

# Automating Builds in Git on IBM i

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# IBM i

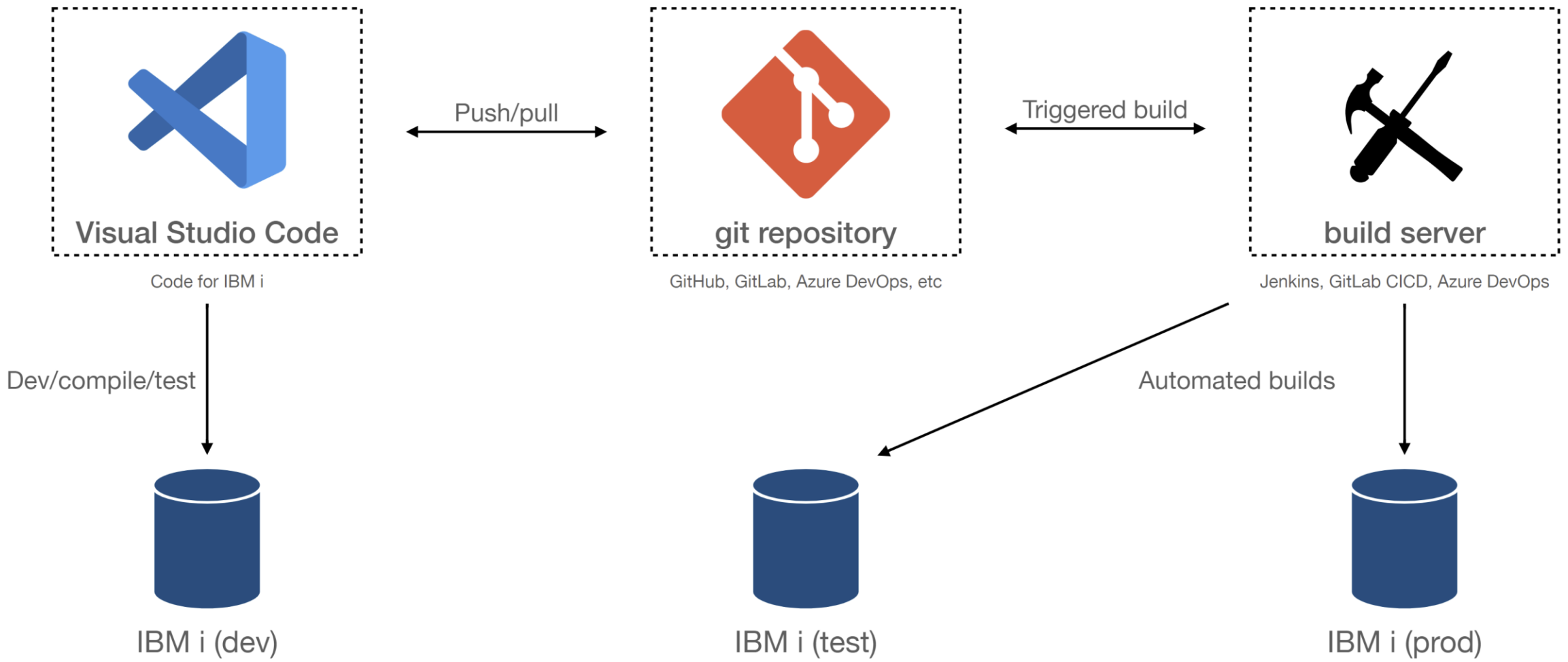


# Agenda

- The Modern Development Lifecycle with Git
- Unlock Automated Builds with ibmi-ci
- ILE Dependency Analysis with Source Orbit
- Practical Use Case
- Demo

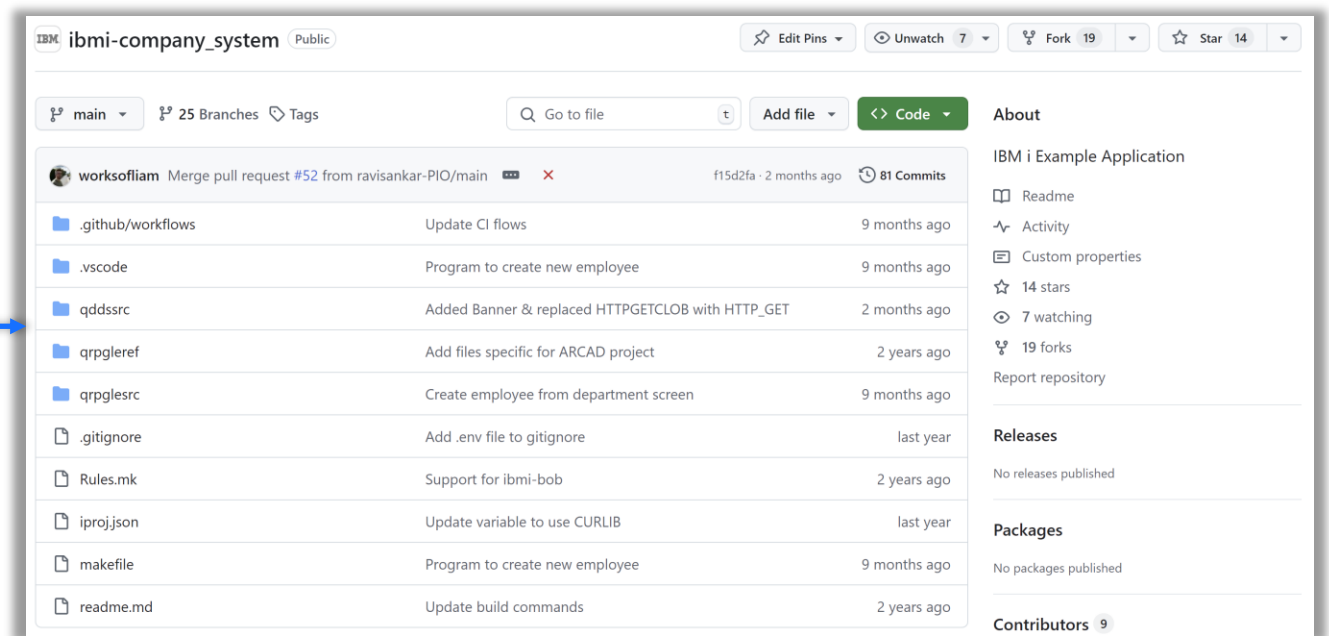
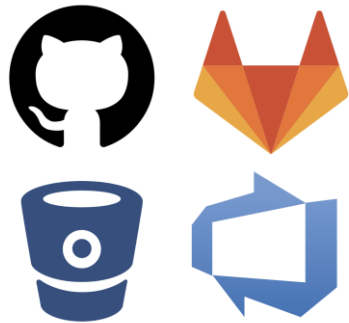
# **The Modern Development Lifecycle with Git**

