LSP or How to unlock builtin IDE features in your favorite text editor

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Introduction

Text editors are often described as lackluster compared to `Integrated Development Environments` (long for **IDE**) and their builtin features that can considerably enhanced the productivity when writing code. As an Emacs user, I found myself pretty jealous of some features of the workflows that my friends or my collegues may use. A good example to illustrate this point is the auto-completion which is enabled by default on most IDEs out there and is sometimes very troublesome to have it work inside Emacs (vanilla or not). Even if some people do not consider it as mandatory and do not value it as much as I can do, it can be an important criteria for the tools one may want to choose to write code. However few years ago, Microsoft managed to find a way that can help implementing such feature in your favorite text editor and help it ascend to the level of an IDE. Its name is `Language Server Protocol`, also known as **LSP**. I found the existence of this tool by inadvertence while I was ricing a bit my Emacs config, and it helped me getting rid off many more issues I would have expected at first. .

This article aims to give some background knowledge about LSP, what it consists of, its main uses and finally its current place.

Context and background

Microsoft and VS Code

In 2015, Microsoft announced the development of **Visual Studio Code**, their homemade open sourced text editor oriented on the programming side. However, the competition was already important on this market, with the presence of the almighties IDEs and fossils still widely used such as Emacs, Vim or Nano. Nonetheless, the team leading the project aimed for high objectives and planned the whole product to scale well and make sure it will get an important share of the programmers on the long run. As a result, they encountered multiple problems while implementing builtin features of the vanilla VS Code you can use such code completion.

The M * N problem

There was a very annoying problem for companies promoting new languages and communities built around them. Given M different languages (C, C++, Java, Lisp, etc) and N different editors (Emacs, Vim, Atom, etc), then there are at least **M * N** different tools to make every languages available on every editors used to write code.

As you can imagine, it can already be very costly and very hard to develop even a naive solution for only one language for only one editor. However with the introduction of the LSP, the editor does not even need to care about the language being used since all the data is seamlessly treated in a different place. In fact, the editor does not think anymore, it only edits and sends some contexts to some servers. With the LSP, the infamous M * N problem is solved and only N tools are needed, one for each language. Of course, this solution only works if the given editor can offer a client that can interact with a server implementing the protocol.

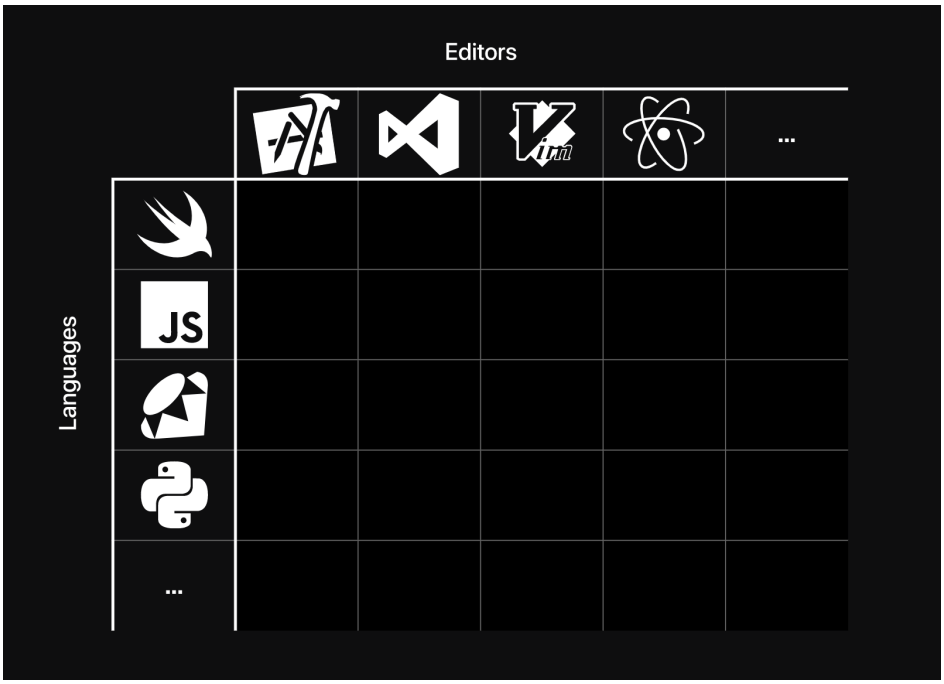

Figure 1: The infamous M * N problem (from freeCodeCamp)

