A «NEW» STATIC ANALYZER: THE COMPILER

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Agenda

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- Need for Speed
- Libraries, Libraries and again Libraries
- Clang/LLVM – SonarQube
- SAFe Toolset
- Future Activities

Need for Speed

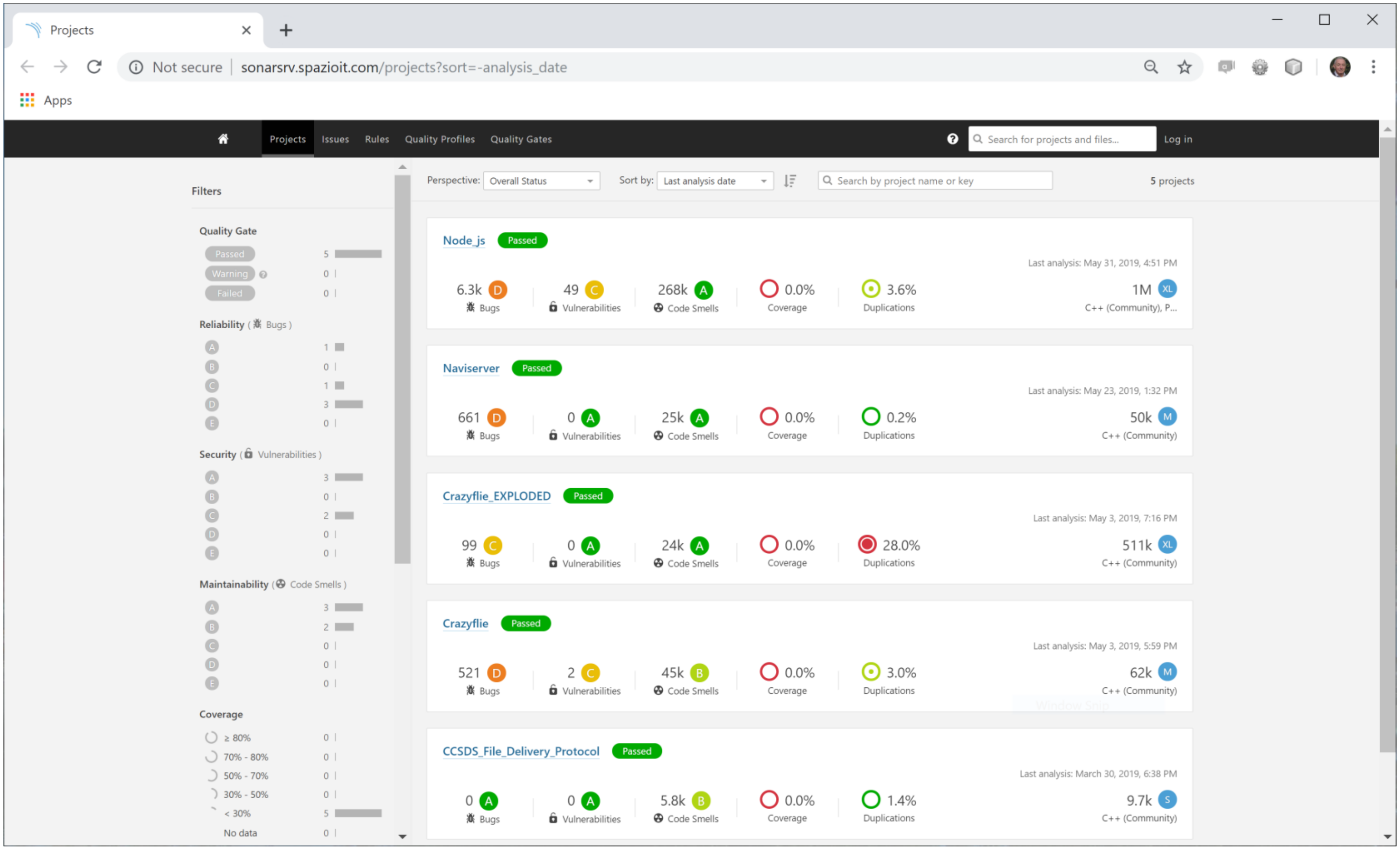
Need for Speed

- The size of software codebases is increasing dramatically:

Year	System	Size
1974	F16A Plane	135 K
1981	Space Shuttle PFS	400 K
2008	ESA ATV	1 M
2012	NASA Curiosity	2.5 M
2012	F35 Plane	10 M
Nowadays	Car	10-150 M

- Compilers and Static Analyzers need to be fast and efficient (i.e. able to “digest” large codebases in a reasonable time).

Need for Speed

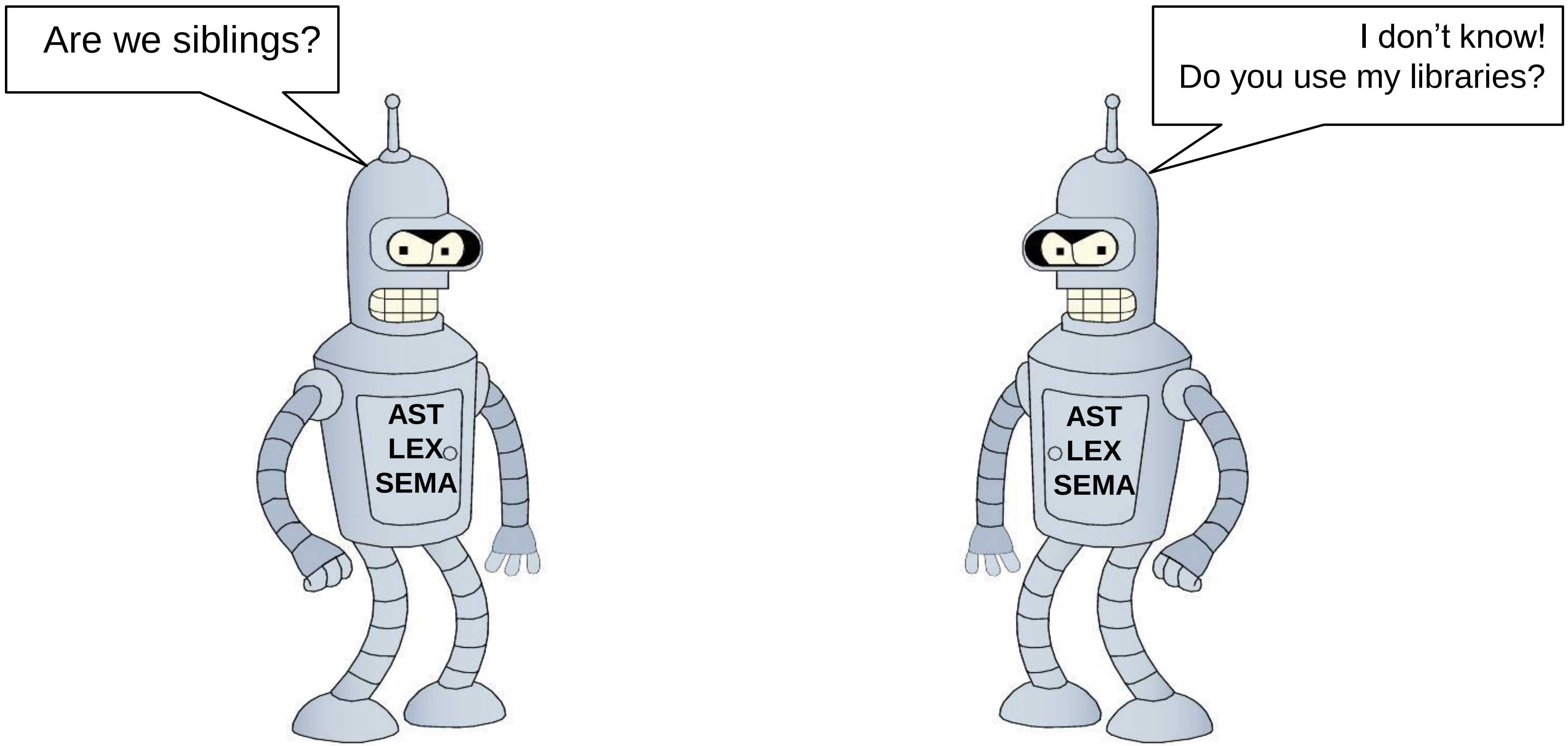


Need for Speed

- Deep vs. Shallow Parsing

- Unforgiving vs. Forgiving Parsing

Libraries, Libraries and Again Libraries



Static Analyzer

Compiler

Libraries, Libraries and Again Libraries

- Suppose that for a given language we have a compiler and a static analyzer that are two separate software products, using different libraries and technologies (each one of them as its own lexer, parser, semantic analyzer and so on).
- Suppose the developer community behind that language and tools is not very big and doesn’t have many resources, lots of energy.
- In case the language changes, evolves, for whatever reason, which of the two tools (the compiler or the static analyzer) will keep up with the language evolution?
- In the same way, which of the two tools will be more performant?

