cREXX Progress Update

The 33rd Annual Rexx Symposium

Adrian Sutherland • 12.09.2022 (Final)

cREXX Progress Update

cREXX Architecture

cREXX Level B MVP

How to Help?

Thanks!

cREXX Architecture

Phases 0 to 2

REXX Level D

A REXX Compatible with Classic REXX but with additional features, e.g. USE

REXX Level C

Classic REXX

REXX Level F

A REXX Compatible with OOREXX but with additional features (features TBC)

REXX Level E

OOREXX

Phase 3

REXX Level G

A REXX Language for General Purpose Use; in terms of scope this can be considered to a modernised and unified version of Classic and OO REXX. In sum, an easy to use modern REXX.

REXX Level L

A REXX Language for Computer Language Engineering with advanced parsing, and inbuilt support for language engineering data structures

REXX Level B (Phase 0)

Base Subset REXX Language with features / grammar *which are incompatible with REXX Level C.*

Designed to be lightweight but with the required features to support cREXX components (e.g. Component 0 - End2end Controller), but unconstrained by existing REXX language specifications.

- Access to environment variables
- ADDRESS COMMAND
- A base set of low-level functions (via ASSEMBLE instruction)

It will have the object orientation and type safety as core features.

2. REXX Validator

8. REXX LLVM IR Generator

LLVM IR Code

LLVM Optimiser and Assembler

REXX Internal Representation

B. REXX Abstract Syntax Tree

C. REXX Symbol Table

Native Binary

A. REXX Source Code

1. REXX Parser

4. REXX Assembler Generator

D. REXX Assembler Code

7. REXX Runtime Library

Run

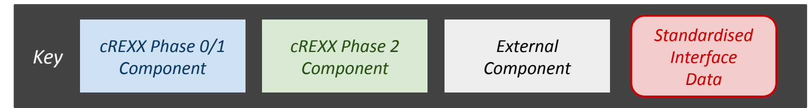
3. REXX Optimiser

5. REXX Assembler

E. REXX Bytecode

6. REXX Bytecode Interpreter

0. cREXX End2end Controller



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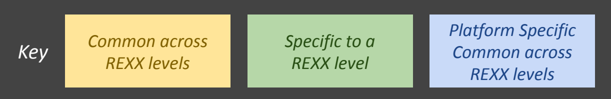

Phase 3

Phase 2

Phase 1

Phase 0

REXX (Level B)

*REXX (Level L)

*REXX (Level L)

*REXX (Level L)

*REXX (Level L)

*REXX (Level L)

*REXX (Level L)

RE2C & Lemon

C

C

C

RE2C, Lemon, C

C

REXX (Level B)

