

Apertium goes SOA: an efficient and scalable service based on the Apertium rule-based 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 environments 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.

We implemented a machine translation and language recognition service by relying on Apertium¹ (Armentano-Oller et al., 2005), a free/open-source rule-based machine translation platform, and on libTextCat², a library implementing n-gram based text categorisation (Cavnar and Trenkle, 1994), which provides an inexpensive and highly effective way of recognising the language used in documents. libTextCat uses small-sized fingerprints of the desired languages (circa 4KB each) rather than resorting to more complicated and costly methods such as natural language parsing or assembling detailed lexicons; it is also used by Bitextor (Esplà-Gomis, 2009), a system to har-

¹<http://www.apertium.org/>

²<http://software.wise-guys.nl/libtextcat/>

vest translation memories from multilingual web-sites.

Our decision to prefer a rule-based machine translation system like Apertium to a statistical or an example-based machine translation system was motivated by the following reasons:³

- Statistical Machine Translation systems tend to produce translations appearing more “fluent” than translations produced by Rule-Based systems (which appear more “mechanical”), but less faithful to the meaning of the original text and with less evidence for translation errors;
- In Rule-Based Machine Translation systems, linguistic knowledge can be encoded explicitly in the form of linguistic data, so that both humans and automatic systems can process it – a great advantage when in presence of domain-specific and proprietary linguistic knowledge;
- Experts who have designed a Rule-Based Machine Translation system tend to find it easier to diagnose and repair sources of translation errors, like wrong rules in modules or wrong entries in dictionaries.

Efficiency and scalability are critical for the service since, especially in collaborative environments, 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 other existing machine translation systems.

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 – to automatically guess the language used in a text;

³This is a summary of comments made by Prof. Mikel L. Forcada on the *apertium-stuff* mailing list in September of 2009.

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.

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.

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:

