of combining human and machine translators for supporting multilingual communication, there is little consideration of how to apply such approaches for supporting professional translation that requires high business qualities in the real world, e.g., localization processes.

To utilize many available language resources that are distributed on the Internet with different interfaces, we have

developed the Language Grid⁴, which is a service-oriented intelligence platform for language services like machine translation services, dictionary services and so on (Ishida, 2006; Ishida, 2008). With the Language Grid, end-users can combine existing language services provided by researchers and professionals, and create new language services for their own purposes by adding their own language services. For example, machine translation services and community dictionary services can be composed for the purpose of improving translation quality using standard composite service provide by the Language Grid. Moreover, the Language Grid is also designed to enable inducing of human activities easily. Therefore, the Language Grid provides the possibilities for improving traditional processes in the language domain.

In this research, we aim at improving localization processes by using the Language Grid. Based on various language services provided on the Language Grid, we propose several localization processes by composing human and machine translation services. To consider both translation quality and translation cost, we also try to combine bilingual roles and monolingual roles with machine translation services in the localization processes since monolingual translators are usually more available and cost less than bilingual roles. In the proposed localization processes, monolingual human roles are introduced to revise the translation results of the machine translation services, while bilingual human roles are introduced to check the revision

¹<http://translate.google.com/>

²<http://honyaku.yahoo.co.jp/>

³<http://www.microsofttranslator.com/>

⁴<http://langrid.nict.go.jp/>

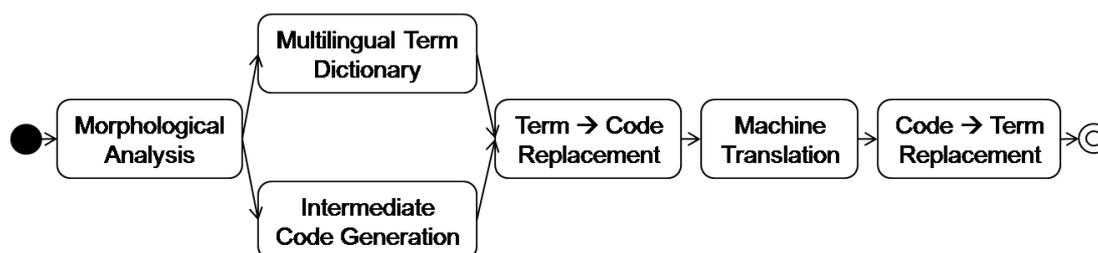


Figure 1: Composite machine translation service combined with dictionaries

results and also translate the contents that cannot be revised by the monolingual revisers.

By applying the proposed localization processes of composing human and the machine translation services on the Language Grid, we expect that (1) composing monolingual roles and dictionary services improves the translation quality of machine translators, and (2) collaboration of human and machine translators reduces translation cost comparing with absolute bilingual human translations. Further, to testify the above hypotheses, we conduct experiments of localization to compare the translation qualities and costs using several translation processes, including absolute machine translation processes, absolute human translation processes and translation processes by human and machine translators.

The rest of the paper is organized as follows: Section 2 introduce the Language Grid, which is the language service platform for this research. In Section 3, localization processes by composing human and machine translation services are proposed. Section 4 introduces a case study of translation processes with experiments, analysis and discussion. Section 5 introduces some related work, followed by the conclusion in Section 6.

2. Language Service Platform for Improving Localization Processes

To provide flexible language services for improving localization processes, we have developed the Language Grid, which is a service-oriented intelligence platform. The Language Grid has been collecting language resources from the Internet, universities, research labs and companies (currently about 60 language resources have been collected covering more than 50 different languages). All the language resources are wrapped as atomic Web services by standard interface including machine translation services, dictionary services, parallel text services, morphological analysis services and so on. Using the atomic Web services, we have also developed a series of composite services (Murakami and Ishida, 2008). All the atomic services and composite services are managed in the Language Grid Service Manager⁵.

The Language Grid also enables users to deploy their own language services following the standard interfaces. Therefore, users can flexibly choose atomic translation services (e.g., Google Translator, J-Server, Parsit, Toshiba, Translution, Web-Transer, YakushiteNet and so on) or composite

translation services (e.g., any combinations of atomic translation services and global dictionaries or user dictionaries for composite machine translation service combined with dictionary) on the Language Grid for their own requirements. Moreover, it is also possible to combine human tasks into the composite translation services on the Language Grid.