C

0. cREXX End2end Controller

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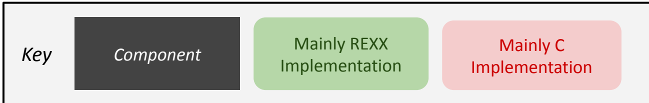
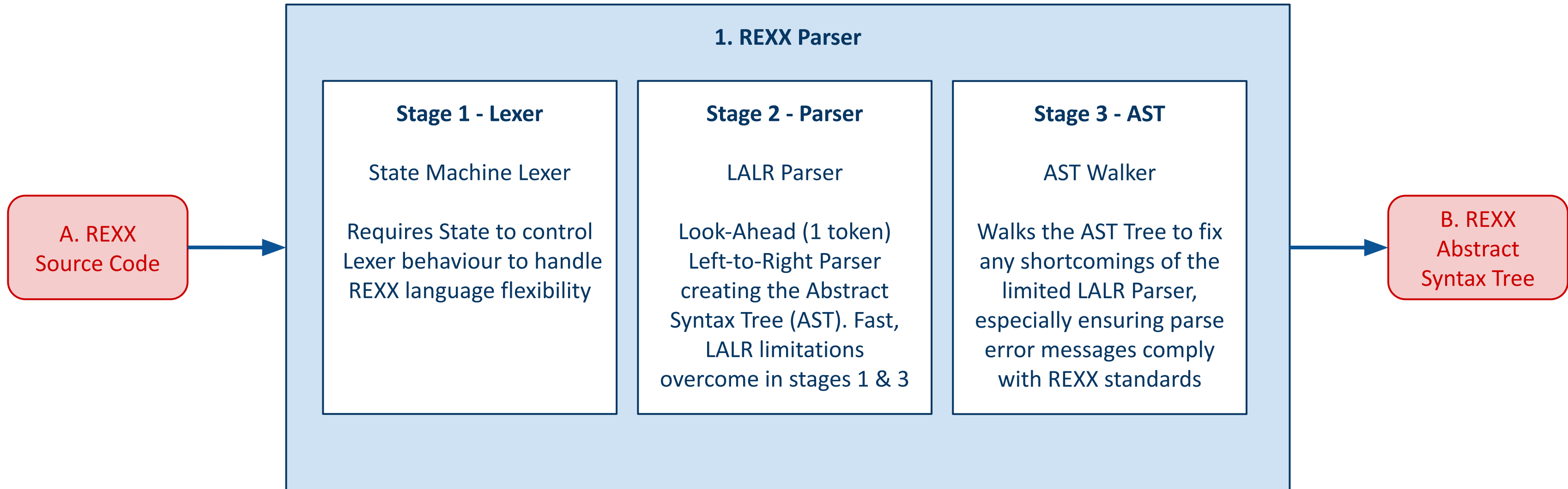
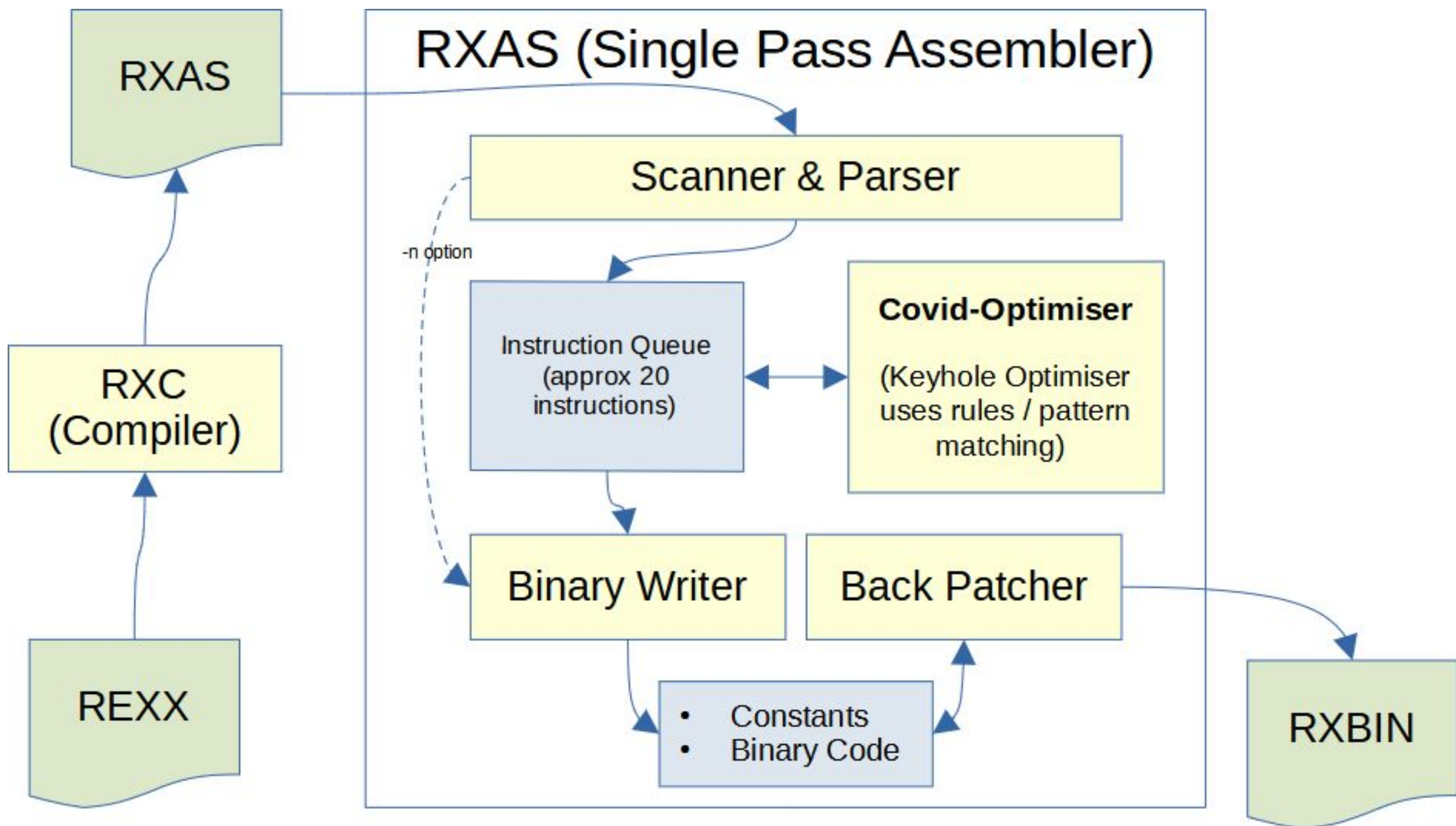
* REXX Level L provides the required:

