Implementing an efficient and scalable service-oriented architecture for the Apertium machine translation platform

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Abstract

Service Oriented Architecture (SOA) is a paradigm for organising and using distributed services that may be under the control of different ownership domains and implemented using various technology stacks. In some contexts, an organisation using an IT infrastructure implementing the SOA paradigm can take a great benefit from the integration, in its business processes, of efficient machine translation (MT) services to overcome language barriers. This paper describes the architecture and the design patterns used to develop an MT service that is efficient, scalable and easy to integrate in new and existing business processes. The service is based on Apertium, a free/open-source rule-based machine translation platform.

1 Introduction

Service Oriented Architecture is an architectural paradigm providing a set of principles of governing concepts used during phases of systems development and integration. In such an architecture, functionalities are packaged as interoperable, loosely coupled services that may be used to build infrastructures enabling those with needs (consumers) and those with capabilities (providers) to interact across different domains of technology and ownership.

Several new trends in the computer industry rely upon SOA as their enabling foundation, including the automation of Business Process Management (BPM) and the multitude of new architecture and design patterns generally referred to as Web 2.0 (O'Reilly, 2005).

In some contexts, an organisation using an IT infrastructure implementing the SOA paradigm can take a great benefit from the integration, in its business processes, of an efficient machine translation service to overcome language barriers; for instance, it could be integrated in collaborative enviroments where people, who have no language in common, attempt to communicate with each other; or in knowledge extraction processes, where data is not available in a language that can be understood by the domain experts or the knowledge extraction tools being used.

A machine translation service was creating using Apertium[1] (Armentano-Oller et al., 2005), a free/open-source rule-based machine translation platform for its translation capabilities, and on libTextCat[2], a library implementing n-gram based text categorisation (Cavnar and Trenkle, 1994) for language recognition, which provides an inexpensive and highly effective way of recognising the language used in documents; this result is reached by using small-sized (about $4KB$) fingerprints of the desired languages rather than resorting to more complicated and costly methods such as natural language parsing or assembling detailed lexicons. The libTextCat library is also used by Bi-

[1] http://www.apertium.org/
[2] http://software.wise-guys.nl/libtextcat/

textor (Esplà-Gomis, 2009), a system to harvest translation memories from multilingual websites.

Efficiency and scalability are critical for the service since, especially in collaborative enviroments, it should be able to sustain a heavy load of traffic. In this paper, the techniques and design patterns used to implement the machine translation service will be described and it will be compared to the standalone system.

2 Service APIs

Our service provides the two following capabilities:

- Translation – for automatic translation of free text from a source language to a destination language;
- Language recognition – for automatic language guessing of free text;

In SOA, interoperability between services is achieved by using standard languages for the description of service interfaces and the communications among services. A widely accepted technique for implementing SOA consists in making use of Web Services (Erl, 2005); a Web Service is defined by the W3C as "a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP-messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards." (Brown and Haas, 2004).

Alternative standards to SOAP are XML-RPC (Winer, 1999), a remote procedure call protocol which uses XML to encode its calls and HTTP as a transport mechanism, and Representational State Transfer (REST) (Fielding, 2000), a style of software architecture for distributed hypermedia systems such as the World Wide Web.

Our service natively provides a XML-RPC interface to the translation and language recognition functionalities, and we also implemented SOAP and REST wrappers to it. All the interfaces follow the schema outlined in tables 1 and 2 to expose, respectively, the translation and the language detection functionalities; those can be subsumed by the following methods:

parameters	`text`
	`source language`
	`destination language`
returns	`translation`
	`detected source language`

Table 1: Parameters and return value(s) for the Translate method.

parameters	`text`
returns	`detected language`

Table 2: Parameters and return value(s) for the Detect method.

- Translate: receives three parameters called `text`, `source language` and `destination language` containing, respectively the text to be translated, the source language and the destination language, and returns a `translation` value containing the translated text; if the source language is omitted, then language recognition is used to guess it, and the guessed language is returned in the `detected source language` value.
- Detect: receives three parameters called `text` containing free text, and returns a `detected language` value containing the language used by the text.