Since users have different requirements over translation quality, it is necessary to provide different services/composite processes with different quality for the same function. In the Language Grid, language services are categorized in several classes. For each service class, multiple services/composite processes are provided for different requirements. For example, the translation service class includes atomic machine translation service, two-hop machine translation service, machine translation service combined with bilingual dictionary, and so on. Figure 1 shows a composite Japanese-Chinese machine translation service which is developed with WS-BPEL specification (Alves et al., 2007) in the Language Grid. The composite service combines several atomic services including Japanese morphological analysis service, Japanese-Chinese term dictionary service, machine translation service and so on. By combining dictionary services and other services, the translation quality can be improved comparing with the atomic machine translation service (Inaba et al., 2007; Ishida, 2010).

3. Localization Processes by Composing Human and Machine Translation Services

Translations were evaluated on the basis of adequacy and fluency in previous reports (White et al., 1994). Adequacy refers to the degree to which the translation communicates information present in the original. Fluency refers to the degree to which the translation is well-formed according to the grammar of the target language. Although many types of services/processes are provided for a service class in the Language Grid, they still have limitations in translation quality, i.e., machine translation services can never have perfect fluency and adequacy in average even when they are combined with dictionaries or other services for quality improvement. That means automatic service-based processes are not able to meet users' requirements in localization processes. For example, composite service in Figure 1 might be able to deal with the requirement for online chatting, while it is difficult to use such service-based process to write business documents or translate the product

⁵http://langrid.org/service_manager/

operation manuals. Therefore, we consider combining machine translation services and human activities in cases of localization processes.

As for human activities, monolingual roles and bilingual roles can be considered in the translation processes that combine human and machine translation services. When there is an existing machine translation service (either atomic service or composite service as described in Section 2), the human activities are possible to be combined with the machine translation service by partially substituting it, processing the original sentences or translation results completely or partially for the purpose of professional translation.

In this research, we mainly consider the localization processes where human roles are induced to process the translation results. In more details, we focus on two types of processes as shown in Figure 2. Figure 2(a) shows a process that combines machine translator and monolingual human tasks, which is mainly used to evaluate how monolingual roles can improve translation quality by machine translation services. Figure 2(b) shows a process that combines machine translator, monolingual human tasks and bilingual human tasks, which is expected to be used for the localization processes.

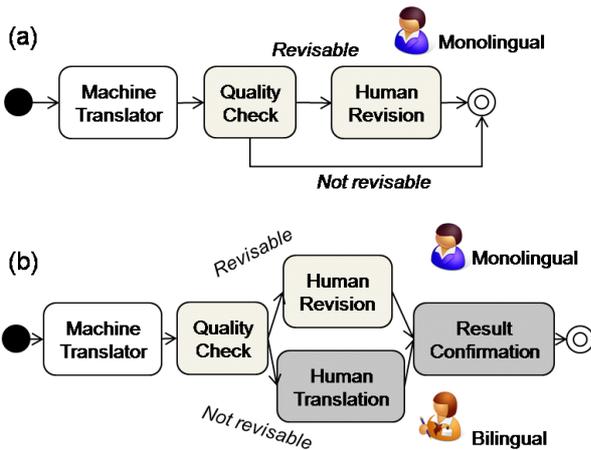


Figure 2: Localization processes by composing human and machine translation services

In the two types of processes, *Machine Translator* indicates the atomic machine translation service or composite machine translation service provided on the Language Grid. Monolingual human roles are induced to revise the translation results of the machine translators, while bilingual human roles are induced to check the revision results and also translate the contents that cannot be revised by the monolingual revisers. These two processes are realized by describing the human tasks using BPEL4People (Kloppmann et al., 2005) to extend the existing machine translation services on the Language Grid.

4. Experiments and Analysis

To observe and analyze the effects of localization processes by composing human and machine translation services, we conduct experiments by using several processes

of Japanese-Chinese translation, including atomic translation service, composite translation service with dictionary, collaborative translation processes, and absolute human translation. The language services and composite services are provided by the Language Grid.