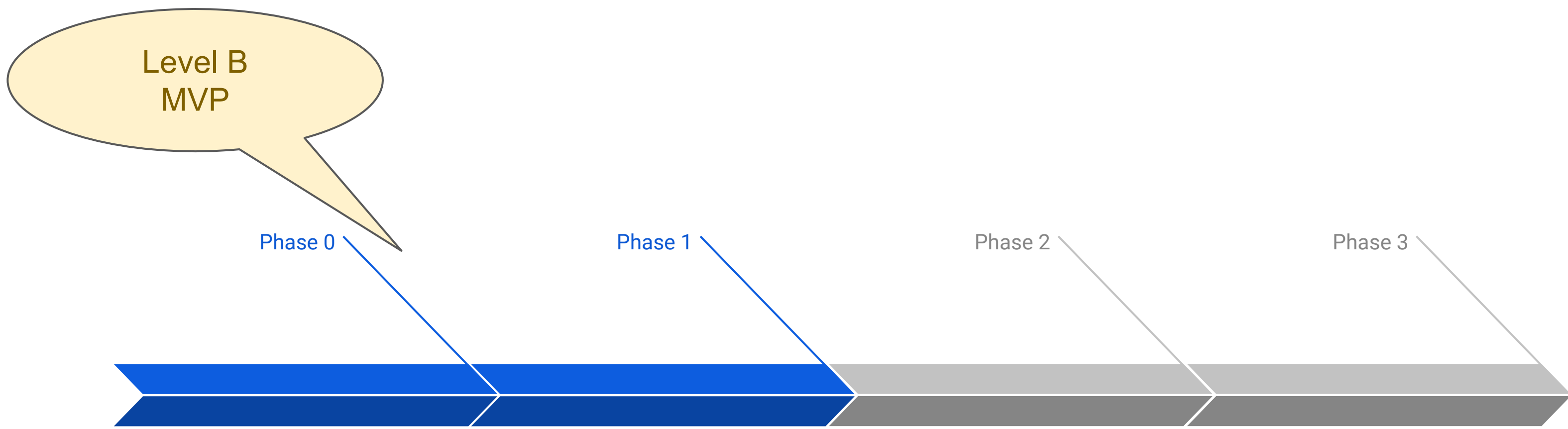
1. Extended PARSE to handle PEG Grammars
2. Native support of Language Engineering data structures (ASTs and Symbol Tables)




A. REXX
Source Code
1. REXX Parser
Stage 1 - Lexer
State Machine Lexer
Requires State to control
Lexer behaviour to handle
REXX language flexibility
Stage 2 - Parser
LALR Parser
Look-Ahead (1 token)
Left-to-Right Parser
creating the Abstract
Syntax Tree (AST). Fast,
LALR limitations
overcome in stages 1 & 3
Stage 3 - AST
AST Walker
Walks the AST Tree to fix
any shortcomings of the
limited LALR Parser,
especially ensuring parse
error messages comply
with REXX standards
B. REXX
Abstract
Syntax Tree