Translate – which receives three parameters called *text*, *source language* and

```
>>> 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 using XML-RPC.

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 – which 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 from the Python⁴ 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 tokenises 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;

The modules composing the Apertium assembly line are implemented in the form of *console programs* and their functionalities are wrapped in the form of C++ classes which can be found in two C++ libraries, called `libltoolbox` and `libapertium`. Modules are then interconnected by using a *UNIX pipeline* to implement a final console program in the form of a *shell script*, called `apertium` which, given an arbitrary 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 the *mode file* corresponding to the given language pair, which specifies which modules should be run, their parameters and order.

Our service has been developed as a multi-threaded C++ program which relies on functionalities implemented in the `libltoolbox` and `libapertium` libraries to execute each step of the aforementioned assembly line. In those libraries, the code implementing each module was projected to manage their input and output text streams in the form of C `FILE` streams; therefore,

⁴<http://www.python.org/>

on some systems, it is not always possible to handle a module's input and output without making use of temporary files. Therefore, to minimise the interaction with the filesystem, our service relies on `open_wmemstream`, a C function conforming to the POSIX.1-2008⁵ standard used to create a C FILE wide-oriented stream associated with a dynamically allocated memory buffer: if present, this function allows our service to store all intermediate representations of the text in in-memory buffers instead of files. In addition, we had to completely rewrite the formatters, since those included in the Apertium project, which rely on the GNU flex lexical analyser⁶, cannot be used concurrently by the same process. Currently, both the plain text and HTML formatters have been converted.

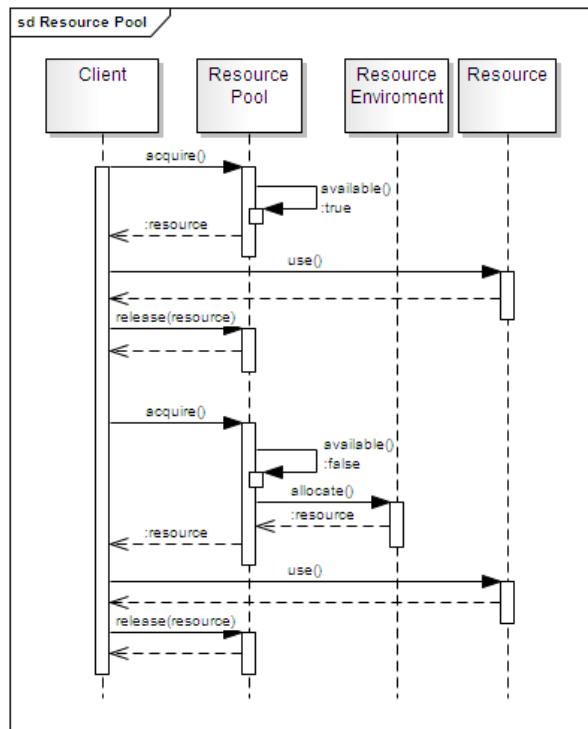


Figure 2: Sequence diagram describing how acquisition and release of resources works in a system implementing the *pooling pattern*: recycled objects are managed in a pool of resources, which allows pool clients to acquire them, and release them back to the pool when they are no longer needed.

To prevent the frequent acquisition and release of the resources required to execute each step of

the Apertium assembly line, our service has been implemented by making use of the *pooling pattern* (Kircher and Jain, 2004); according to this design pattern, it is desirable to keep all reusable, not currently in use resources in the same resource pool so that they can be managed by a coherent policy. 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 life-cycle 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 environment 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 – Preventing repetitious acquisition, elaboration and release of resources;

Predictability – Direct acquisition of a resource from an external resource environment (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);

⁵<http://www.opengroup.org/onlinepubs/969919799/>

⁶<http://flex.sourceforge.net/>

Stability – 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 – Resources can be recycled by multiple types of translation tasks – for example, Formatters can be used in multiple contexts since they are usually not language pair-specific.

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 advantages and disadvantages with respect to the one followed by Sánchez-Cartagena and Pérez-Ortiz (2009); advantages can be summarised 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);

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

While one disadvantage would be with maintainability. Apertium internals still lack standardised API interfaces, therefore future changes to `liblttoolbox` and `libapertium` might make updates to our service necessary.

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 time required by the following systems:

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

- `apertium-ws`, a REST service based on Apertium and described in Sánchez-Cartagena and Pérez-Ortiz (2009), using one *slave* instance attached to one *request router*;
- `apertium-service`, the system described in this paper

All the Apertium-based systems (`apertium`, `apertium-service` and `apertium-ws`) were employing the `apertium-en-es` language pair.⁷

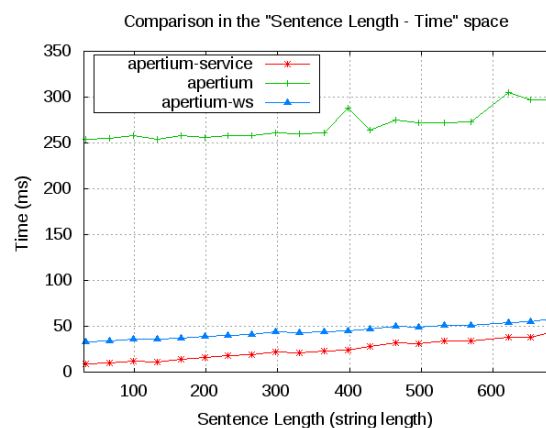


Figure 3: Comparison in the “sentence length – time” space between `apertium` and `apertium-service`; measurements are in *string length* for the sentence length dimension and in *ms* for the time dimension.

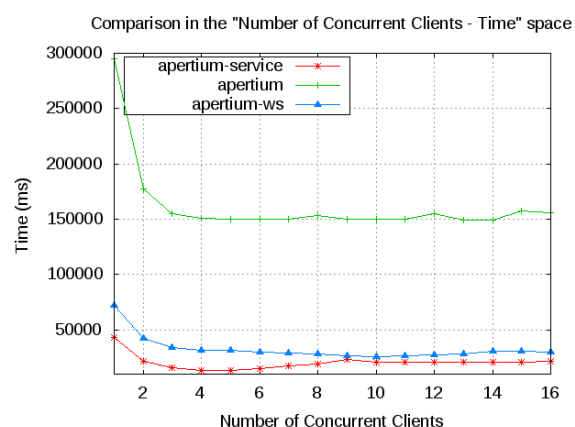


Figure 4: Comparison in the “number of concurrent clients – time” space between `apertium`, `apertium-service` and `apertium-ws`.

⁷SVN Revision 16218

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. `apertium-service` was accepting translation requests in the form of XML-RPC calls, `apertium-ws` in the form of REST HTTP GET requests, `apertium` through standard input (a new process was created for each translation task). The free text used for timing all the systems was also taken from EuroParl corpus. Figure 3 shows the time required to translate increasingly longer sentences for all systems (values in the time dimension are shown on a logarithmic scale).