Libraries, Libraries and Again Libraries

- PC-Lint does not support the latest C/C++ Standards.
- Frama-C Semantic Analyzer cannot process all C/C++ constructs.
- Cppcheck sometimes stops when “digesting” “strange” codebases (e.g. Brotli).
- Ada ASIS does not support Ada 2012 (but the GNAT compiler does).
- In the Ada “libadalang” GitHub website we have: “Libadalang does not (at the moment) provide full legality checks for the Ada language. If you want such a functionality, you’ll need to use a full Ada compiler, such as GNAT.”
- and so on…

Libraries, Libraries and Again Libraries

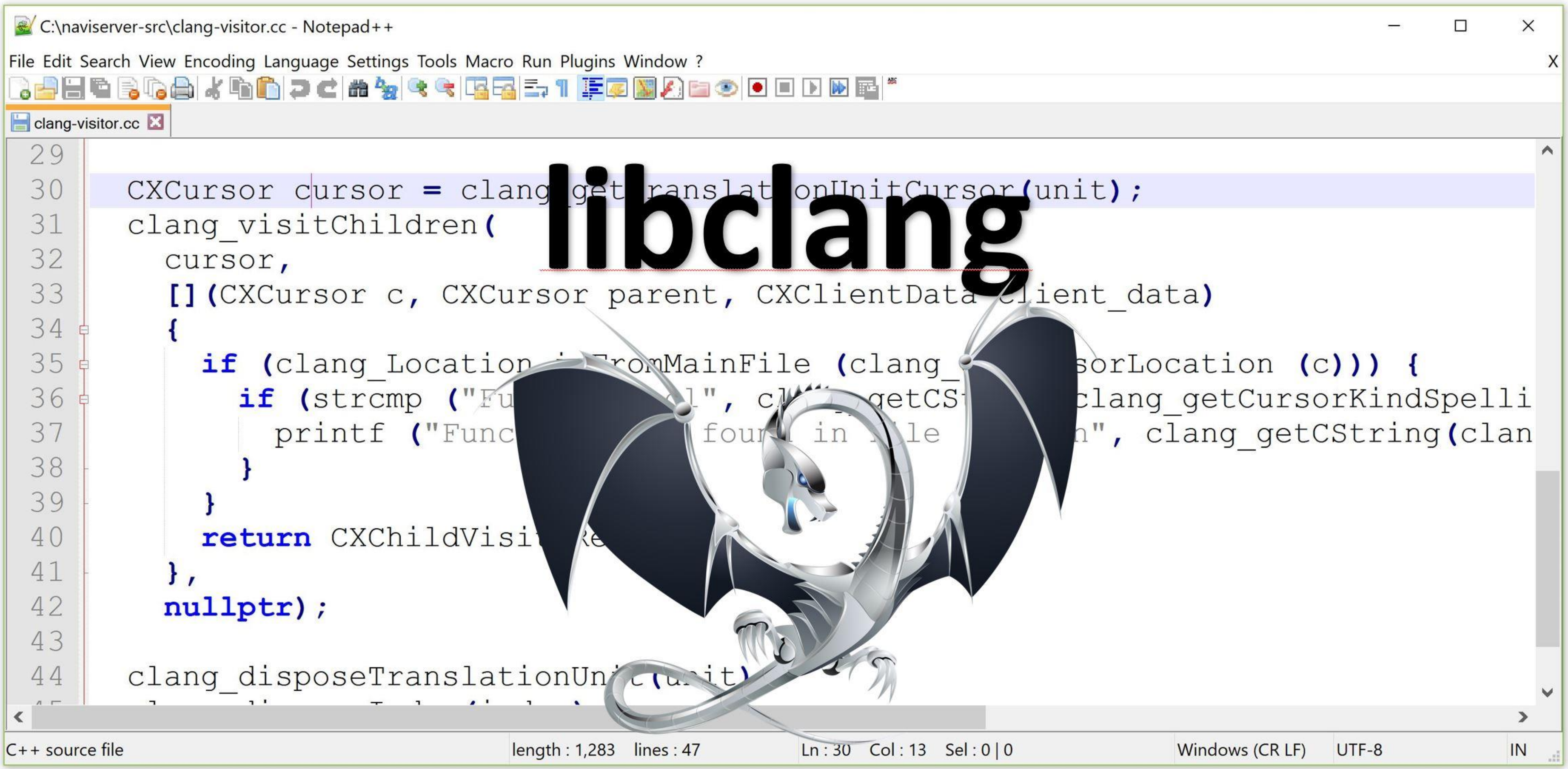
- “The LLVM Project is a collection of modular and reusable compiler and toolchain technologies. (…) The LLVM Core libraries provide a modern source- and target-independent optimizer, along with code generation support for many CPUs. (…) Clang is an LLVM native C/C++/Objective-C compiler, which aims to deliver amazingly fast compiles.”

- In fewer words Clang/LLVM is a compilation toolchain where absolutely everything is built in a modular fashion as collection of reusable libraries.

Libraries, Libraries and Again Libraries

- In the Clang/LLVM toolchain the two static analyzers are Clang-Check (a.k.a. Clang-SA) and Clang-Tidy.
- Clang-Check relies on a set of Clang modules to perform things like lexical analysis, parsing, semantic analysis, AST manipulation and the like.
- Clang-Tidy relies on the very same Clang modules plus some additional modules of Clang-Check itself (this is why Clang-Tidy can be considered a sort of superset of Clang-Check).