RXAS
RXAS (Single Pass Assembler)
Scanner & Parser
-n option
RXC
(Compiler)
Instruction Queue
(approx 20
instructions)
Covid-Optimiser
(Keyhole Optimiser
uses rules / pattern
matching)
Binary Writer
Back Patcher
REXX
Constants
Binary Code
RXBIN

cREXX Level B MVP



Proof of Concept

Goal: Sustainability

Prove architectural concepts and the ability for the project to deliver by creating a modern REXX implementation

Classic REXX

Goal: Standards compliancy

Formalise the implementation by creating a high quality, stable, performantand compliant Classic REXX

Native Performance

Goal: Native Binaries

Integrate to the LLVM backend to allow optimised native binaries for multiple target operating systems

REXX Modernisation

Goal: Contemporary REXX

Re-imagine REXX for new users and workloads, and with contemporary language features

cREXX Level B MVP

Implemented

1. Statically typed language
2. Rexx assembler (rxas) based
3. Compiler, Assembler, Interpreter, Debugger (WIP in REXX)
4. Windows, Mac, Linux, VM/370CE + all good C90 targets
5. Metadata (debugging, linking, introspection, interfacing)
6. UTF
7. PROCEDURE, IF, THEN, UNTIL, WHILE, FOREVER, LEAVE, ITERATE, CALL, ARG, SAY, LOOP
8. ASSEMBLER (for low level functionality)
9. Runtime library including runtime “exits” (WIP)
10. Libraries (rxbin)
11. Libraries as “C-Arrays” and linking to standalone native exe’s
12. NAMESPACEs and IMPORTing
13. EXPOSE (Static Scoping)
14. EXPOSE across source files
15. Line Comments

To Complete

1. PARSE
2. SELECT
3. Objects
4. Arrays
5. STEM Object (Implemented in REXX)
6. File IO
7. ADDRESS
8. Native Function Calling
9. Inlining
10. Level B “System” Library

Will not include

1. Variable Pool (Level C)
2. SAA Interface (Level B) - To be implemented in REXX
3. LLVM
4. Full Runtime Library (Level C & G)
5. Math[s]

How to Help?

How to Help?

- Github - https://github.com/adesutherland/CREXX
- Contact myself or René
- Fortnightly Evening Zoom meetings

- **Code - Test - Use - Feedback - or just lurk!**

Thanks to ...

- René Jansen - Our PM; for all his encouragement and work on the built in functions
- Peter Jacob - Our microcode engineer!
- Mike Großmann - For rolling up his sleeves when needed
- Michael Beer, Bob Bolch and everyone else who comes to our project meetings when they should be having a beer!

Adrian Sutherland

- Journeyman Architect
- Keeps “hands-on” through numerous projects, from Raspberry PI toys and Domain Specific Languages to open architectural papers and other assets.

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Questions

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Typical Bytecode Optimisation

1. Threaded code
2. Super-instructions / inlining
3. Top-of-stack in a register
4. Scheduling the dispatch of the next VM instruction

In all about 2x faster than classic bytecode

We should be aiming for performance of only 2-5 times slower than native code

NOTE - We could be talking about any language ...

```
char code[] = {
  ICONST_1, ICONST_2,
  IADD, ...
}
char *pc = code;

/* dispatch loop */
while(true) {
  switch(*pc++) {
  case ICONST_1: *++sp = 1; break;
  case ICONST_2: *++sp = 2; break;
  case IADD:
    sp[-1] += *sp; --sp; break;
  ...
}}
```

Pure Bytecode

```
void *code[] = {
  &&ICONST_1, &&ICONST_2,
  &&IADD, ...
}
void **pc = code;

/* implementations */
goto **(pc);

ICONST_1: pc++; *++sp = 1; goto **(pc);
ICONST_2: pc++; *++sp = 2; goto **(pc);
IADD:
  pc++; sp[-1] += *sp; --sp; goto **(pc);
...
```

Threaded Interpreter

REXX Assembler

This is where optimisations become REXX specific ...