A story that started with a compiler and ended with a communication protocol

Microsoft already tried to solve the M * N problem with their C# cross-platform compiler, codenamed **Roslyn**. At the opposite of traditional compilers, it was not a black box that would try to isolate itself as much as possible from the developpers and prevent them to modify its inside. Indeed, Roslyn was developed with the idea to be hacked by its users and let them extend its basic functionnalities. As a result, most of its APIs are available to work with so that it is possible to develop tools to realize tasks like source code analysis, which is the first basis for features like code completion.

Following Microsoft's efforts on their Roslyn compiler to bring cross-platform support of C# and .NET, a new project was born: the Omnisharp project. It is basically a simple server that leverages some integration toolings made on top of the Roslyn compiler. By communicating with it, it is possible for any editor that has integrated such server to access language-dependant features for any language without having to reimplement the complicated details every time.

The idea proved itself simple and successful among the communities of the .NET environment. Integrations for some well-known editors such as Emacs, Vim, VS Code or Sublime Text can be found on their respective package distributions. However, the generic integration was still missing and the Omnisharp project was only a proof that such solution was possible. There was a need to standardized the protocol being used as well as the integration of the server inside the editor, which Microsoft did with their version of the LSP.

The protocol in itself

Overview

LSP is really simple to understand and requires only some basic knowledge about networking.

Consider you have two actors in the process: a client, which can be a programmer asking for some completion a point, and a server, which can provide auto-completion if a context is given to him. If this condition is satisfied, then only the communication between the two is missing, and that is where Microsoft's LSP solution comes into action.

Here, the server designates either a local server exchanging `HTTP` messages using `TCP/IP` or a process that communicates through its `standard input and output`. Using a custom version of the JSON-RPC protocol to send the data, the information is easily exchanged and the process is fast even compared to the builtin implementation that can be found in some IDEs.

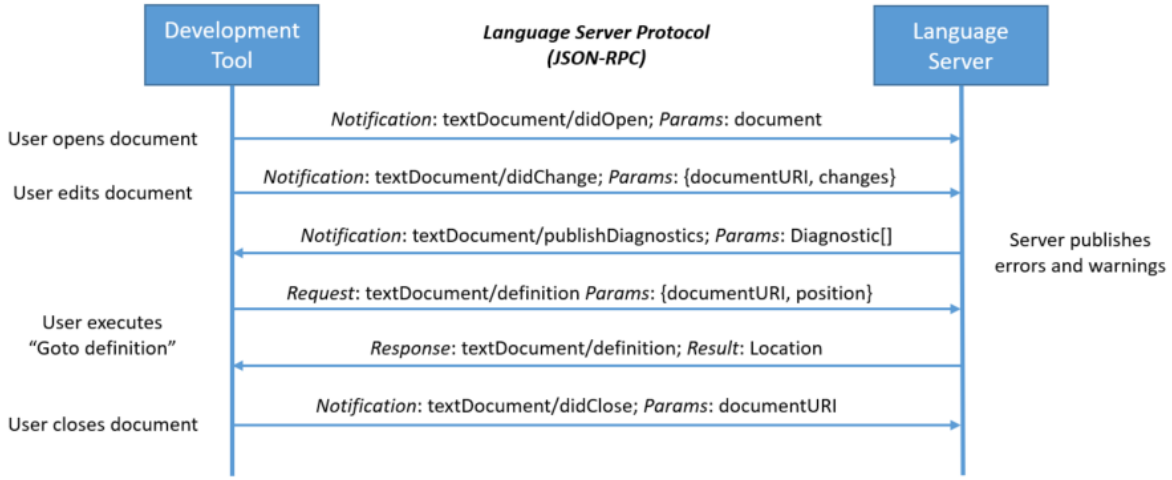

Figure 2: Explanation on what happens during the exchange between the client and the server (from the official documentation of Microsoft)

As illustrated in `Figure 2`, the client sends lots of different notifications about various changes by contacting what could be compared to the endpoints of a REST API. Even if it's a huge shortcut to put it this way, the logic is more or less the same. For example in `Figure 2`, the client will send a request to contact the method `didChange` each time the user decides to save the current state of the file. That way, the server will be able to update the state of the same file he was watching to make sure he will not publish outdated reports after a request from the client.