Libraries, Libraries and Again Libraries

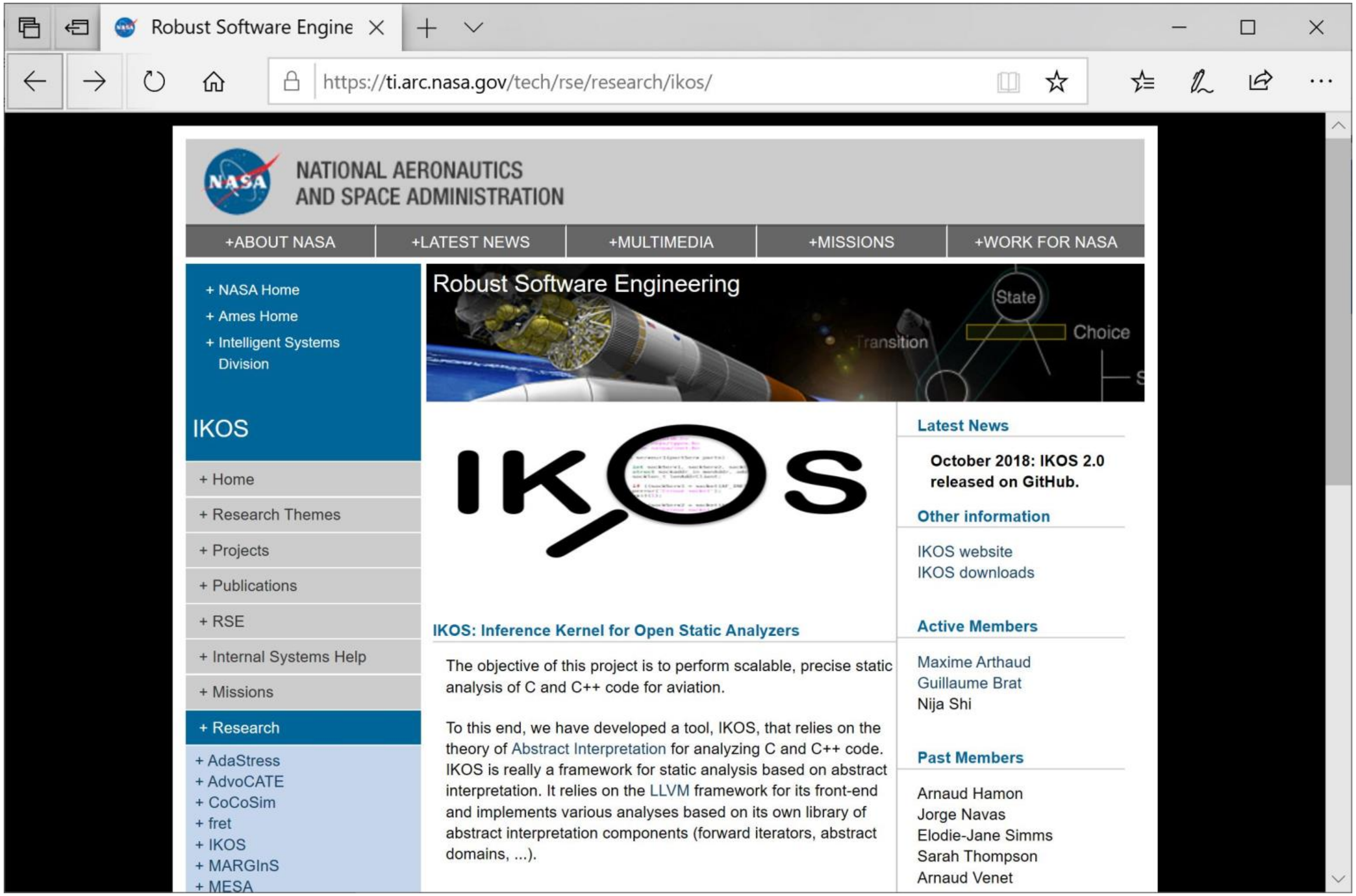


Libraries, Libraries and Again Libraries

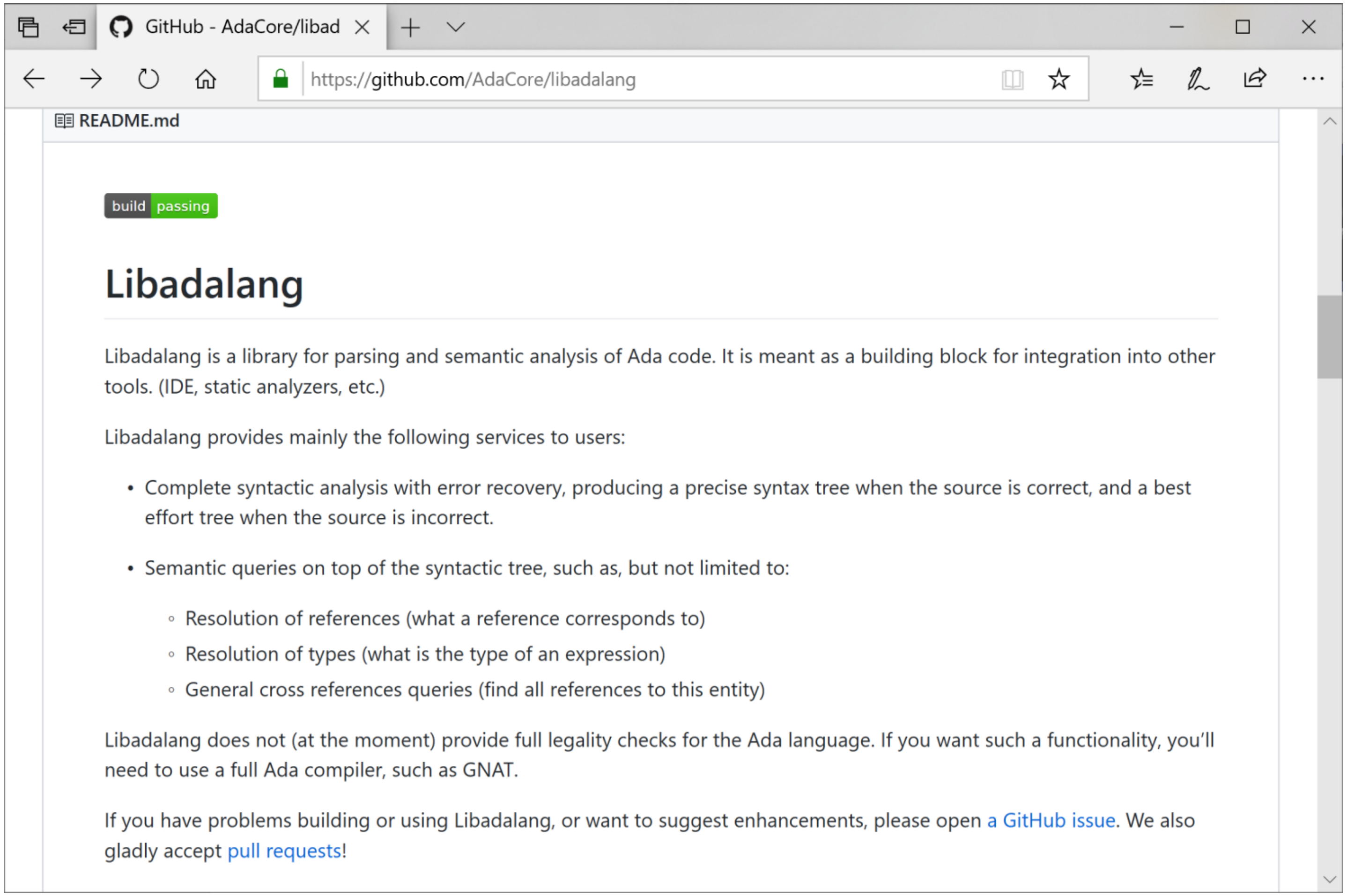
- "libclang" is nothing but a simple C API (with Python bindings) exposing Clang functionalities (i.e. modules) to external applications (deep / forgiving parsing);

- thanks to "libclang" also these third-party applications can use the very same modules/libraries of Clang (for instance they could parse a C program as efficiently as Clang does).

Libraries, Libraries and Again Libraries



libadalang



GitHub - AdaCore/libad

https://github.com/AdaCore/libadalang

README.md

build passing

Libadalang

Libadalang is a library for parsing and semantic analysis of Ada code. It is meant as a building block for integration into other tools. (IDE, static analyzers, etc.)