In addition, our service provides a `language pairs` method that returns a sequence of all the language pairs supported by the translation system, each represented by a pair containing the corresponding `source language` and the `destination language`.

In all methods, languages are represented by their ISO 639-1 (ISO:639-1, 2002) code. Figure 1 shows a short example of how our service's XML-RPC interface can be invoked by the Python[3] shell.

[3] `http://www.python.org/`

```
>>> import xmlrpclib
>>> proxy = xmlrpclib.ServerProxy
        ('http://xixona.dlsi.ua.es:8080/RPC2')
>>> print proxy.translate("Test for the machine
        translation service", "en", "es")
        ["translation"]
Prueba para el servicio de traducción automática
```

Figure 1: Example – invoking our service from the Python shell.

3 Internal architecture of the service

Apertium is a transfer-based machine translation system which uses finite-state transducers for lexical processing, hidden Markov models (HMMs) for part-of-speech tagging and finite-state-based chunking for structural transfer. Its translation engine consists of an *assembly line*, composed by the following modules:

Formatters – which handle format-specific information with respect to text to be translated;

Morphological analyser – which tokenizes the text in *surface forms* and delivers, for each surface form, one or more *lexical forms* consisting of lemma, lexical category and informations about morphological inflection;

Part-of-speech tagger – which chooses one of the analyses of an ambiguous word, according to its context;

Lexical transfer module – which reads each lexical form of the surface form and delivers the corresponding destination language lexical form;

Structural transfer module – which detects and processes patterns of words that need special processing due to grammatical divergences between two languages;

Morphological generator – that, from a lexical form in the destination language, generates a suitably inflected surface form;

Post-generator – that performs some orthographic operations in the destination language such as contractions;

Actually, in Apertium those functionalities in two libraries, called `liblttoolbox` and `libapertium`, and uses them to implement a set of *console programs* managing their input and output in the form of *text streams*; the console programs are then assembled by using a *UNIX pipeline* to implement a final console program, called `apertium`, which, given a language pair, handles a translation process in its entirety. All the informations required to execute a translation task associated to a language pair are contained in a *mode file*, which specifies which modules should be run, their parameters and order.

Our service has been realized in the form of a multithreaded program, which relies on `liblttoolbox` and `libapertium` to execute each step of a translation process.

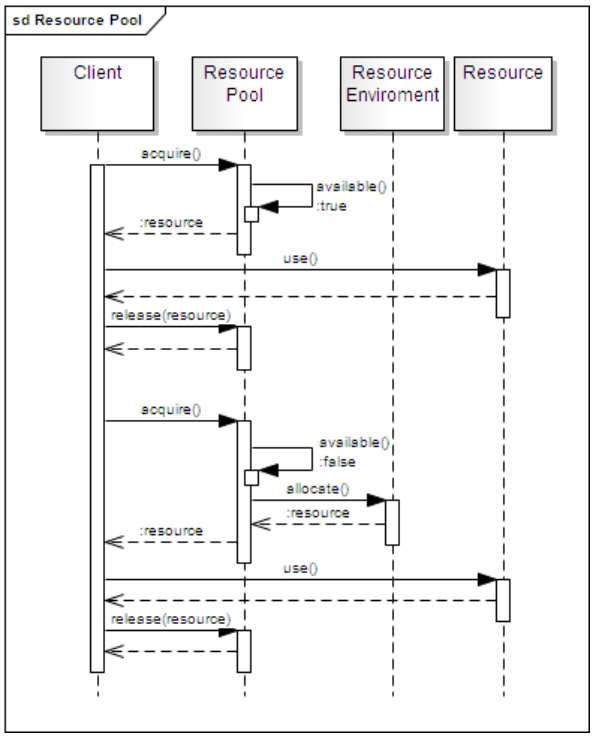

Figure 2: Sequence diagram describing how acquisition and release of resources works in a system implementing the *pooling pattern*: recycled objects are managed in a pool of resources, which allows pool clients to acquire them, and release them back to the pool when they are no longer needed.