For more precisions about the available endpoints, Microsoft offers in its specifications of the protocol a list of the classic ones that should be present in any implementation of a server supporting the LSP.

Structure of the messages exchanged during the process

HTTP Headers

Following Microsoft'specifications, the base protocol relies on two HTTP headers:

- `Content-Length`: the length of the content part in bytes.
- `Content-Type`: the type of the content in the body. This header is optional and by default set to 'application/vscode-jsonrpc; charset=utf-8'

The Request

The body of the request is a JSON that contains at least four fields:

- `jsonrpc`: a string or an integer of the version of JSON-RPC being used, in most cases it will be `2.0`.
- `id`: an integer representing the id of the request
- `method`: a string corresponding to the method of the server that has to be invoked. It is similar to the endpoint of a REST API.
- `params`: either a JSON array or a JSON object that contains the context required by the invoked method

The Response

The body of the response is also a JSON that contains at least the same `jsonrpc` and `id` field as in the former request. In addition, it also has a field depending if there was an error while processing the request or not:

- `result`: present if there was no error, a JSON object in most cases but it can also be a string, a number, a boolean or even null.
- `error`: a JSON object that contains an error code `code` and a string `message` that provides of a short description of the error. It can also have a `data` field for additional information about the error.

A concrete example

The following request is a generic example of a client that asks to the server to apply the "completion" feature:

```
HTTP / 2.0
Content-Length: 146

{
    "jsonrpc" : "2.0",
    "method": "completion",
    "params": { "file": "foo.txt", "line": 10, "begin": 6, "end": 8},
    "id": 1
}
```

As you may have guessed, the server will try to provide code completion for the word of `length` 2 at `line` 10 of the file `foo.txt`. If the prefix were to be `'is'`, an example of an answer from the server could be:

```
200 / OK
Content-Length: 272

{
"jsonrpc": "2.0",
"result": {
    "completions":[
        {
            "value": "isBoolean",
            "type": "variable"
        },
        {
            "value": "isDigit",
            "type": "function"
        }
    ]},
"id": 1
}
```

After processing the file `foo.txt`, the language server found two possible completions: a **variable** `isBoolean` and a **function** `isDigit`.

If it has no method named `completion`, the backend would have send a similar response but with an `error` field instead of the `result` one:

```
"error": { "code": -32601, "message": "no such method 'completion'" }
```

Note that the error codes should not be dependant of the server used for compatibility reasons. In the above example, `32601` is the error code associated to `'Method not found'` as defined by JSON-RPC. Also, Microsoft decided to use negative values for error codes, this is why it is `-32601` and not `32601`.

Pros and Cons of the LSP

As illustrated with the previous example, what is exchanged between the client and the server is fairly simple to understand and easy to deal with. Integrating a server supporting LSP seems way more easier than developping several times the same extension for each language. Moreover, there's no need to stick anymore to PyCharm for developping Python and Intellij to write Java code. Both can be done with LSP in your favorite text editor if it has an integration with LSP.

There are still some downsides with this solution. The main one is that there will always be the same number of servers running in background as they are languages using LSP. In a

same way, a server is bound to a tool which means that if a programmer is using both Emacs and VS Code to write some C++ code, then this person will need to run two LSP servers for C++ **at the same time**. In addition, some editors do not support multiple servers for the same language. This can be troublesome since a custom implementation would not be able to be used at the same time at the major one. Finally, the performances aren't always that good since the server is an external factor and do not depend on the editor. Using an IDE is still relevant on this aspect since most of them are at least as fast as what editors using LSP could hope to be.