# What Does Modern Development Look Like?



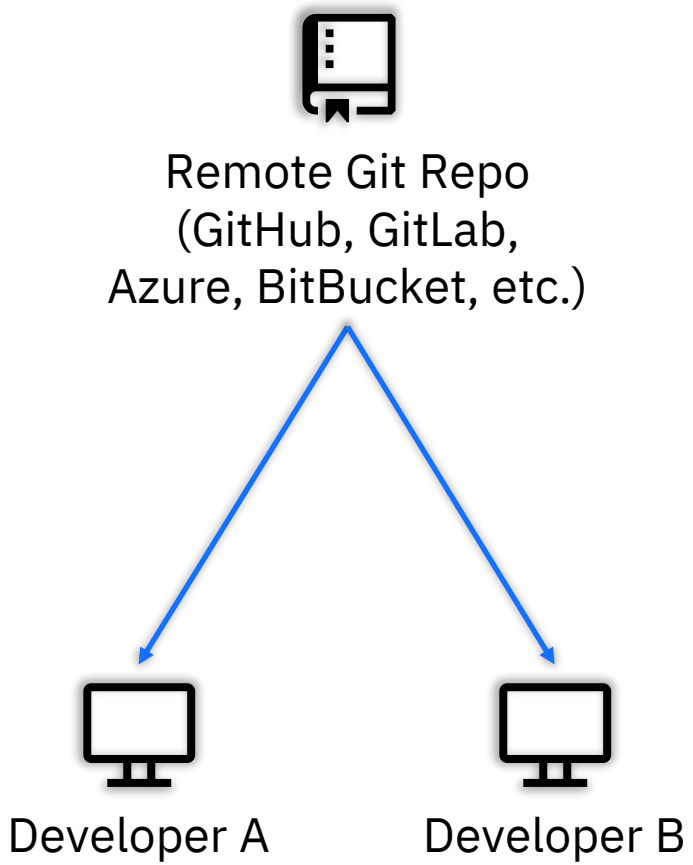
# Development with Git

- Source is managed by Git
  - Complete change history
  - Branching and merging capabilities
  - Traceability
- Variety of options for Git hosting services
  - GitHub, GitLab, Azure DevOps, etc