To prevent the frequent acquisition and release of the resources required to execute each step of the aforementioned assembly line, our service makes use of the *pooling pattern* (Kircher and Jain, 2004), in which multiple instances of one

type of resource are managed in a pool. This pool of resources allows for reuse when resource clients release resources they no longer need: released resources are put back into the pool and made available to resource clients needing them, as shown in figure 2.

To improve efficiency, the resource pool can eagerly acquire a number of resources after its creation; then, if demand exceeds the number of available resources in pool, more resources can be *lazily* acquired.

There are various valid approaches to free unused resources, like those consisting of monitoring the use of a resource and controlling its lifecycle by using strategies such as "least recently used" (LRU) or "least frequently used" (LFU), or introducing a *lease* for every resource that specifies a time duration for which a resource can remain in the pool.

In our service, the default policy is to allocate new resources from the resource enviroment if there are no resources of the requested type available in the pool; the service also allows the setting of a *high water mark*, i.e. a maximum number of allocated objects: if the number of allocated objects is equal to the high water mark, the requesting client has to wait in a queue until a resource of the requested type is available in the pool. In addition, as we made no prior assumptions about how the service would be used, it does not apply any garbage collection policy by default.

Relying on a resource pool is designed to result in the following improvements for our rule-based machine translation service:

Performance – By preventing repetitious acquisition, elaboration and release of resources;

Predictability – Because direct acquisition of a resource from an external resource enviroment (for example, a filesystem or a DBMS) can lead, in some cases, to unpredictable results and dynamic memory allocation and deallocation can be non-deterministic with respect to time (Douglass, 2002);

Stability – Because repetitious acquisition and release of resources can increase the risk of system instability due, for example, to memory fragmentation problems (Utas, 2005; Douglass, 2002);

Scalability – As resources can be used also in different types of translation tasks, avoiding the allocation of a complete set of resources for each different translation task (for example, translation tasks on different language pairs using different dictionaries can make use of the same resource for managing the removal and restoration of formatting).

Another approach to implement a service based on Apertium by Sánchez-Cartagena and Pérez-Ortiz (2009) consists in making use of a pool of `apertium` processes: each translation request is routed to a process making use of the required language pair, and then its output is returned back to the service client.

Our approach has a series of pros and cons with respect to the one followed by Sánchez-Cartagena and Pérez-Ortiz (2009); advantages can be summarized by the following:

Efficiency – Threads usually require less resources when compared to processes, and Inter-Process Communication (IPC) between multiple processes tend to be more complex and expensive than IPC between multiple threads belonging to the same process (Tanenbaum, 2007);

Efficiency (2) – Resources can be shared between multiple translation tasks (even belonging to different language pairs) without the need of allocating them for each translation process;

Portability – Our service relies on the Boost C++ libraries[4] for portable multithreading, regular expressions, filesystem operations and so on, making it capable to run in enviroments still not supported by the `apertium` application;

While disadvantages can be synthesized by the following:

Maintainability – Changes to Apertium modules or to the Apertium assembly line can make necessary updates to our service;

[4] `http://www.boost.org`

4 Results

To evaluate the efficiency of our service, which we will refer to as `apertium-service`, we compared the time it requires to compute and answer to a translation request from Spanish to English with the `apertium-en-es` language pair[5] with the time required by the following systems:

- `apertium`, a console application implemented as a part of the Apertium project;

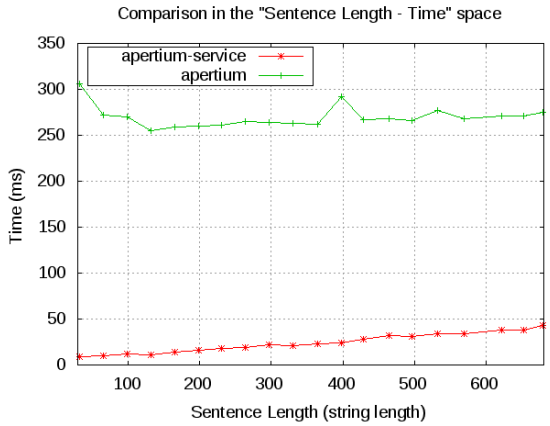

Figure 3: Comparison in the "Sentence Length - Time" space between `apertium` and `apertium-service`; measurements are in *string length* for the Sentence Length dimension and in *ms* for the Time dimension.