BREXX

- Stack Based
- Leaves work to the interpreter

CREXX

- Register Based
- Trying to handle REXXisms at the low level

We need to get this right for LLVM ...

```
/* SIMPLE */
A = 10
B = 5
SAY A + B
```

BREXX

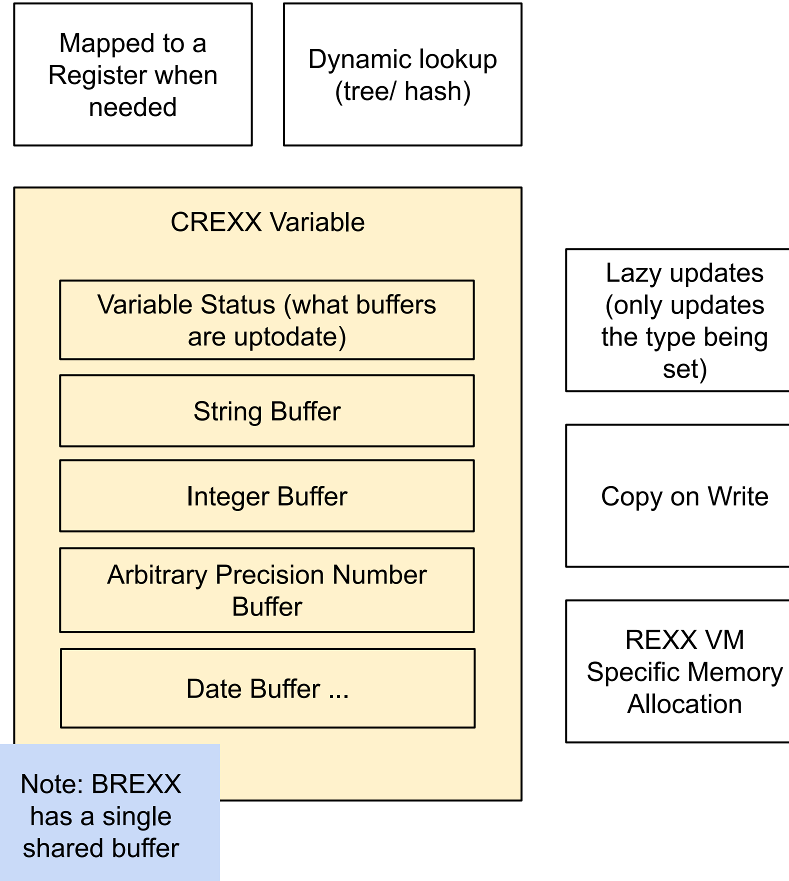
```
NEWCLAUSE
CREATE      "A"
PUSH        10
COPY
NEWCLAUSE
CREATE      "B"
PUSH        5
COPY
NEWCLAUSE
PUSHTMP
LOAD        "A"
LOAD        "B"
ADD
SAY
NEWCLAUSE
IEXIT
```

CREXX

```
.def main: locals=3 {r1="A", r2="B"}
ILOAD   r1,10
ILOAD   r2,5
IADD    r3,r1,r2
ISAY    r3
HALT
```

REXX Variable Types

1. Rexx is typeless … and more than that conceptually all variables are strings
2. Rexx stems provide a flexible and arbitrary index scheme
3. VALUE(), INTERPRET(), and REXXSAA/EXECOMM all require dynamic variable name resolution
4. Performance requires compile time resolution of variable names and types, wherever possible



CREXX

C Library

REXX Lexer & Parser
ANTLR 3
BREXX
PackCC
Regina

REXX AST & Static Optimisation
ANTLE 3
Custom

REXX Compiler
ANTLE 3
Custom
BREXX

REXX Assembly Tools
VMGEN
Custom

REXX ByteCode Interpreter
VMGEN
Custom

REXX native backends (Compiled / JIT)
LLVM

REXX Variables
BREXX
Regina

REXX Maths
Regina
LibBF

REXX Strings
BREXX
Regina

REXX ADDRESS
External Calls
BREXX
ShellSpawn
Regina

REXX BIF
Built in Functions
BREXX
Regina

REXX IO

Linux. Windows,Mac OS, VM/370 Drivers

BREXX
Regina
POSIX

High Level Components & Implementation Leverageable Tools