As a result, LSP has some negative points. Even though, this trade-off is not that bad considering the kind of a mess this problem was for both the companies and the users. Finally, this solution manages to save considerable ammount of time and costs and help developping new languages through the growth of the communities built around them.

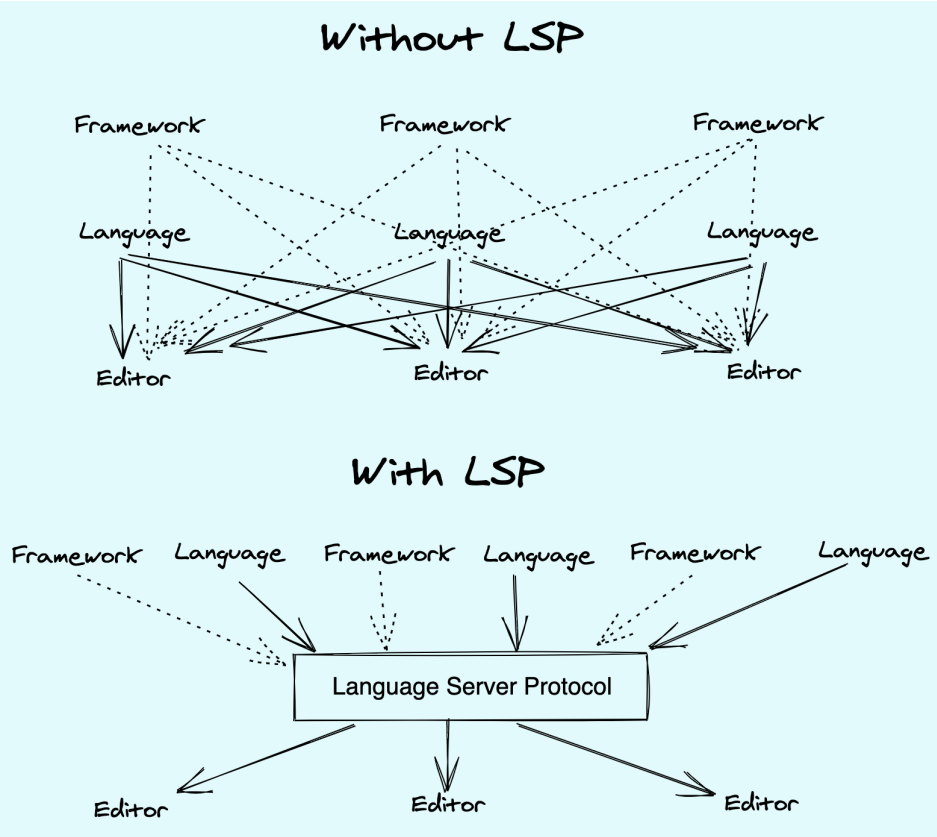

Figure 3: What the LSP manages to clean (from swyx.io)

What it can offer

- Amazing IDEish features

What's amazing with the LSP is that it has many possible use cases other than code completion. Among the listed implementations on the official website, most of them have five main uses of

the LSP:

- `Hovering`: complementary information such as documentation, uses or signature function appearing when placing the cursor on a given word,
- `Goto definitions`: find the definitions of a symbol, for example a variable, a function or a class,
- `Workspace Symbols`: offers a list of all the matches within the workspace of a given query string.
- `Find references`: search in the workspace for all the uses of a given symbol.
- `Diagnostics`: the backend language server handles diagnostics on either a whole project or a specific file. A diagnostic can be for example checking that no variable is written in uppercase. As a result, this feature can be a good support on developping tools for spell checking or coding style reports.

The above features are not the only ones described in the specifications. More advanced ones code lens (somewhat hidden source code) or code action (refactoring tools), can still sometimes be implemented in the language servers even if it is less likely.