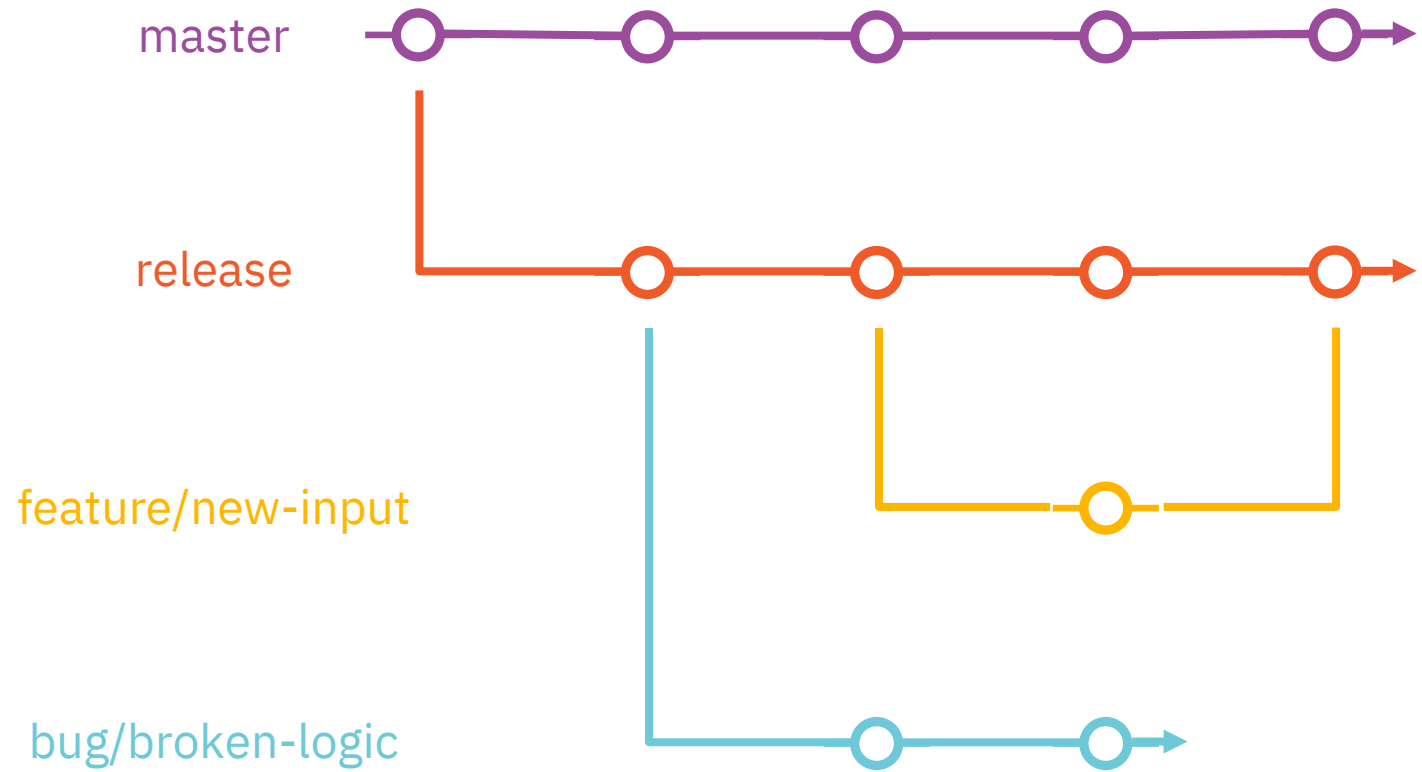


# Why use Git?

## Distributed Development



## Version Control and Git Workflow

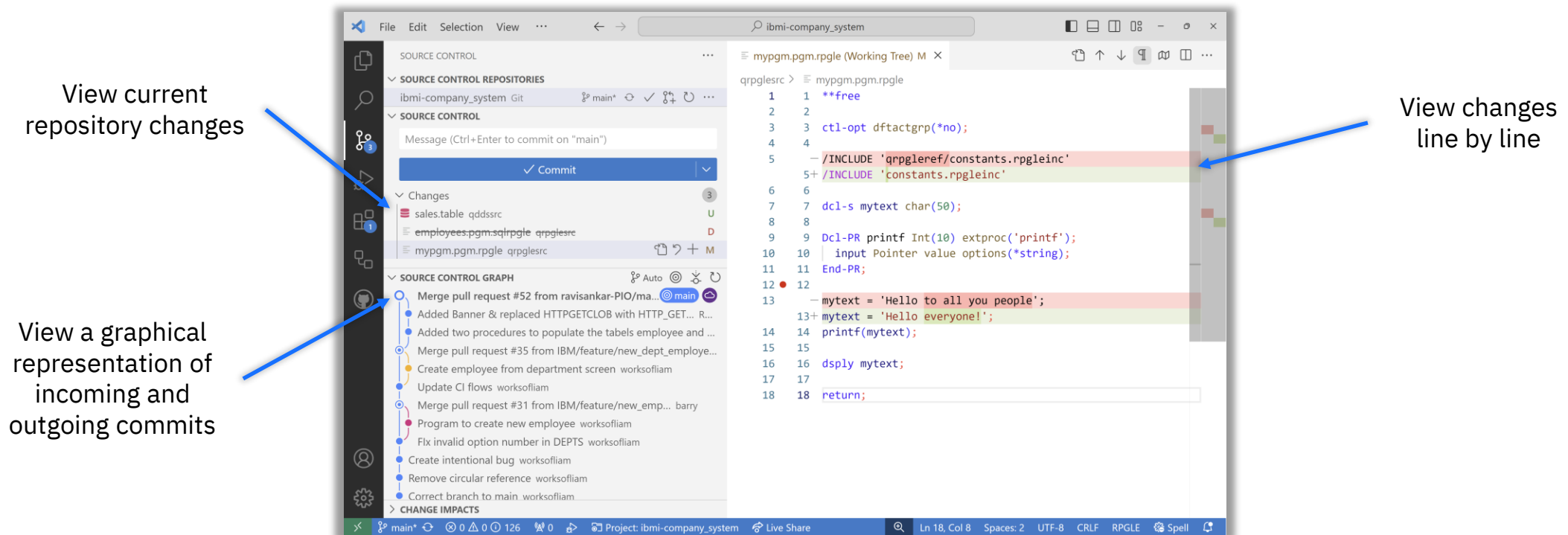


# Local Development Experience

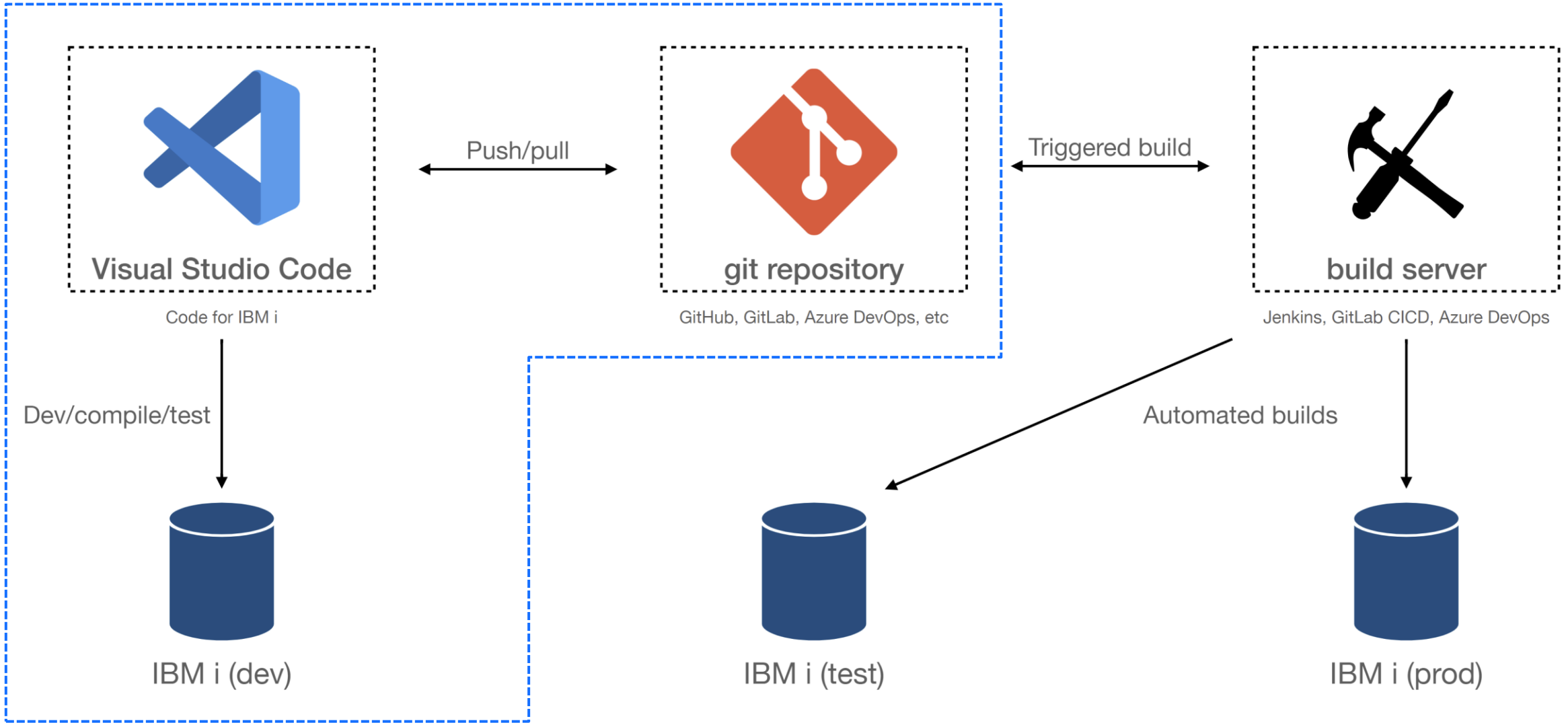
- IBM i
  - IBM i integration via open-source extensions
  - Support for RPGLE, COBOL, CL, SQL, and more!
- Git
  - First class Git support
  - Hundreds of Git tools