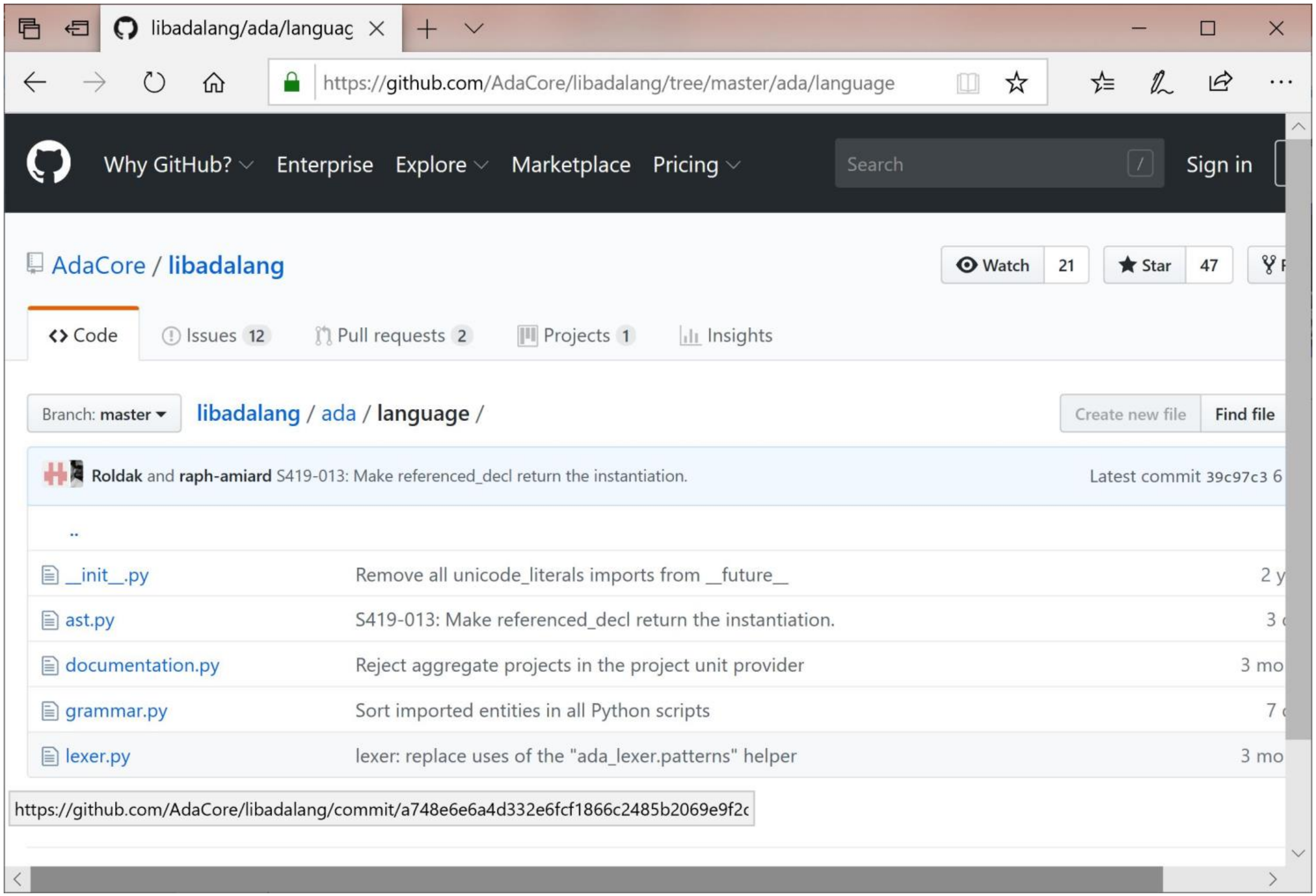
Libadalang provides mainly the following services to users:

- Complete syntactic analysis with error recovery, producing a precise syntax tree when the source is correct, and a best effort tree when the source is incorrect.
- Semantic queries on top of the syntactic tree, such as, but not limited to:
  - Resolution of references (what a reference corresponds to)
  - Resolution of types (what is the type of an expression)
  - General cross references queries (find all references to this entity)

Libadalang does not (at the moment) provide full legality checks for the Ada language. If you want such a functionality, you'll need to use a full Ada compiler, such as GNAT.

If you have problems building or using Libadalang, or want to suggest enhancements, please open a GitHub issue. We also gladly accept pull requests!

libadalang



libadalang/ada/languag
https://github.com/AdaCore/libadalang/tree/master/ada/language
Why GitHub?
Enterprise
Explore
Marketplace
Pricing
Search
Sign in
AdaCore / libadalang
Watch 21
Star 47
Code
Issues 12
Pull requests 2
Projects 1
Insights
Branch: master
libadalang / ada / language /
Create new file
Find file
Roldak and raph-amiard S419-013: Make referenced_decl return the instantiation.
Latest commit 39c97c3
__init__.py
Remove all unicode_literals imports from __future__
ast.py
S419-013: Make referenced_decl return the instantiation.
documentation.py
Reject aggregate projects in the project unit provider
grammar.py
Sort imported entities in all Python scripts
lexer.py
lexer: replace uses of the "ada_lexer.patterns" helper
https://github.com/AdaCore/libadalang/commit/a748e6e6a4d332e6fcf1866c2485b2069e9f2c

libadalang

GitHub - AdaCore/libad

https://github.com/AdaCore/libadalang

Libadalang and ASIS

ASIS is widely used for static analysis of Ada code, and is an ISO standard. It is still the go-to tool if you want to create a tool that analyses Ada code. Also, as explained above, Libadalang is not mature yet, and cannot replace ASIS in tools that require semantic analysis.

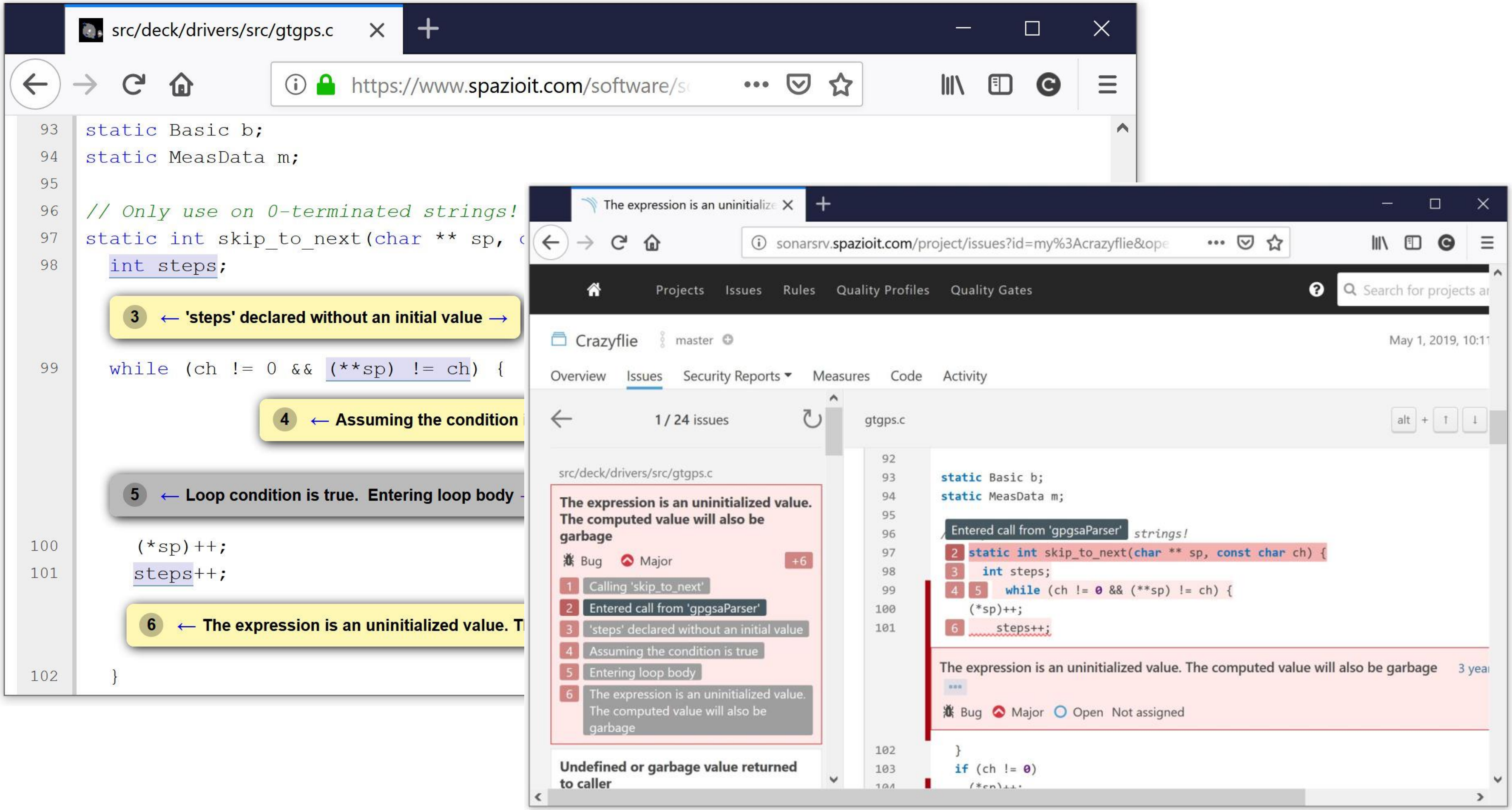
However, there are a few reasons you might eventually choose to use Libadalang instead of ASIS:

1. The ASIS standard has not yet been updated to the 2012 version of Ada. More generally, the advantages derived from ASIS being a standard also means that it will evolve very slowly.
2. Syntax only tools will derive a lot of advantages on being based on Libadalang:
   - Libadalang will be completely tolerant to semantic errors. For example, a pretty-printer based on Libadalang will work whether your code is semantically correct or not, as long as it is syntactically correct.
   - Provided you only need syntax, Libadalang will be much faster than ASIS' main implementation (AdaCore's ASIS), because ASIS always does complete analysis of the input Ada code.
3. The design of Libadalang's semantic analysis is lazy. It will only process semantic information on-demand, for specific portions of the code. It means that you can get up-to-date information for a correct portion of the code even if the file contains semantic errors.
4. Libadalang has bindings to C and Python, and its design makes it easy to bind to new languages.
5. Libadalang is suitable to write tools that work on code that is evolving dynamically. It can process code and changes to code incrementally. Thus, it is suitable as an engine for an IDE, unlike AdaCore's ASIS implementation.

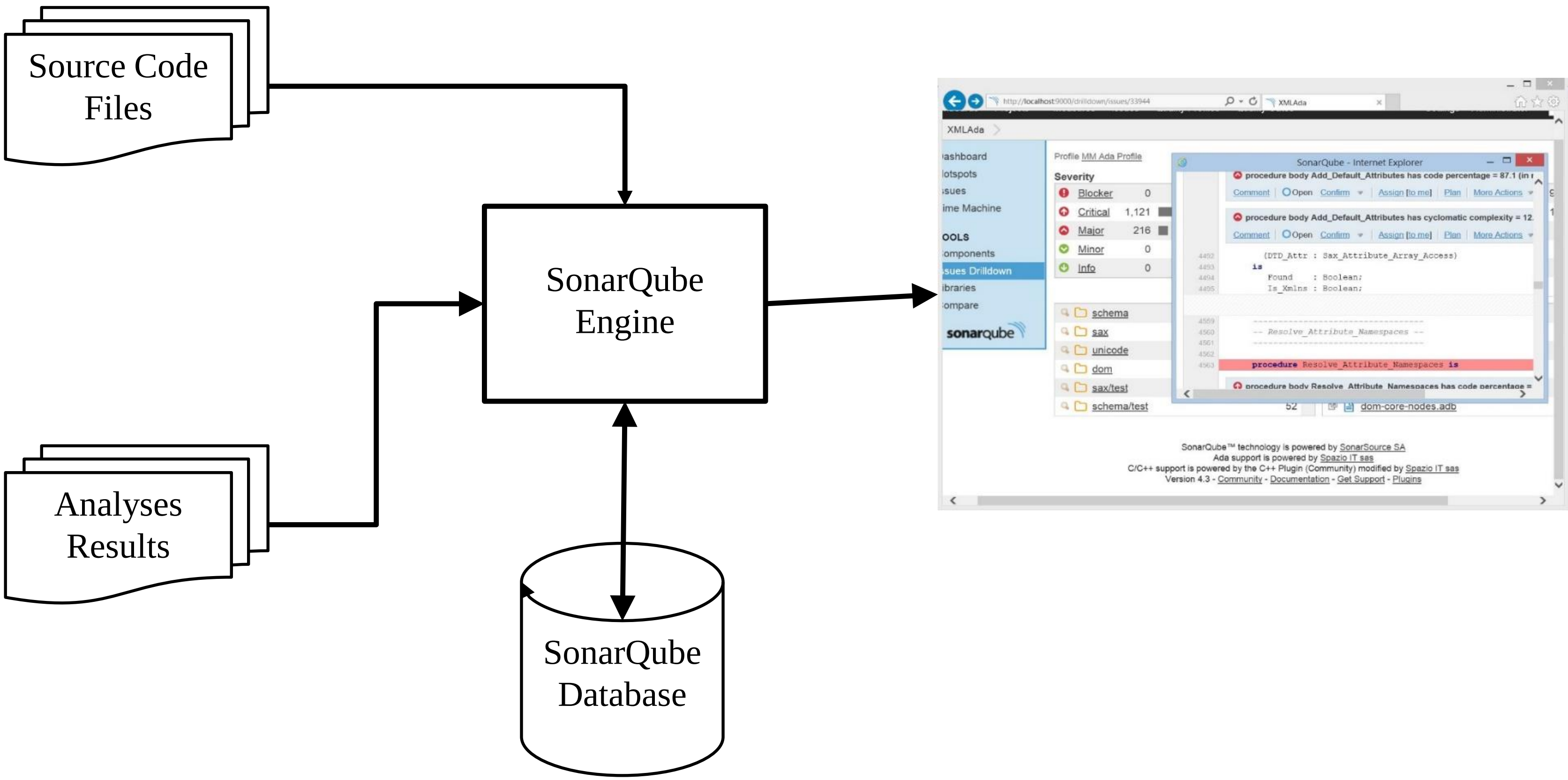
libadalang

- Interesting related projects:
  - **libadalang-tools** - Libadalang-based tools
  - **lal-checkers** - Libadalang-based code checking infrastructure
  - **ada_language_server** - prototype implementation of the Microsoft Language Server Protocol for Ada/SPARK
  - **langkit** - Language creation framework.