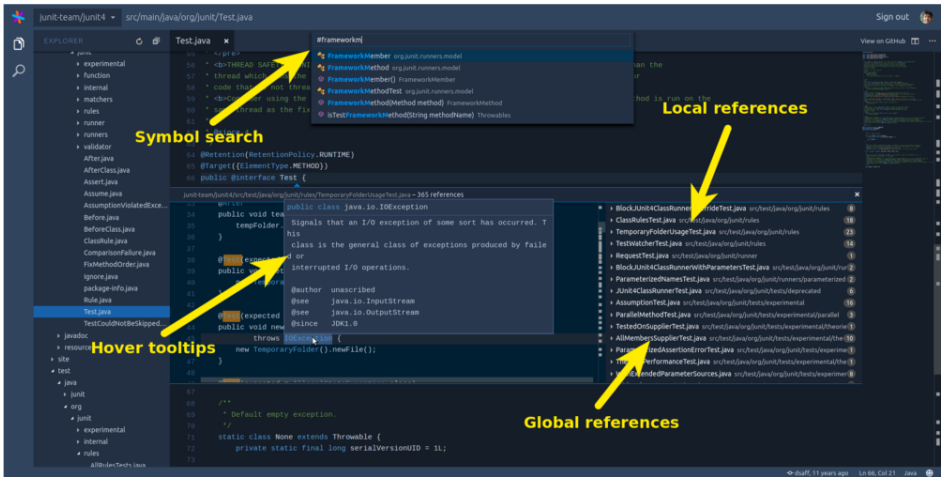

Figure 4: Some features offered by the LSP implementation of VS Code (from Sourcegraph)

- The possibility to write your own language server

Since the LSP is very easy to work with, writing your own language server with customized validations is pretty accessible. There are many APIs available to getting started with the language of your choice, may it be Python, C#, Java, Lisp and many others. However, most of the articles I found to write this article were using Typescript, probably because this is both the language used to write VS Code extensions and the one used in the tutorial proposed by Microsoft to get started with the LSP. If you are interested in trying to write one, I would recommend these readings:

- VS Code official language server extension guide: a simple tutorial to write a language server built on a VS Code extension in Typescript.

- Extending a client with the language server protocol by Florian Rappl: a detailed explanation about the calls made on the Typescript API. It is followed with a detailed demo on how to implement some simple functionalities of a language server in Typescript.
- Language Server Protocol tutorial: From VS Code to Vim by Jeremy Greer: an article about the implementation of a language server that blacklist some words and how its author made it work for several editors without having to modify the source code of the server.
- Java implementation of a language server maintained by Eclipse: a github repository that proposes an implementation of an LSP API in Java.

The LSP since then

Quickly after the first integration on VS Code, many language servers as well as extensions to editors to integrate LSP support were developped. As of now, there are more than 140 maintained language servers listed on Microsoft's official page on LSP. Even old languages such as COBOL found people among their communities to develop a version of LSP and bring support of modern features to them. As a result, they becomes way easier to learn and it gives them a relative second youth by making them more accessible to newcommers.

Concerning the editors, some have builtin integration such as VS Code and NeoVim, others need complementary extension like Emacs or Atom and others do not support it at all like Notepad++.

A list driven by the community built around the LSP of all the implementations and the available clients can be found by clicking here. As you may have seen, this list also includes in the clients section IDEs like the Jetbrains Product or Eclipse, which were not at all the target of the LSP but in the end found some good use of the LSP. The main reason is because it becomes easier to develop new extensions and it may offer approach that were not available if the devs were to stick only on the builtin functionalities of the IDEs.

Conclusion

The **Language Server Protocol** is one of these tools that fixes very annoying issues in a very simple way. It's a blessing considering all the features it can bring to many different tools, may it be a **text editor** or an **IDE*. However, it is still far from being perfect and there are many possible upgrades that are very anticipated by the community it has build over the past few years. Your text editor won't be as fast as most IDEs would be even with the use of the LSP but it will definetily help it ascend to a level that is closer to them with the new oppurtunities it offers.

Thank you for reading this small article, I hope you learned something new today through it!

Sources

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- Microsoft's offical webpage on the LPS: https://microsoft.github.io/language-server-protocol/
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