Code for IBM i

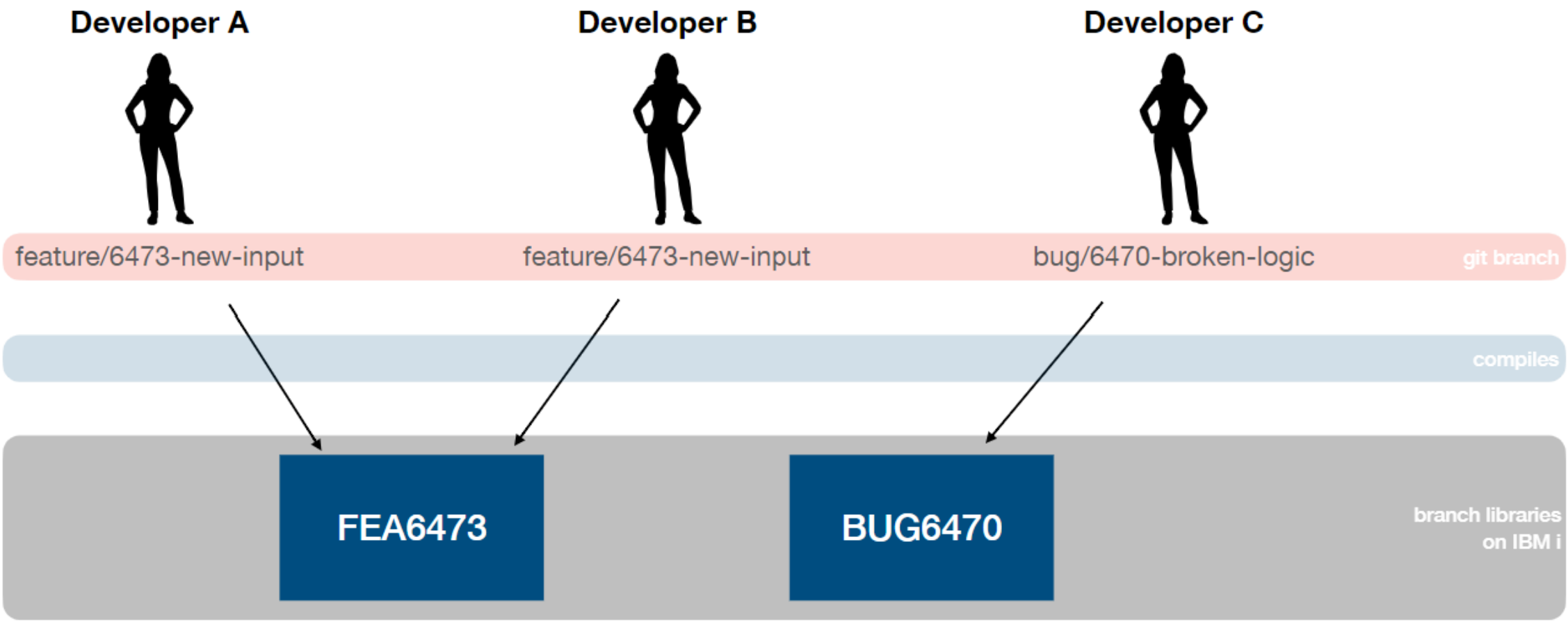


# How to work efficiently with these 3 components?



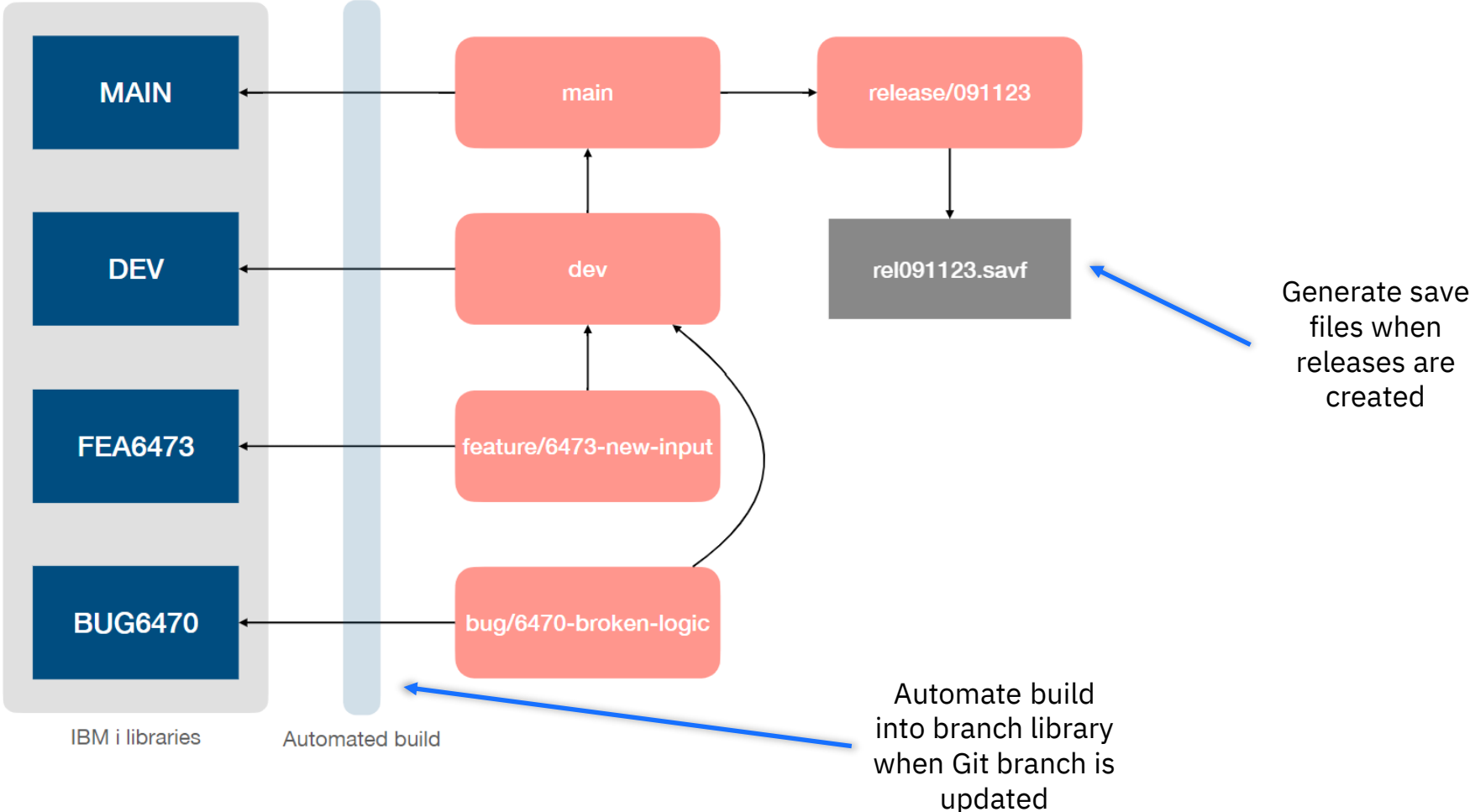


# Map Git branches to libraries on IBM i



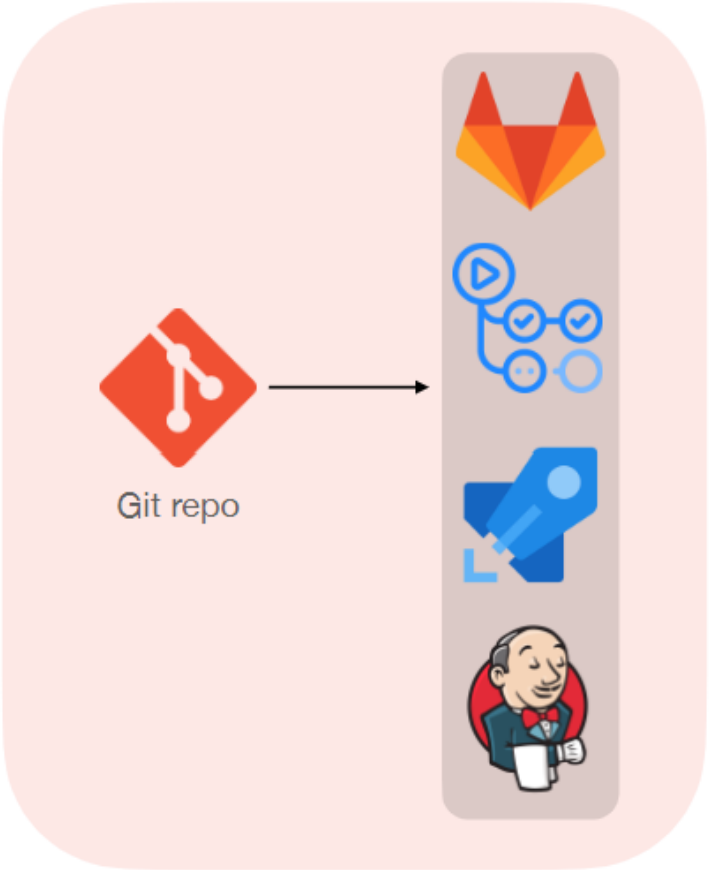
# Build Server

*Let's go one step further and automate this process*



# How to create workflows?

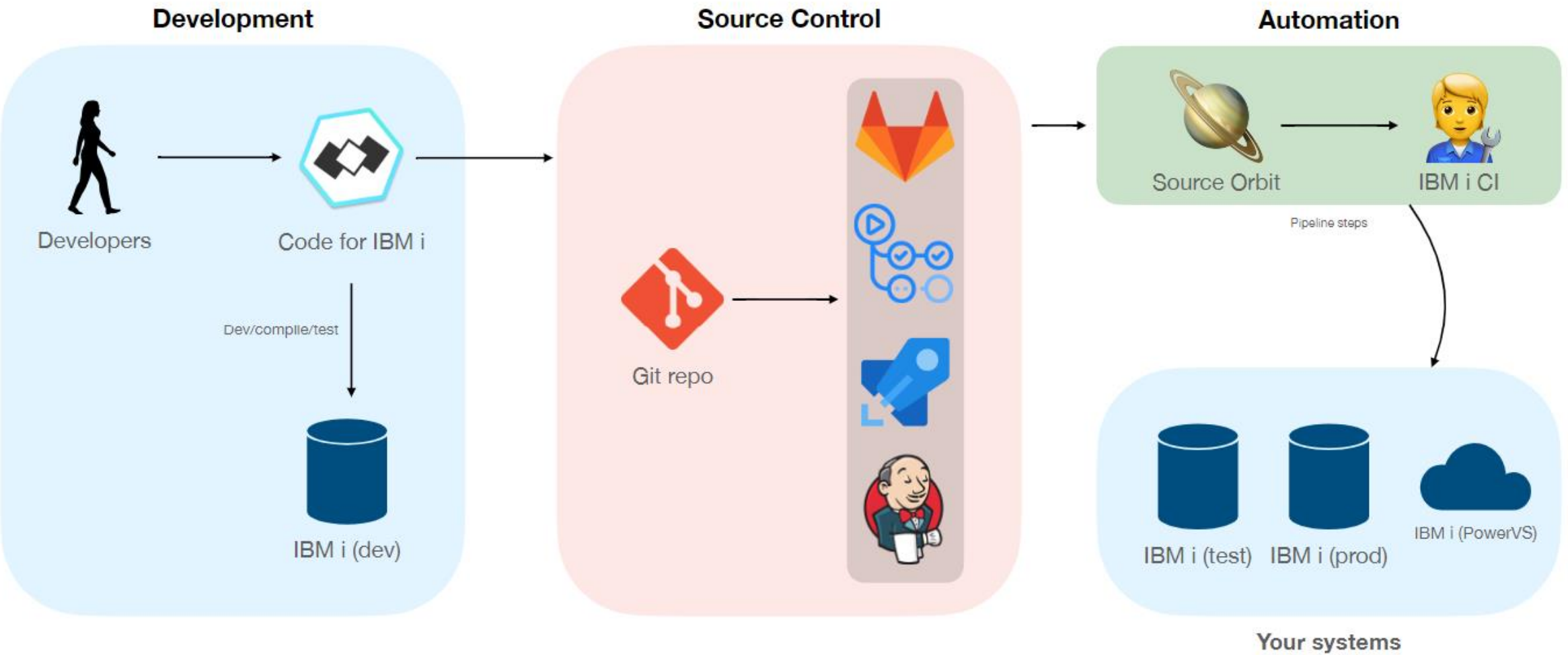
## Source Control & Automation



GitLab	<code>.gitlab-ci.yml</code>
Azure DevOps	<code>azure-pipeline.yml</code>
GitHub	<code>anything.yml</code>
Jenkins	<code>Jenkinsfile</code>