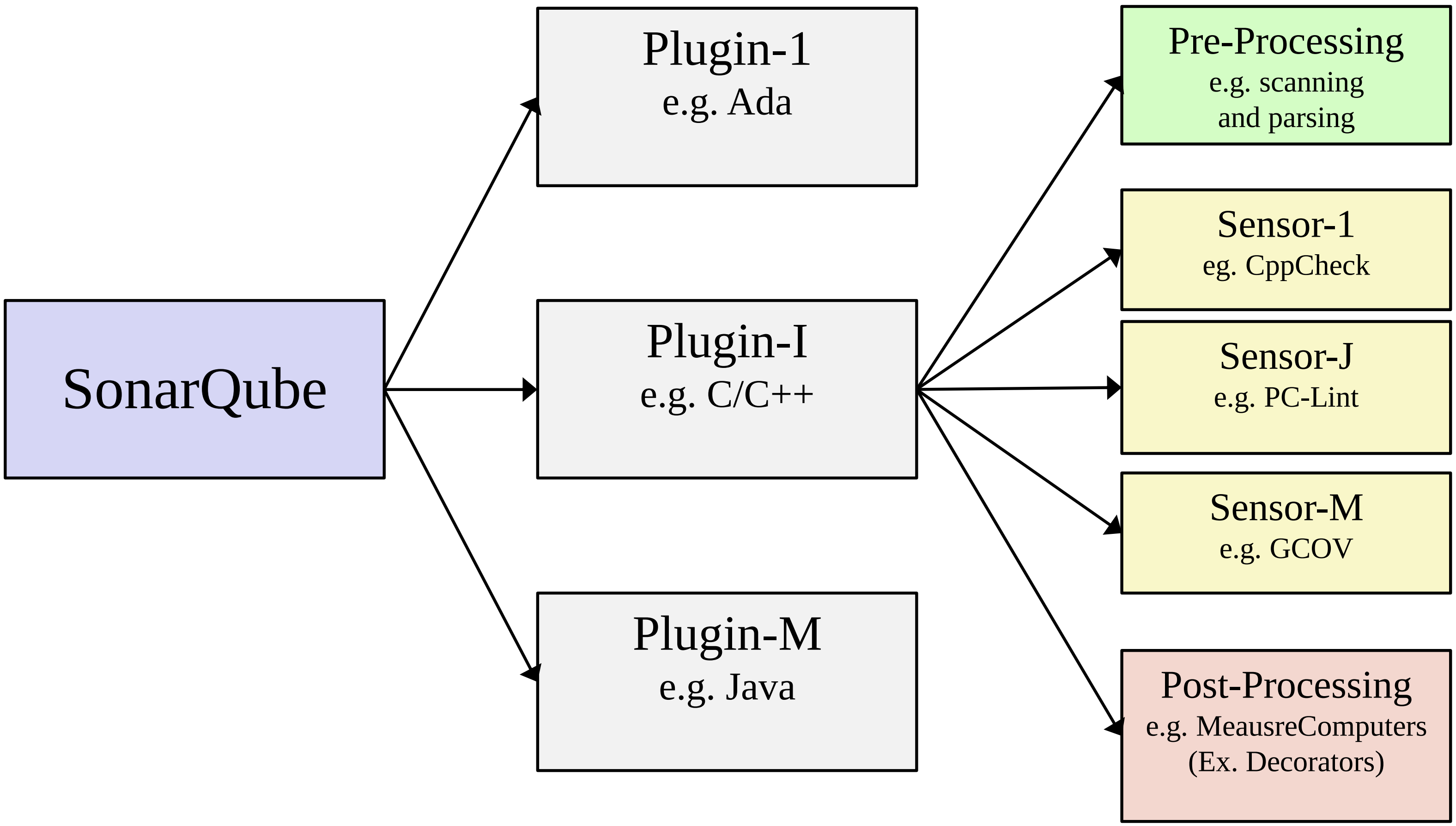
Clang / LLVM – SonarQube Integration



SonarQube – What is it?



SonarQube / Plugins / Sensors

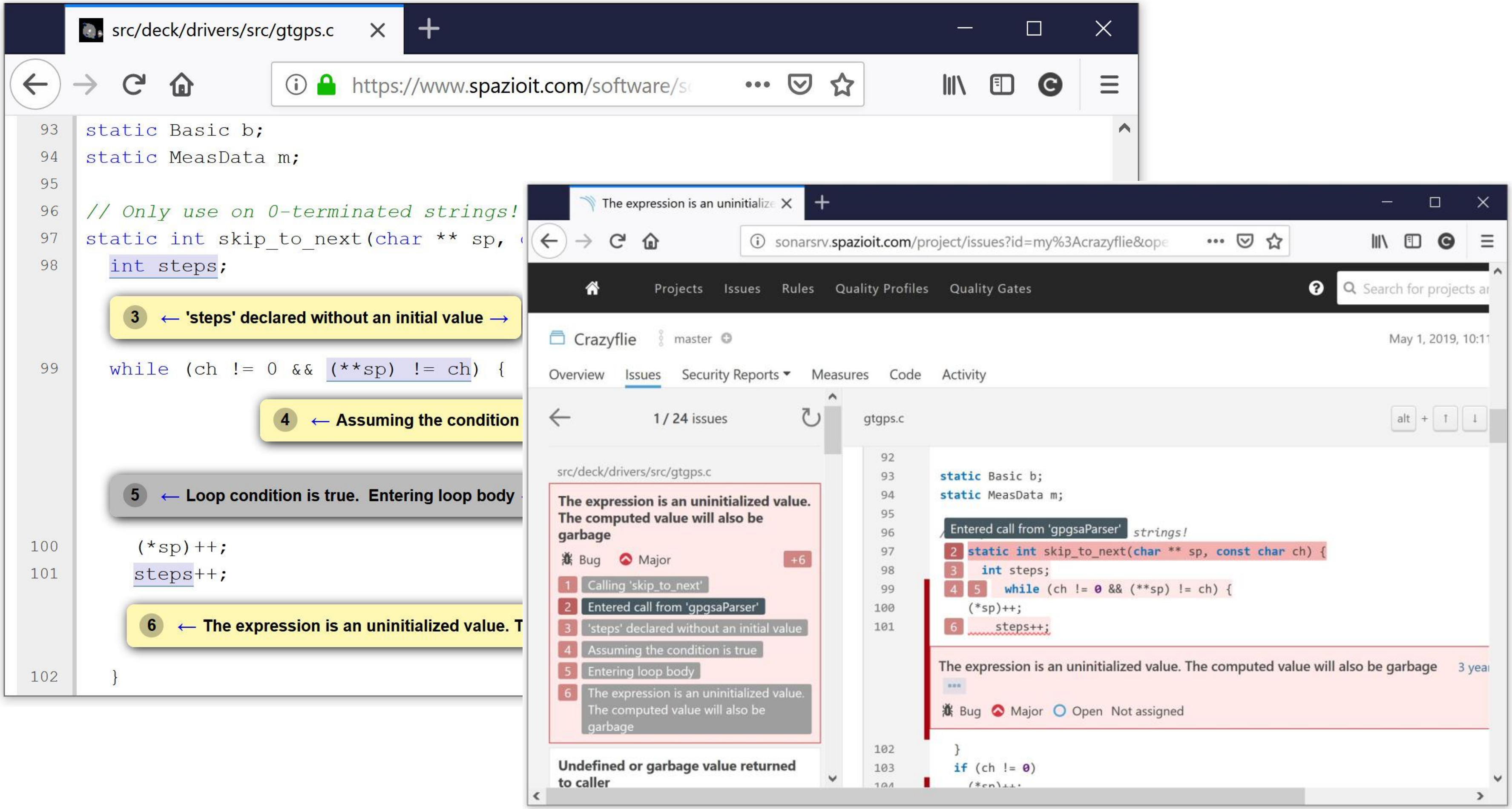


SonarQube C++ plugin (Community)

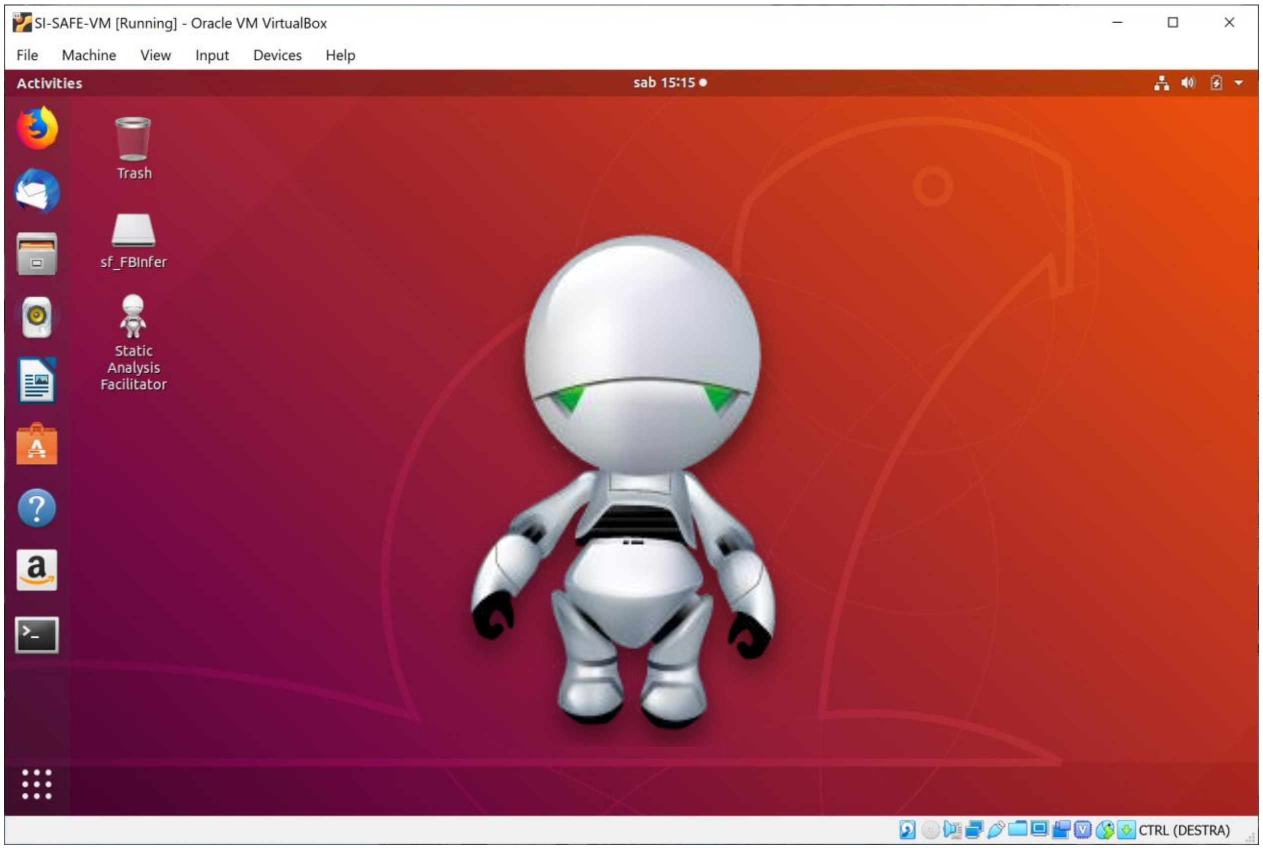
- Parser supporting C89, C99, C11, C++03, C++11, C++14 and C++17 standards
  - Microsoft extensions: C++/CLI, Attributed ATL
  - GNU extensions
  - CUDA extensions