4.1. Hypotheses

The localization processes can be improved if the translation quality keeps high while the translation cost decrease. Therefore, both translation quality and translation cost should be considered in the localization processes we propose in Section 3. First, the translation quality is expected to be kept high by including machine translation services comparing with the absolute human processes since we still have human roles in the proposed processes. Second, the translation cost is expected to be decreased since we include machine translation services and monolingual human roles in the proposed processes that might be less expensive than bilingual human roles.

We have the following hypotheses for the experiments: (1) composing monolingual roles and dictionary services improves the translation quality of machine translators, and (2) collaboration of human and machine translators reduces the cost comparing with the absolute bilingual human translation.

4.2. Experiments

Settings of translation quality measurement, processes, process instances, language services and human roles in the experiments are as follows.

Translation quality measurement. In this research, we use the two dimensions (fluency and adequacy) that we have introduced in Section 3 to evaluate the quality of translations as the method in the DARPA TIDES Project⁶ at University of Pennsylvania, with a five-level score for each dimension. When evaluating the Chinese translation result, the evaluation criteria of fluency is {5: Flawless Chinese, 4: Good Chinese, 3: Non-native Chinese, 4: Disfluent Chinese, 5: Incomprehensible}, and the evaluation criteria of adequacy is {5: All, 4: Most, 3: Much, 4: Little, 5: None}.

Processes. We use following processes in this experiment. *MT* is an atomic machine translation service. *MT+Dic* is a composite translation service with dictionary as shown in Figure 1. *MT+Mono* and *MT+Dic+Mono* are collaborative translation processes by human and machine translation services as shown in Figure 2 (a). *MT+Mono+Bi* and *MT+Dic+Mono+Bi* are collaborative translation processes shown in Figure 2 (b). Machine translation services are atomic translation services in *MT+Mono* and *MT+Mono+Bi*, while composite translation service combined with dictionary in *MT+Dic+Mono* and *MT+Dic+Mono+Bi*. *Bi* is an absolute human process. *Bi+TM* is an absolute human process with the aid of tools like translation memory which can automatically complete 15% of the translation tasks. The descriptions of above processes is given in Table 1 in details.

Process instances. For each process described in Table 1, we run 17 process instances to translate each Japanese sen-

⁶<http://projects ldc.upenn.edu/TIDES/Translation/TransAssess04.pdf>

Translation Process	Process Description
MT	An atomic Japanese-Chinese machine translation service.
MT+Dic	A composite Japanese-Chinese machine translation service combined with user dictionaries.
MT+Mono	An atomic Japanese-Chinese machine translation service combined with human tasks. The human tasks are conducted by a Chinese monolingual people for revising the understandable machine translation results.
MT+Dic+Mono	A composite Japanese-Chinese machine translation service combined with user dictionaries and human tasks. The human tasks are conducted by a Chinese monolingual people for revising the understandable machine translation results.
MT+Mono+Bi	An atomic Japanese-Chinese machine translation service combined with human tasks. The human tasks are conducted by a Chinese monolingual people for revising the understandable machine translation results and a Chinese-Japanese bilingual people for confirming the correctness of the revised results in <i>MT+Mono</i> as well as translating the unrevised parts in <i>MT+Mono</i> .
MT+Dic+Mono+Bi	A composite Japanese-Chinese machine translation service combined with user dictionaries and human tasks. The human tasks are conducted by a Chinese monolingual people for revising the understandable machine translation results and a Chinese-Japanese bilingual people for confirming the correctness of the revised results in <i>MT+Dic+Mono</i> as well as translating the unrevised parts in <i>MT+Dic+Mono</i> .
Bi+TM	A human translation process conducted by a Japanese-Chinese bilingual people with translation memory software.
Bi	A human translation process conducted by a Japanese-Chinese bilingual people without any Web services or translation memory software.