yml can also be yaml

# How to achieve automation with IBM i?



# Unlock Automated Builds with ibmi-ci

# Overview

- A CLI tool to simplify working with IBM i from pipelines (ex. GitHub Actions, GitLab CICD, etc.)
- Outline a series of steps to perform with the first default step being to connect to an IBM i
- Requirements
  - SSH server is running on IBM i
  - Node.js needs to be installed
- Installation
  - `npm i -g @ibm/ibmi-ci`
- Establishing IBM i connection
  - Required
    - IBMI\_HOST
    - IBMI\_USER
    - IBMI\_SSH\_POST
  - At least one required
    - IBMI\_PASSWORD
    - IBMI\_PRIVATE\_KEY

The screenshot shows the GitHub repository page for `@ibm/ibmi-ci`. The repository is a TypeScript (TS) project, version 0.2.5, published a year ago. It has 1 dependency and 0 dependents. The page includes tabs for Readme, Code (Beta), 1 Dependency, 0 Dependents, 4 Versions, and Settings. The main content area is titled `ibmi-ci` and describes it as a command line tool to make it easier to work with IBM i from pipelines. It includes sections for Installation and How to use. The installation section shows the command `npm i @ibm/ibmi-ci`. The how to use section shows the command `ici \` followed by several options: `--rcwd "/builds/myproject" \`, `--push "." \`, and `--cmd "/QOpenSys/pkgs/bin/gmake BIN_LIB=MYLIB"`. On the right side, there is a sidebar with a Weekly Downloads graph showing 56 downloads, a table with Version (0.2.5) and License (Apache 2), a table with Unpacked Size (1.75 MB) and Total Files (21), and a section for Collaborators with three user avatars. At the bottom right, there is a button labeled `>Try on RunKit`.

# CLI Usage

<code>--lcwd &lt;localDirectory&gt;</code>	Sets the current working directory on the local system
<code>--rcwd &lt;remoteDirectory&gt;</code>	Sets the current working directory on the remote system. It will be created if it does not exist.
<code>--push &lt;remoteRelativeDirectory&gt;</code>	Pushes the current working directory to a chosen directory on the IBM i
<code>--pull &lt;remoteRelativeDirectory&gt;</code>	Pulls a directory from IBM i to the local current working directory
<code>--get &lt;remoteRelativeDirectory&gt; &lt;localRelativePath&gt;</code>	Gets a specific file from IBM i
<code>--cmd &lt;shellCommand&gt;</code>	Execute a command on the remote system
<code>--cl &lt;clCommand&gt;</code>	Execute a CL command on the remote system

# Simplistic Example

Upload the local  
working directory to  
the remote working  
directory (.)

Build project with  
gmake

```
ici \  
  --rcwd "./builds/myproject" \  
  --push "." \  
  --ignore --cl "CRTLIB LIB(MYLIB)" \  
  --cmd "/QOpenSys/pkgsrc/bin/gmake BIN_LIB=MYLIB"
```

Set the remote  
working directory to  
./builds/myproject

Create build library if  
it does not exist

★ IBM i connection is specified as environment variables

Suppress errors and  
continue execution




# GitHub Action Example

```
jobs:
  ibmi-build:
    environment: COMMON1
    runs-on: ubuntu-latest
    steps:
      # Checkout repository and setup node steps omitted

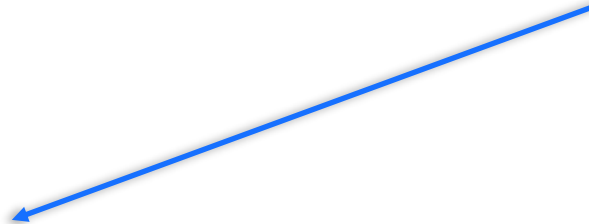
      - name: Install Dependencies
        run: npm i -g @ibm/ibmi-ci

      - name: Deploy to IBM i
        run: |
          ici \
            --cmd "mkdir -p './builds/ics_${GITHUB_HEAD_REF}'" \
            --rcwd "./builds/ics_${GITHUB_HEAD_REF}" \
            --push "." \
            --cmd "/QOpenSys/pkg/bin/gmake BIN_LIB=CMPSYS"
        env:
          IBMI_HOST: ${ secrets.IBMI_HOST }
          IBMI_USER: ${ secrets.IBMI_USER }
          IBMI_PASSWORD: ${ secrets.IBMI_PASSWORD }
          IBMI_SSH_PORT: ${ secrets.IBMI_SSH_PORT }
```

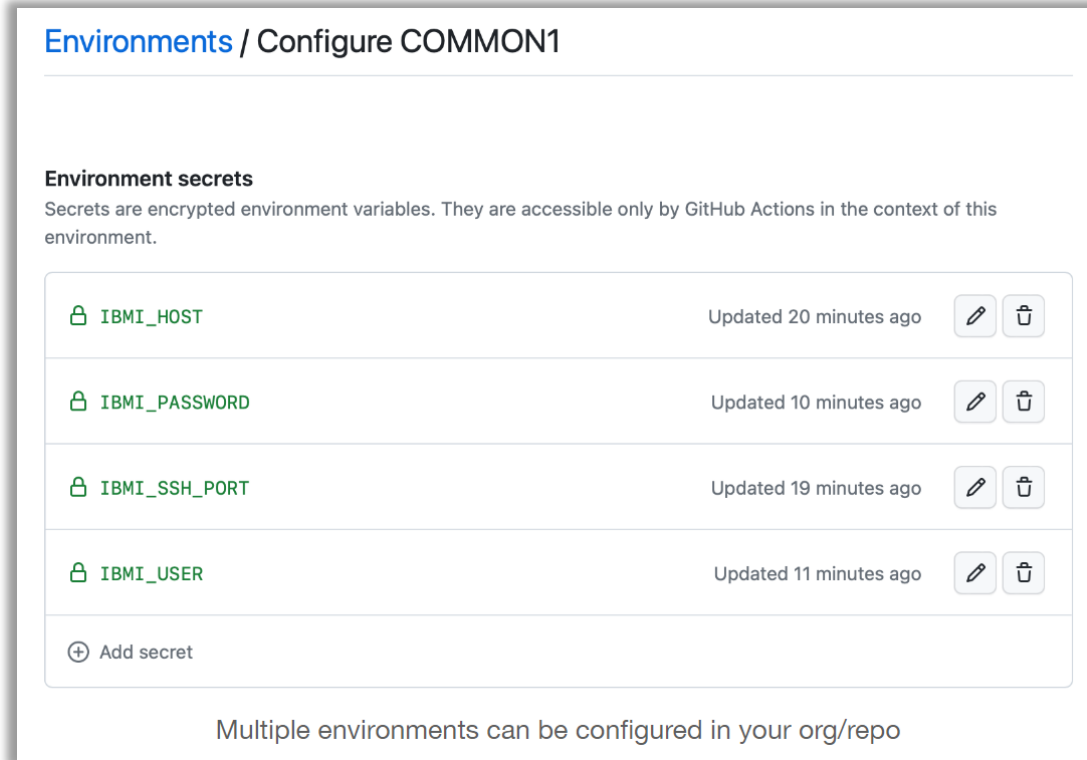
IBM i connection is  
specified as  
environment  
variables