- Sensors for static code analysis:
  - Cppcheck warnings support (http://cppcheck.sourceforge.net/)
  - GCC/G++ warnings support (https://gcc.gnu.org/)
  - Clang Static Analyzer support (https://clang-analyzer.llvm.org/)
  - Clang Tidy warnings support (http://clang.llvm.org/extra/clang-tidy/)
  - PC-Lint warnings support (http://www.gimpel.com/)
  - (…) many others

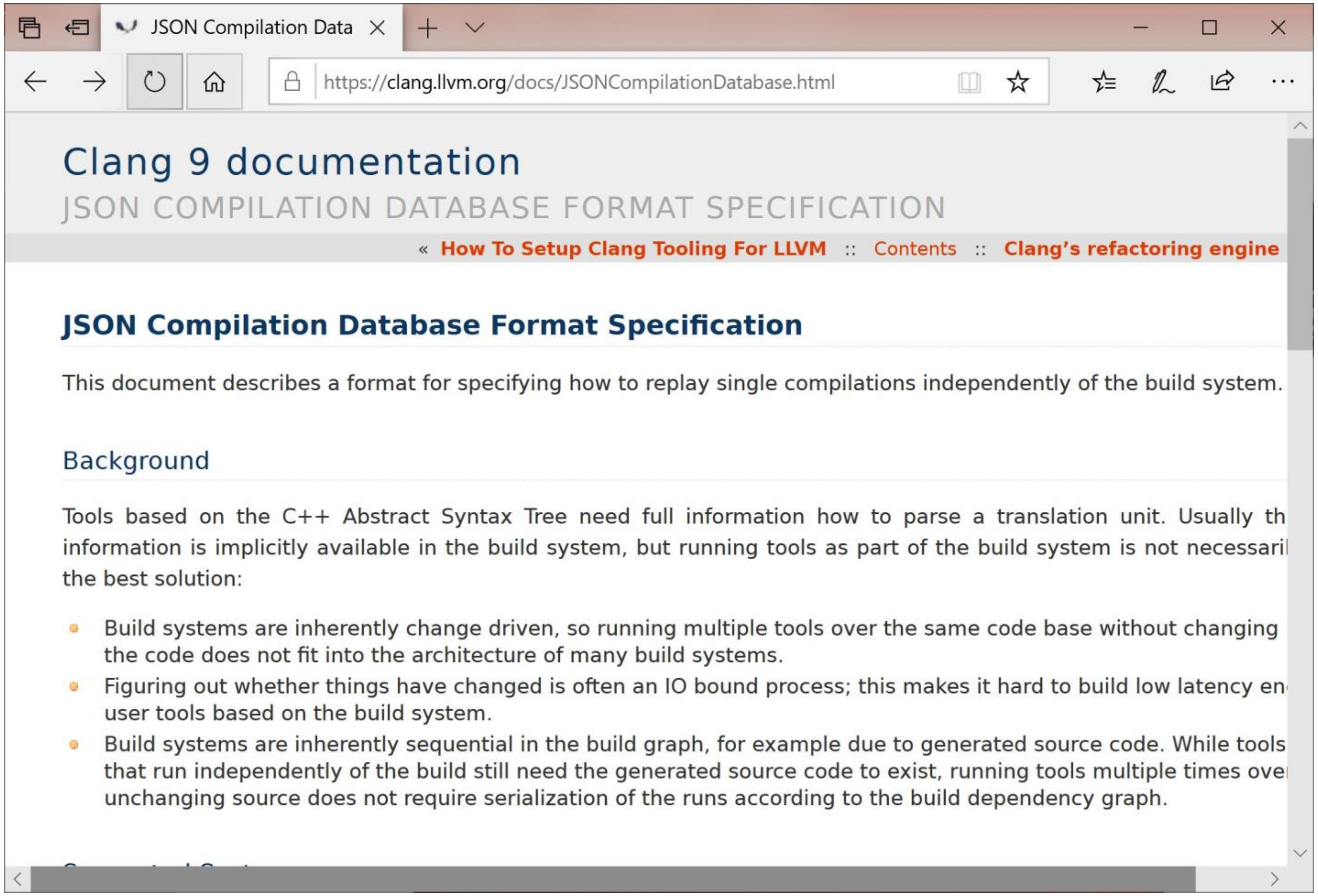
Clang / LLVM – SonarQube Integration



SAFe Toolset



SAFe Toolset



JSON Compilation Data

https://clang.llvm.org/docs/JSONCompilationDatabase.html

Clang 9 documentation

JSON COMPILATION DATABASE FORMAT SPECIFICATION

« How To Setup Clang Tooling For LLVM :: Contents :: Clang's refactoring engine

JSON Compilation Database Format Specification

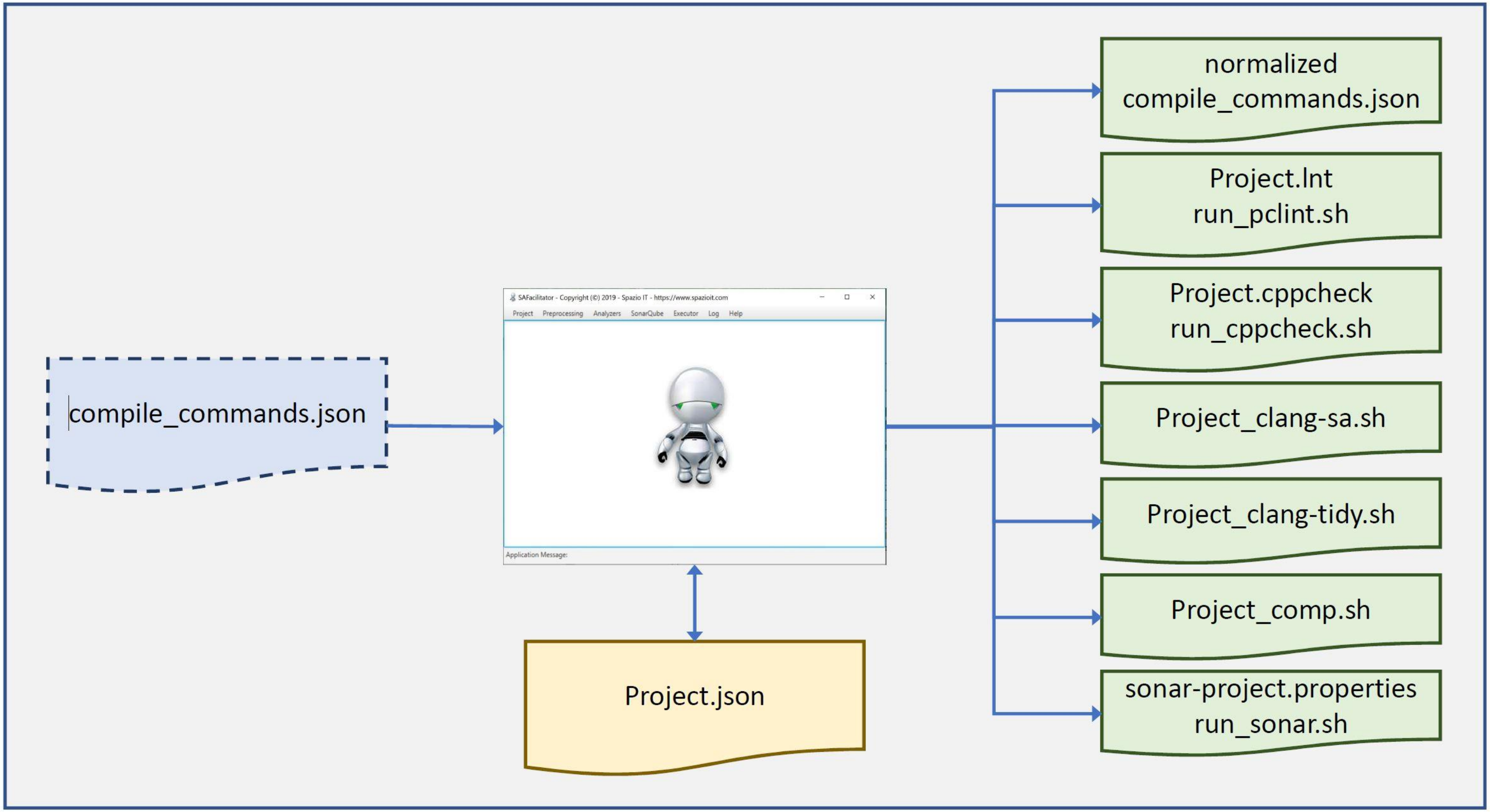
This document describes a format for specifying how to replay single compilations independently of the build system.