Scalability for the systems has been evaluated by calculating the average time required by the systems to answer to 1,024 translation requests sequentially sent by a variable number of clients; the requests consisted to translating the longest sentence from the EuroParl evaluation corpus (679 characters), so to obtain a worst case score, from Spanish to English. Figure 4 shows the results of this comparison.

5 Future work

In terms of developing the service further, there are two principle avenues. We would like to finish implementing the rest of the formatters. Currently only plain text and HTML are supported. Apertium supports several more file formats, such as ODT and RTF, and it would be desirable to support these as well.

The other task would be to implement a JSON/REST interface to the API as used by Google Translate, and the `apertium-ws`. Having a standard API for interfacing with Apertium on the web would make it easier to use.

The service could be lent to a number of interesting applications. For example, one avenue we would like to pursue is the use of the service in cross-language information retrieval in the biomedical domain. MetaMap (Aronson, 2001) is an application that allows mapping text to UMLS Metathesaurus⁸ concepts, which have proved to be useful for many applications, including de-

cision support systems, management of patient records, information retrieval and data mining within the biomedical domain.

Currently, MetaMap is only available for English free text, which makes it difficult the use of UMLS Metathesaurus to represent concepts from biomedical documents written in languages other than English. To enable cross-lingual text classification, Carrero et al. (2008) proposes to make use of general purpose statistical machine translation tools, such as Google Translate⁹, to translate the documents from their source language to English, and then process them through the traditional English MetaMap; unluckily, this approach presents some important mistakes when translating terms specific for the biomedical domain.

To overcome this limitation, it should be possible to employ our Apertium-based service, in conjunction with bilingual dictionaries, transfer rules etc. specific for the biomedical domain, to obtain an accurate translation of biomedical documents before profitably processing them.

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 in both efficiency and scalability when compared to other machine translation systems.

Source code for our service is released under the GNU General Public Licence version 3¹⁰ and is available on the Apertium SVN repository.¹¹

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⁹<http://translate.google.com/>

¹⁰<http://www.gnu.org/licenses/gpl.html>

¹¹<http://apertium.svn.sourceforge.net/svnroot/apertium/trunk/apertium-service>

¹²<http://code.google.com/soc/>

⁸The 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.

References

- Armentano-Oller, C., Corbí-Bellot, A. M., Forcada, M. L., Ginestí-Rosell, M., Bonev, B., Ortiz-Rojas, S., Pérez-Ortiz, J. A., Ramírez-Sánchez, G., and Sánchez-Martínez, F. (2005). An open-source shallow-transfer machine translation toolbox: consequences of its release and availability. In *OSMaTran: Open-Source Machine Translation, A workshop at Machine Translation Summit X*, pages 23–30.
- Aronson, A. R. (2001). Effective mapping of biomedical text to the umls metathesaurus: the metamap program. *Proc AMIA Symp*, pages 17–21.
- Brown, A. and Haas, H. (2004). Web services glossary. World Wide Web Consortium, Note NOTE-ws-gloss-20040211.
- Carrero, F. M., Cortizo, J. C., Gómez, J. M., and de Buena, M. (2008). In the development of a spanish metamap. In *CIKM '08: Proceeding of the 17th ACM conference on Information and knowledge management*, pages 1465–1466, New York, NY, USA. ACM.
- Cavna, W. B. and Trenkle, J. M. (1994). N-gram-based text categorization. In *In Proceedings of SDAIR-94, 3rd Annual Symposium on Document Analysis and Information Retrieval*, pages 161–175.
- Douglass, B. P. (2002). *Real-Time Design Patterns: Robust Scalable Architecture for Real-Time Systems*. Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA.
- Erl, T. (2005). *Service-Oriented Architecture : Concepts, Technology, and Design*. Prentice Hall PTR.
- Esplà-Gomis, M. (2009). Bitextor: a Free/Open-source Software to Harvest Translation Memories from Multilingual Websites. In *Proceedings of MT Summit XII*, Ottawa, Canada. Association for Machine Translation in the Americas.
- Fielding, R. T. (2000). *Architectural Styles and the Design of Network-based Software Architectures*. PhD thesis, University of California, Irvine.
- ISO:639-1 (2002). Iso 639-1:2002 – codes for the representation of names of languages – part 1: Alpha-2 code.
- Kircher, M. and Jain, P. (2004). *Pattern-Oriented Software Architecture Volume 3: Patterns for Resource Management*. Wiley.
- O'Reilly, T. (2005). What Is Web 2.0: Design Patterns and Business Models for the Next Generation of Software.
- Sánchez-Cartagena, V. M. and Pérez-Ortiz, J. A. (2009). An open-source highly scalable web service architecture for the apterium machine translation engine. In *Proceedings of the First International Workshop on Free/Open-Source Rule-Based Machine Translation*.
- Schuyler, P. L., Hole, W. T., Tuttle, M. S., and Sherertz, D. D. (1993). The umls metathesaurus: representing different views of biomedical concepts. *Bull Med Libr Assoc*, 81(2):217–222.
- Tanenbaum, A. S. (2007). *Modern Operating Systems*. Prentice Hall Press, Upper Saddle River, NJ, USA.
- Utas, G. (2005). *Robust Communications Software: Extreme Availability, Reliability and Scalability for Carrier-Grade Systems*. John Wiley & Sons.
- Winer, D. (1999). XML/RPC specification. Technical report, Userland Software.