GITHUB\_HEAD\_REF  
is the head ref or  
source branch of the  
pull request




# Why use environments?

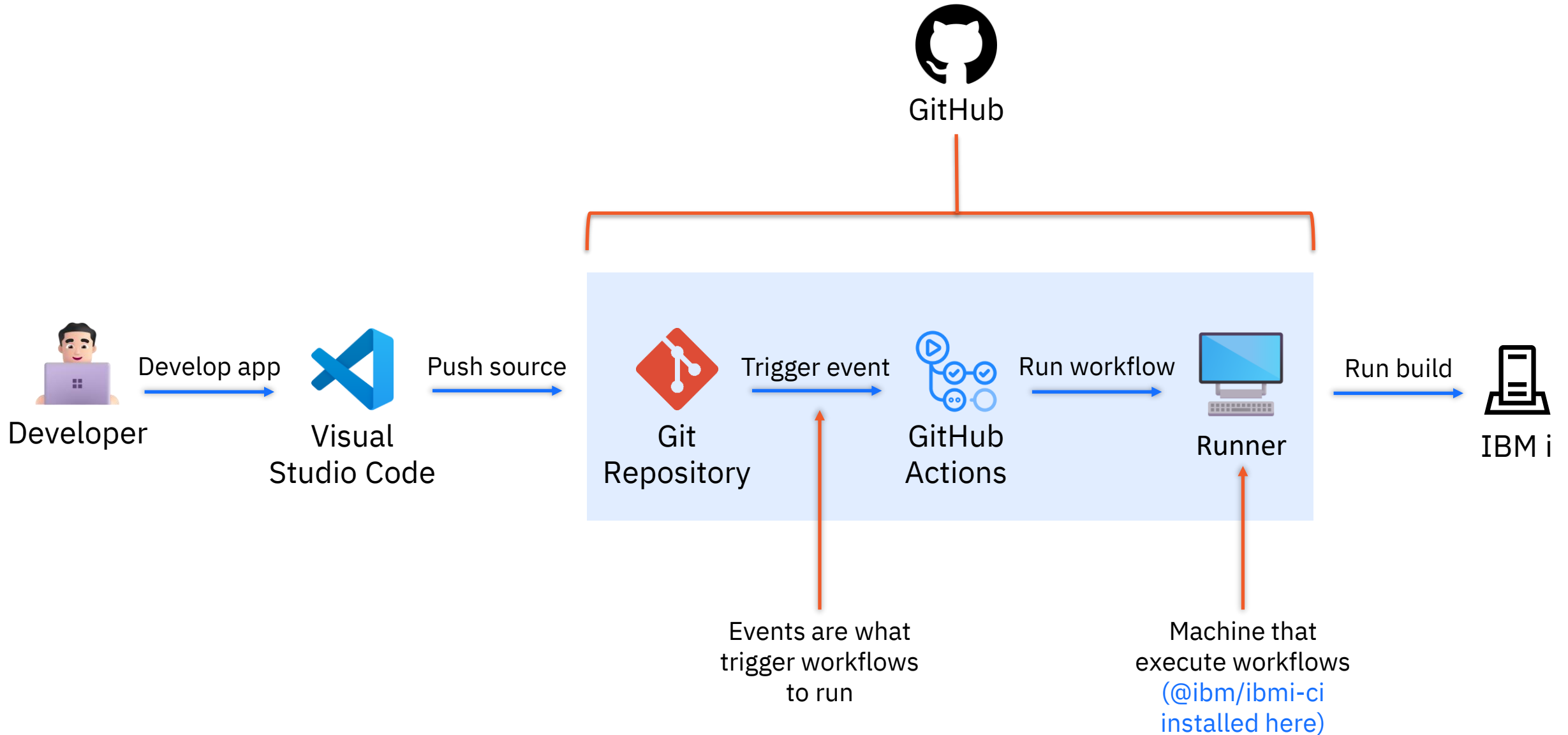


```
jobs:  
  ibmi-build:  
    strategy:  
      matrix:  
        environment: [COMMON1, OSSBUILD]  
environment: ${{ matrix.environment }}  
runs-on: ubuntu-latest
```

Use a matrix to run a workflow on multiple IBM i machines



# How do GitHub Actions work?



# What are Events and Runners?

## Events



Workflow triggers that cause a workflow to run

```
on:
  push:
    branches: [ main ]

  pull_request:
    branches: [ main ]
    types: [opened]

  release:
    types: [created]

  workflow_dispatch:
```

## Runners



Machines that execute jobs in a workflow

Virtual Machine	Processor (CPU)	Memory (RAM)	Storage (SSD)	Workflow label
Linux	4	16 GB	14 GB	<a href="#">ubuntu-latest</a> , <a href="#">ubuntu-24.04</a> , <a href="#">ubuntu-22.04</a> , <a href="#">ubuntu-20.04</a>
Windows	4	16 GB	14 GB	<a href="#">windows-latest</a> , <a href="#">windows-2022</a> , <a href="#">windows-2019</a>
macOS	3	14 GB	14 GB	<a href="#">macos-12</a>
macOS	4	14 GB	14 GB	<a href="#">macos-13</a>
macOS	3 (M1)	7 GB	14 GB	<a href="#">macos-latest</a> , <a href="#">macos-14</a> , <a href="#">macos-15</a> [Public preview]

*-latest* runner images are the latest stable images that GitHub provides, and might not be the most recent version of the operating system

# **ILE Dependency Analysis with Source Orbit**

# Overview

- A dependency management tool (CLI and VS Code extension!)
  - Build dependency tree for RPGLE, DDS, SQL, CL, etc.
  - Generates impact analysis information
  - Generate scripts to automate builds
  - Clean up your project
- Requirements
  - Node.js needs to be installed
- CLI Installation
  - `npm i -g @ibm/sourceorbit`
- Extension Installation
  - <https://marketplace.visualstudio.com/items?itemName=IBM.vscode-sourceorbit>

The screenshot shows the npm package page for @ibm/sourceorbit. The package is version 0.11.1, published 11 days ago, and is public. It has 1 dependency, 0 dependents, and 21 versions. The page includes a 'Readme' tab, a 'Code' tab (marked as Beta), and a 'Settings' tab. The 'Source Orbit' section describes it as a dependency management tool for RPGLE/CLLE/SQL/DDS/binder sources. The 'General usage' section lists several features: listing project objects with --verbose, showing object dependencies with -l, generating a makefile based on the dependency tree, renaming files easily, and fixing RPGLE includes. The 'Install' section shows the command `npm i @ibm/sourceorbit`. The 'Homepage' is [ibm.github.io/sourceorbit/#/](https://ibm.github.io/sourceorbit/#/). The 'Weekly Downloads' section shows 56 downloads. The 'Version' is 0.11.1 and the 'License' is Apache 2. The 'Unpacked Size' is 164 kB and the 'Total Files' is 20. The 'Last publish' was 11 days ago.

The screenshot shows the Source Orbit extension page on the Visual Studio Marketplace. The extension is for IBM i and is available for free. It has 44 installs and a rating of 2 stars. The page includes an 'Install' button and a 'Trouble Installing?' link. The 'Overview' tab is selected, showing a description of the tool and its purpose. The 'Categories' section shows 'Other'. The 'Tags' section shows 'as400', 'ibmi', 'iseries', and 'multi-root ready'. The 'Works with' section shows 'Universal'. The 'Resources' section includes links to 'Issues', 'Repository', 'Homepage', 'License', and 'Download Extension'. The 'Extension' section shows version v1.0.2 with 44 installs. The 'CLI' section shows version v1.0.2 with 369 downloads per month.