Table 1: Translation services/processes used in the experiments

tence to Chinese sentence in one instance. The Japanese sentences are randomly picked from a description manual for a digital camera in a Japanese company for localization, with the average sentence length of 42 Japanese characters. **Machine translation services.** Machine translation services used in the experiments include atomic machine translation service and composite machine translation service as shown in Figure 1. Main language services used in our experiments are provided in the Language Grid by wrapping language resources including J-Server Japanese-Chinese machine translation service provided by Kodensha Co., Ltd⁷, Mecab Japanese morphological analysis service provided by NTT Communication Science Laboratories⁸, a user Japanese-Chinese dictionary service for digital cameras which covers 18.75% words in the Japanese sentences for execution.

Human roles. Human tasks in the experiments are conducted by a Japanese-Chinese bilingual translator and a Chinese monolingual reviser with the cost of 30 units and 15 units per hour respectively.

4.3. Analysis

In our experiments, we compare the translation qualities and costs in different translation processes. To testify the two hypotheses in Sect.4.1, we analyze the experimental results in the following two aspects.

Translation quality. Figure 3 is the experimental results on fluency and adequacy of translation for *MT*, *MT+Dic*, *MT+Dic+Mono*. Besides, we also evaluate the translation quality for *MT+Mono* with the average fluency as 3.5 and adequacy as 3.3. Results of *MT+Mono+Bi*, *MT+Dic+Mono+Bi*, *Bi+TM* and *Bi* are not listed because fluency and adequacy are both 5 for each instance. The result shows that the machine translation quality in *MT* is limited and cannot meet the requirements for localization processes. However, it can be improved by using composite translating service by combing dictionaries and other services. For *MT+Dic*, adequacy of the translation result is not less than 3 in 88% of process instances (15 of 17). By combining machine translator and dictionaries, the translation quality can be further improved from *MT* to *MT+Dic* (*fluency*: 2.8 → 3.2, *adequacy*: 3.0 → 3.7). Composing monolingual human tasks with the composite translation service with dictionaries, the translation quality can be further improved from *MT+Dic* to *MT+Dic+Mono* (*fluency*: 3.2 → 4.5, *adequacy*: 3.7 → 4.4). There is also an interesting observation that adequacy of translation result in *MT+Dic* (*adequacy*: 3.7) is even better than that of *MT+Mono* (*adequacy*: 3.3), which means that collaborative translation by human and machine translator also has limitations if the original translation quality is not good. The result reveals that community dictionary services are very important to improve machine translation quality. In one word, the results in Figure 3 give evidence to support our first hypothesis that composing monolingual roles and

⁷<http://www.j-server.com/>

⁸<http://sourceforge.net/projects/mecab/>

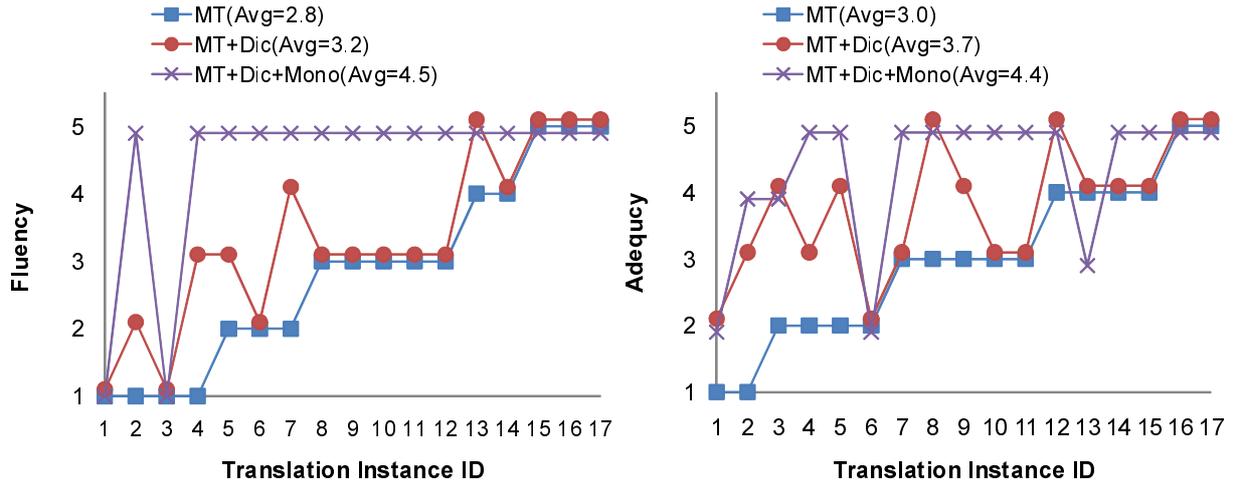


Figure 3: Comparison of translation quality (fluency and adequacy) for different translation processes

dictionary services improves the translation quality of machine translators. From Figure 3, we can also see that the improvement is very effective when the original translation quality (fluency and adequacy) of machine translation is among the level of 2 to 4.