Background

Tools based on the C++ Abstract Syntax Tree need full information how to parse a translation unit. Usually th information is implicitly available in the build system, but running tools as part of the build system is not necessaril the best solution:

- Build systems are inherently change driven, so running multiple tools over the same code base without changing the code does not fit into the architecture of many build systems.
- Figuring out whether things have changed is often an IO bound process; this makes it hard to build low latency en user tools based on the build system.
- Build systems are inherently sequential in the build graph, for example due to generated source code. While tools that run independently of the build still need the generated source code to exist, running tools multiple times ove unchanging source does not require serialization of the runs according to the build dependency graph.

SAFe Toolset



SAFe Toolset

- The **SAFe Toolset** is an **Ubuntu Virtual Machine** containing **various open source tools** that can be used to perform **Software Verification** and **Validation**.

- In particular the current version (June 2019) of the SAFe VM contains:
  - **cppcheck** – v. 1.87 - http://cppcheck.sourceforge.net/ - a C/C++ static analyzer.
  - **Clang** – v. 9.0.0 - https://clang.llvm.org – the "new" compiler toolset from LLVM Foundation, with its **Clang-SA** and **Clang-Tidy** static analyzers.
  - **SonarQube** – v. 7.7. – https://www.sonarqube.org/ - a code quality platform used to show and manage the issues found by the static analyzers.

SAFe Toolset

- Optionally the SAFe VM may also contain:
  - **PC-Lint** (or PC-Lint Plus) – v. 9.0.0L - https://www.gimpel.com/ - but its license needs to be acquired from Gimpel.

- Apart from the static analyzers the SAFe VM contains also some (native and cross) build environments, that is:
  - **GNU GCC** Version 7.3.0 - https://gcc.gnu.org/gcc-7/ - Native
  - **Clang** Version 9.0.0 - - https://clang.llvm.org - Native and Cross (Multiplatforms – use the command "llc --version" to see the supported architectures).
  - **BCC2**: Bare-C Cross-Compiler System for LEON2/3/4 GCC 7.2.0 - https://www.gaisler.com/ - Cross.
  - **GNU Arm Embedded Toolchain** - v. 5-2016-q3 - https://launchpad.net/gcc-arm-embedded - Cross.

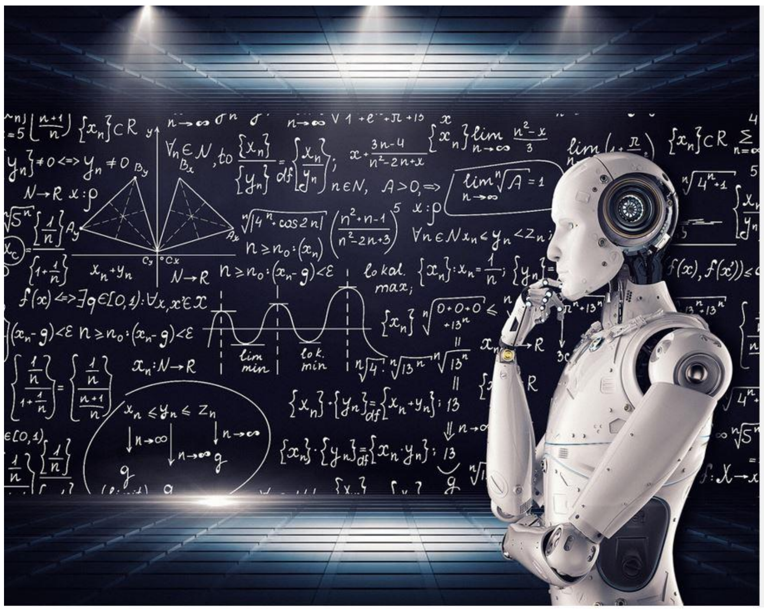
SAFe Toolset

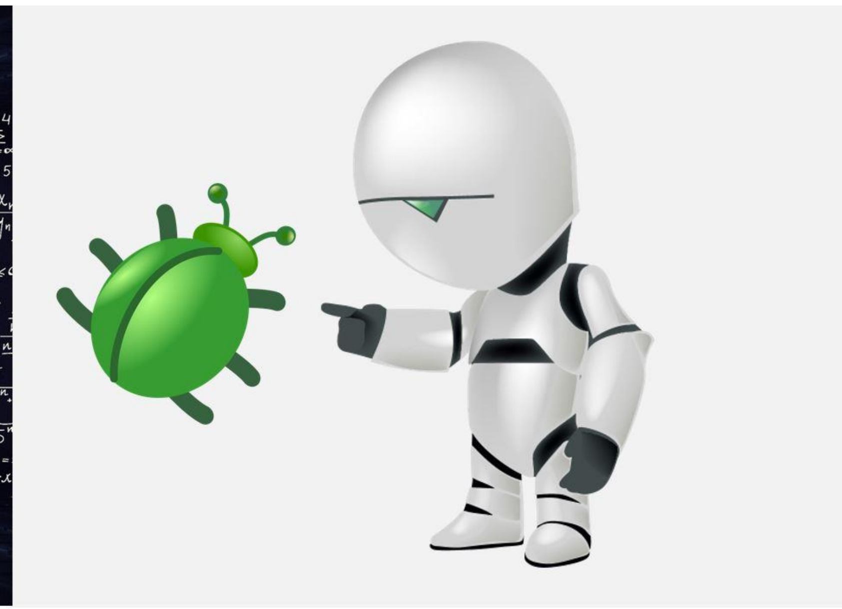
- Should a user need to work on a codebase not supported by the provided build environments, she would need to install the corresponding compilation toolchain.
- Additionally Spazio IT has complemented the SAFe Toolset with:
  - a specially **modified version of SonarQube** - https://www.sonarqube.org/ ;
  - a specially **modified version of the SonarQube C++ Community Plugin** - https://github.com/SonarOpenCommunity/sonar-cxx ;
  - the **SAFacilitator** – an application largely simplifying the static analyzers usage and the integration of their results into SonarQube – more info @ https://www.spazioit.com/pages_en/sol_inf_en/code_quality_en/safe-toolset/

SAFe Toolset

- The development of the SAFe Toolset has been funded by the European Space Agency Contract # RFP/3-15558/18/NL/FE/as.

Future/Current Activities





Future/Current Activities

- Spazio IT has just started working on Software Verification and Validation and Artificial Intelligence (especially Machine Learning). This research work is active on two complementary fronts:
  1. how to verify and validate AI software
  2. how to improve the “traditional” verification and validation activities with the adoption of AI techniques.
- Some new generations of static analyzers may be based on AI techniques.

Thank you for your time!