# CLI Usage

- `so -ar`
  - Scan all source code and fix extensions
    - Rename programs to have *.pgm.*
    - Rename include files to use *.rpgleinc*
    - Rename SQL source to use extension based on *CREATE* statement
- `so -fi`
  - Fix include/directory directives to use UNIX style paths if found in local source
- `so -bf <type>`
  - Generate build and dependency files
    - make: Generate single makefile with targets and rules
    - bob: Generate Rules.mk files for Bob
    - imd: Generate impact analysis for branches
    - json: Generate dependency info as JSON
- `so -bl <name>`
  - Generate a deterministic library name given a branch name

# Repository Cleanup

Source Locally

Filter 23 PAYROLLORG/\*/\* (\*SRCPF)

qddssrc

mstdsp.dspf Master DSPF

qprotosrc include files

errortable.rpgle error table include

qrpglesrc ILE RPG source for programs and includes

payroll.rpgle Payroll main program

qsqlsrc SQL TABLES

empmst.table Employee Master table

prjmst.table Project Master

rsnmst.table Reason Master

Original source in QSYS

PAYROLL-DEMO

QDDSSRC

mstdsp.dspf

QPROTOSRC

errortable.rpgleinc

QRPGLSRC

payroll.pgm.rpgle

QSQLSRC

empmst.table

prjmst.table

rsnmst.table

Cleaned up file extensions

Clipboard payroll.pgm.rpgle M X

QRPGLSRC payroll.pgm.rpgle

29 32 Dcl-F MSTDSP WORKSTN;

30 33 Dcl-F EMPMST Usage(\*Update:\*Delete:\*Output) Keyed;

31 34 Dcl-F PRJMST Usage(\*Update:\*Delete:\*Output) Keyed;

32 35 Dcl-F RSNMST Usage(\*Update:\*Delete:\*Output) Keyed;

33 36

34 37 Dcl-S EMESS Char(50);

35 38

36 39+ /include QPROTOSRC,ERRORTABLE

37 40 /copy 'QPROTOSRC/errortable.rpgleinc'

38 41

39 42 //

40 43 // \*\*\*\*\*

41 44 //

42 45 // This mainline routine controls the display file processing and

43 46 // editing. Using the function keys described on each display

44 47 // format, you can transfer from one maintenance application to

45 48 // another. The action code you select on the selection formats

46 49 // determines if the program will add a new record to the file or

47 50 // update an existing record in the file.

48 51 // \*\*\*\*\*

49 52 // Housekeeping, clear display fields and reset indicators.

50 53 //

51 54 CALLP MAIN();

Cleaned up source code



# Impact Analysis...What Objects Am I Affecting?

so-impact summary

Impact Analysis

Touched objects:

NEMP.FILE : qddssrc/nemp.dspf

NEMP.FILE

▼Click to expand

NEMP.FILE ( qddssrc/nemp.dspf )

NEWEMP.PGM ( qrpglesrc/newemp.pgm.sqlrpgle )

DEPTS.PGM ( qrpglesrc/depts.pgm.sqlrpgle )

Messages

No messages to show.

Impacted objects based on source changes

Dependencies of impacted objects

Full project dependency tree

Project Listing

▼Click to expand

-	Object	Type	Path	Warnings	Parents	Children
📁	DEPARTMENT	FILE	qddssrc/department.table	▶ ⓘ	▶ 2	0
📁	DEPTS	FILE	qddssrc/depts.dspf	✓	▶ 1	0
📁	EMPLOYEE	FILE	qddssrc/employee.table	▶ ⓘ	▶ 2	0
📁	EMPS	FILE	qddssrc/emps.dspf	✓	▶ 1	0
📁	NEMP	FILE	qddssrc/nemp.dspf	✓	▼ 1 NEWEMP.PGM	0
🔗	POPDEPT	PGM	qddssrc/popdept.sql	▼ ⚠ Extension should be based on type. Suggested name is 'popdept.sqlprc'	0	▶ 1
📁	POPEMP	FILE	qddssrc/popemp.sql	✓	0	0
🔗	DEPTS	PGM	qrpglesrc/depts.pgm.sqlrpgle	▶ ⓘ	0	▶ 4
🔗	EMPLOYEES	PGM	qrpglesrc/employees.pgm.sqlrpgle	▶ ⓘ	▶ 1	▶ 2
🔗	MYPGM	PGM	qrpglesrc/mypgm.pgm.rpgle	▶ ⓘ	0	0
🔗	NEWEMP	PGM	qrpglesrc/newemp.pgm.sqlrpgle	▶ ⓘ	▶ 1	▶ 2

• Parents are objects that depend on this object.

• Children are objects that this object depends on.

# GitHub Action Example

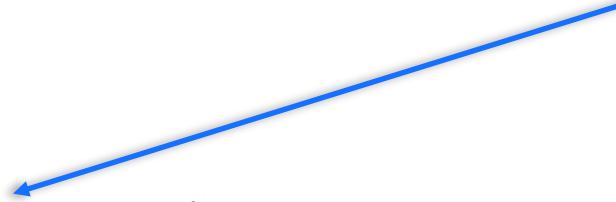
```
jobs:
  so-impact:
    runs-on: ubuntu-latest
    steps:
      # Checkout repository and setup node steps omitted

      - name: Install Dependencies
        run: npm i -g @ibm/sourceorbit

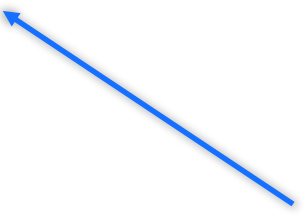
      - name: Generate impact information
        run: so -bf imd -l `git diff --name-only origin/main origin/${GITHUB_HEAD_REF}`

      - name: Adding markdown
        run: cat impact.md >> $GITHUB_STEP_SUMMARY
```

Generate impact analysis  
for changed files (compare  
main branch with pull  
request branch)



Redirect output to  
GITHUB\_STEP\_SUMMARY  
to create a custom  
Markdown job summary



# What is built into the Source Orbit VS Code extension?

View impacted objects for the current active editor

▼ SOURCE IMPACTS

EMPLOYEE.FILE qddssrc\employee.table

▼ EMPLOYEES.PGM qrpglesrc\employees.pgm.sqlrpgle

DEPTS.PGM qrpglesrc\depts.pgm.sqlrpgle

▼ NEWEMP.PGM qrpglesrc\newemp.pgm.sqlrpgle

DEPTS.PGM qrpglesrc\depts.pgm.sqlrpgle

View impacted objects for any changed files detected by Git

▼ CHANGE IMPACTS

DEPARTMENT.FILE qddssrc\department.table

POPDEPT.PGM qddssrc\popdept.sql

DEPTS.PGM qrpglesrc\depts.pgm.sqlrpgle

NEMP.FILE qddssrc\nemp.dspf

▼ NEWEMP.PGM qrpglesrc\newemp.pgm.sqlrpgle

DEPTS.PGM qrpglesrc\depts.pgm.sqlrpgle

▼ EMPLOYEES.PGM qrpglesrc\employees.pgm.sqlrpgle

DEPTS.PGM qrpglesrc\depts.pgm.sqlrpgle

MYPGM.PGM qrpglesrc\mypgm.pgm.rpgle

▼ PROJECT EXPLORER

ibmi-company\_system Company System project

> Source /home/SANJULA/builds/ibmi-company\_system (compare)

> Variables

> Library List

> Object Libraries

> Include Paths

▼ Source Orbit

DEPARTMENT.FILE (table)

DEPTS.FILE (dspf)

EMPLOYEE.FILE (table)

EMPS.FILE (dspf)

▼ NEMP.FILE (dspf)

No dependencies

▼ POPDEPT.PGM (sql)

DEPARTMENT.FILE (table)

▼ POPEMP.FILE (sql)