Translation cost. Table 2 is the experimental results on translation cost and time duration for $MT+Mono+Bi$, $MT+Dic+Mono+Bi$, $Bi+TM$ and Bi , which have the equal translation qualities with fluency and adequacy both 5 and can be used as localization processes. The results show that collaborative translation processes by human and machine translator ($MT+Mono+Bi$ and $MT+Dic+Mono+Bi$) can reduce the translation cost comparing with the human translation process (Bi and $Bi+TM$) with 35% in maximum. However, the time duration of the four processes do not significantly differ from each other since we simply add the execution duration of the machine translator and human tasks for all 17 process instances when computing the execution duration in collaborative translation processes ($MT+Mono+Bi$ and $MT+Dic+Mono+Bi$). However, if we consider the parallel execution of process instances and human tasks, the execution duration are expected to be reduced in collaborative translation process ($MT+Mono+Bi$ and $MT+Dic+Mono+Bi$). In summary, the results in Table 2 give evidence to support our second hypothesis that collaboration of human and machine translators is possible to reduce the cost comparing with the absolute bilingual human translation.

4.4. Discussion

Generality of the experimental results. Since the experimental results described in Section 4.3 are based from an experiment of very small scale, we cannot simply conclude that the hypotheses in Section 4.1 are true for all cases. Actually, when inducing human activities to keep high translation quality, the translation cost is affected in different ways by varying execution rate of human activities and machine translation services in the proposed localization processes. In cases where human activities are

Process	Human	Time	Cost
Bi	Bilingual(1)	40min	20.00
Bi+TM	Bilingual(1)	35min	17.50
MT+Mono+Bi	Bilingual(1) Monolingual(1)	39min	16.50
MT+Dic+Mono+Bi	Bilingual(1) Monolingual(1)	36min	13.00

Table 2: Comparison of translation cost and duration for different translation processes

induced but not efficiently executed, the translation cost of composite process by machine translation services and human activities is even higher than an absolute human process. In the experiments we conduct, the monolingual human task *human revision* is executed in 88% of process instances in $MT+Dic+Mono$ and $MT+Dic+Mono+Bi$. To analyze how the execution rate of *human revision* would affect the translation cost of the proposed process, we conduct further simulations. To keep the translate quality as *fluency* = 5.0 and *adequacy* = 5.0, we use $MT+Dic+Mono+Bi$ as the simulation process. We conduct the simulation by varying the execution rate (rr) of the monolingual human task *human revision* with other settings the same as we have described in Section 4.2. For example, $rr = 25\%$ means that the execution probability of *human revision* in $MT+Dic+Mono+Bi$ is 25%. We simulate several cases ($rr = 100\%, 75\%, 50\%, 25\%, 0\%$) for all the 17 process instances. The simulation result is shown in Table 3. From the result, we can see that with the increase of rr , translation cost and translation duration both decrease. The case of $rr = 100\%$ can save 38.5% of translation cost and 15.6% of translation duration comparing to the case of $rr = 0\%$, where monolingual human activity is intended to be induced for revising translation result but actually nothing can be revised and all the translations are done again by the bilingual human trans-

Simulation Items	Revision rate of translation result in <i>MT+Dic+Mono+Bi</i>				
	<i>rr</i> = 100%	<i>rr</i> = 75%	<i>rr</i> = 50%	<i>rr</i> = 25%	<i>rr</i> = 0%
Translation Cost	14.75	17.50	19.25	22.25	24.00
Translation Time	38min	39min	41min	43min	45min

Table 3: Simulation results of translation cost and time for different translation revision rate (*rr*)

lator. The simulation also acquires the result that the execution cost and execution duration of the case $rr < 55\%$ in *MT+Dic+Mono+Bi* are even more than those in *Bi* because of the waste execution of composite machine translation services and monolingual human tasks. The simulation is conducted with IBM's Websphere Business Modeler Advanced V6.2⁹.