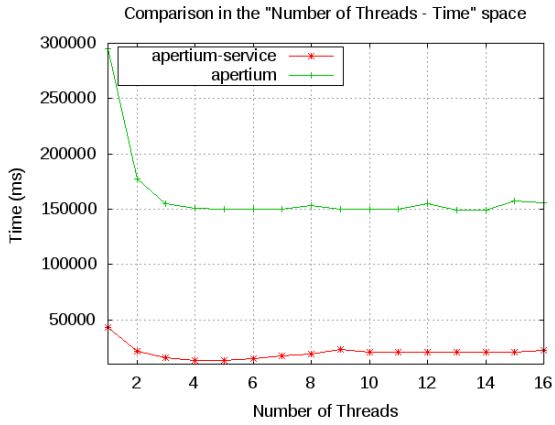

Figure 4: Comparison in the "Number of Threads - Time" space between `apertium` and `apertium-service`.

All the experiments were run on a server with four 2GHz Dual-Core AMD Opteron processors and 4GB of main memory, using the GNU/Linux operating system. Both `apertium-service` and `moses-service` were accepting translation requests in XML-RPC format, and the free text used for timing all the systems was also taken from Europarl corpus. Figure **??** shows the time required to translate increasingly longer sentences for all systems (values in the time dimension are shown on a logarithmic scale), and figure 3 only for `apertium-service` and `apertium`.

Scalability for `apertium` and `apertium-service` have been evaluated by calculating the average time required by the two systems to answer to 1,024 translations requests sequentially sent by a variable number of clients; the requests consisted to translating the longest sentence from the Europarl evaluation corpus (679 characters) from Spanish to English. Figure 4 shows the results of this comparison.

5 Future work

UMLS concept identification in non-English medical documents: MetaMap (Aronson, 2001) is an application that allows mapping text to UMLS Metathesaurus[6] concepts, which have proved to be useful for many applications, including decision support systems, management of patient records, information retrieval and data mining within the biomedical domain.

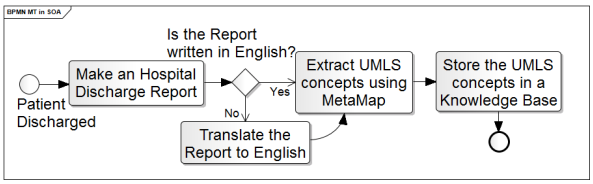

Figure 5: Representation of a business process in which a clinical document, if written in a language different than English, is fist translated to English and then processed using MetaMap to extract UMLS concepts.

Currently MetaMap is only available for English free text, which makes it difficult the use of UMLS Metathesaurus to represent concepts from biomedical texts written in languages other than

[5] SVN Revision 16218

[6] The UMLS® Metathesaurus® (Schuyler et al., 1993) provides a representation of biomedical knowledge consisting of concepts classified by semantic type and both hierarchical and non-hierarchical relationships among the concepts.

English. A possible way to overcome this limitation consists in using machine translation specific for the biomedical domain to translate the free text from its original language to English, and then process it as in Figure 5. This approach is discussed in Carrero et al. (2008).

6 Conclusions

We presented `apertium-service`, a machine translation service based on Apertium, a free/open-source rule-based machine translation platform. It has been shown to be competitive compared to the baseline system in both efficiency and scalability.

Source code for our service is released under the GNU General Public Licence version 3[7] and is available on the Apertium SVN repository.[8]

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[7] `http://www.gnu.org/licenses/gpl.html`

[8] `http://apertium.svn.sourceforge.net/svnroot/apertium/trunk/apertium-service`

[9] `http://code.google.com/soc/`

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