Challenging issues. To cover translation quality and translation cost, composition of human activities and machine translation services can be regarded as a promising approach. However, it is necessary to consider how to design mechanisms to reduce translation cost while keeping the translation quality. Although the experimental results in this paper might not be supported in a statistical perspective, many lessons can be obtained from an empirical perspective as a fundamental trial of composing human and machine translation services for improving localization processes. We have also learned several important issues of controlling human tasks that should be considered in the future. First, although this paper mainly focuses on the translation quality and translation cost of the localization processes that composed by human and machine translation services, the design of interaction mechanisms among human and translation services, between human activities in a localization process is actually an important issue to be considered. If the interactions are not effective, translation cost might be increased because of the additional interaction cost. Second, it is necessary to unify human activities and Web services for composition to control human assignment, quality control of human tasks, dynamic human service selection and so on. Third, the dynamic management of human task execution is also important for reducing translation cost of human tasks.

5. Related Work

In this section, we review some related work on the perspective of both Web service composition and intercultural collaboration using machine translation services.

Web service composition has been an important issue for past several years in the service-oriented computing area. Recently, QoS-aware service composition has become the focus in this area (Zeng et al., 2004; Aggarwal et al., 2004; Menasce, 2002; Cardoso et al., 2004). The work of Zeng *et al.* (Zeng et al., 2004) is among the earliest ones for QoS-aware service composition. The authors propose a multidimensional QoS model for Web service composition including dimensions of execution price, execution duration, reputation, successful execution rate and availability. In this research, we also use QoS dimensions like execution cost

and execution duration for analysis. However, we also consider the application-specific QoS (fluency and adequacy of translation) and focus more on it.

Human activities has been considered in workflow management from the perspective of link of organization elements and business process (Zhao et al., 2008) and from the perspective of organization management (Zur Muehlen, 2004). BPEL4People has been used as specification for human tasks in previous work (Russell and Aalst, 2008; Zhao et al., 2008; Mendling et al., 2008). However, our research is the first to use human tasks for improving application-specific QoS and conduct experiments in the language domain in real world for analyzing the composition of human activities and machine translation services.

In the area of intercultural collaboration, machine translators have been applied in multilingual communication in previous research. From the view of communication analysis, effects and difficulties of using machine translation in collaborative work have been discussed (Yamashita and Ishida, 2006; Yamashita et al., 2009). Moreover, it has been reported that combining community dictionaries and machine translators can improve mutual understanding in multilingual communications (Inaba et al., 2007). Further, effectiveness of collaborative translation by machine translators and monolingual human have been shown in some work (Hu, 2009; Morita and Ishida, 2009). However, effects of applying machine translation services in localization processes with the aid of human activities are rarely observed in this area, which is the focus of this research.

6. Conclusion

Possibility of combining human and machine translators has been discussed in previous research. However, practical efforts of how to support such approaches for improving localization processes in the real world are rarely reported. The main contribution of this paper is to propose an approach of composing human activities and machine translation services for localization processes considering both translation quality and translation cost.

First, we propose the approaches of improving localization processes by composing human and machine translation services based on the Language Grid, a language service platform that we have developed. Then, we show how to conduct localization processes on the Language Grid. Further, we conduct experiments to compare the translation qualities and costs using several translation processes, including absolute machine translation processes, absolute human translation processes and translation processes by human and machine translators. The experiment results show that (1) composing monolingual roles and dictionary services improves the translation quality of machine trans-

⁹<http://www-01.ibm.com/software/integration/wbimodeler/advanced/>

lators, and (2) collaboration of human and machine translators is possible to reduce the cost comparing with the absolute bilingual human translation.

Currently, larger scale experiments on localizing community contents based on the proposed processes are being conducted within local communities. These efforts are expected to yield a significant impact on the localization industry for creating new business models.

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