No dependencies

▼ DEPTS.PGM (sqlrpgle)

EMPLOYEES.PGM (sqlrpgle)

NEWEMP.PGM (sqlrpgle)

DEPARTMENT.FILE (table)

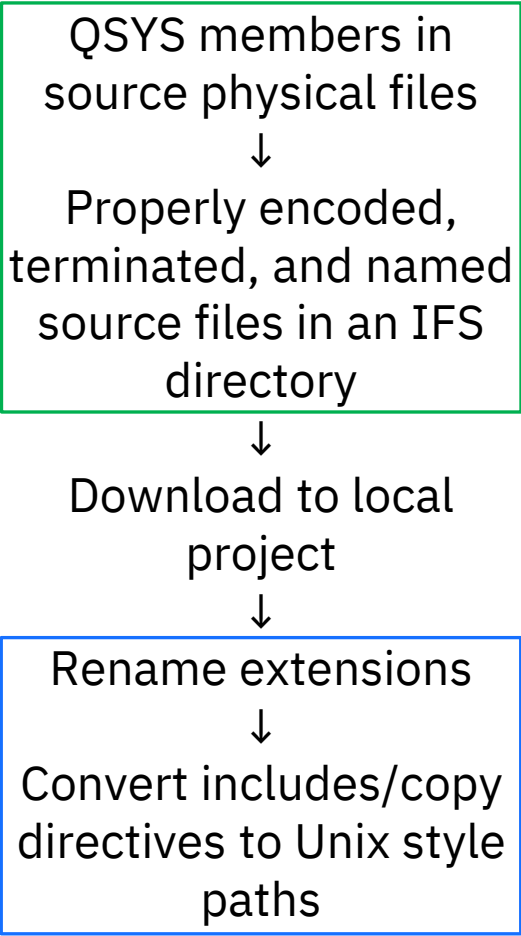
DEPTS.FILE (dspf)

View project's dependency tree with integration in IBM i Project Explorer

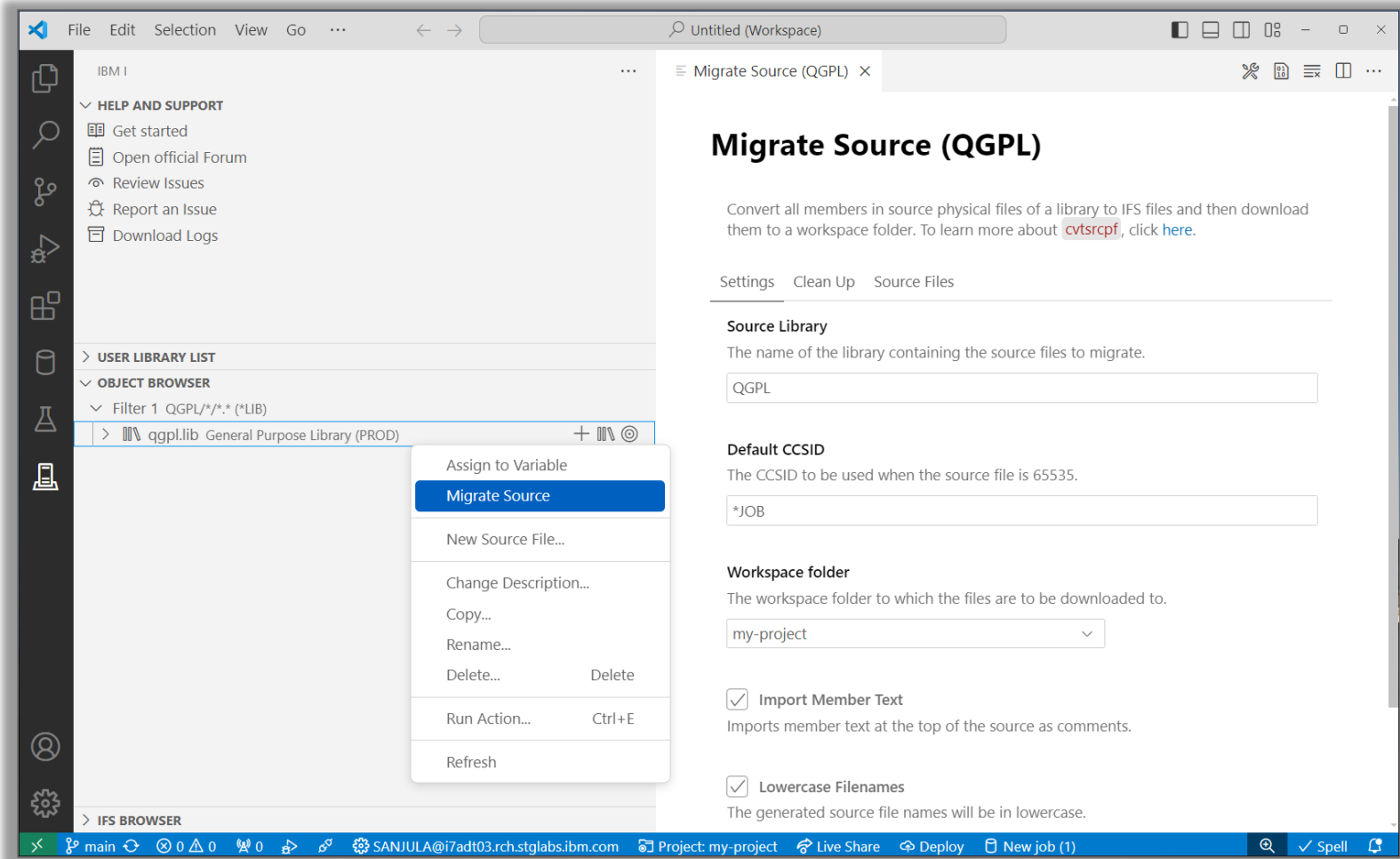
Actions to “Autofix” and “Generate Build Files”

# Source migration made easy

CVTSRCPF  
from BOB



Source Orbit



# Source Code Rules – Supported Extensions



Extension	Extension meaning	Notes
sqlrpgle	RPGLE (SQL)	Can use .pgm notation
rpgle	RPGLE	Can use .pgm notation
clle	CLLE	Can use .pgm notation
cl	CLLE	Can use .pgm notation
clp	CL (OPM)	Should be renamed to clle
pf	Physical File	Table
lf	Logical File	View/Index
dspf	Display File	
prtfr	Printer File	
msgfr	Message filee	
sql	Any SQL object	Type determined by create statement

table	SQL table	Expects CREATE TABLE
view	SQL view	Expects CREATE VIEW
index	SQL index	Expects CREATE INDEX
alias	SQL alias	Expects CREATE ALIAS
sqlalias	SQL alias	Expects CREATE ALIAS
sqlprc	SQL procedure	Expects CREATE PROCEDURE
sqludf	SQL function	Expects CREATE FUNCTION
sqludt	SQL table function	Expects CREATE FUNCTION
sqltrg	SQL trigger	Expects CREATE TRIGGER
sqlseq	SQL sequence	Expects CREATE SEQUENCE
bnd	Binder source	
binder	Binder source	Should be renamed bnd
cmd	Command	

# Source Code Rules – Object Names



- Base name of source file becomes object name
- If source includes *.pgm*, then it will become a program
- If source does not include *.pgm*, then it will become a module, cmd, dtaara, etc.
- Assumes binder source (*.bnd/.binder*) is a service program

Source name	Resulting object
LCUS.LF	LCUS.FILE
CUS.PF	PCUS.FILE
dothing.cmd	DOTHING.CMD
pos123.dspf	POS123.FILE
faq500.rpgle	FAQ500.MODULE
faq401.pgm.sqlrpgle	FAQ401.PGM
faq500.bnd	FAQ500.SRVPGM

# Source Code Rules – Long File Names



Source Orbit will generate a deterministic object name based on the file name

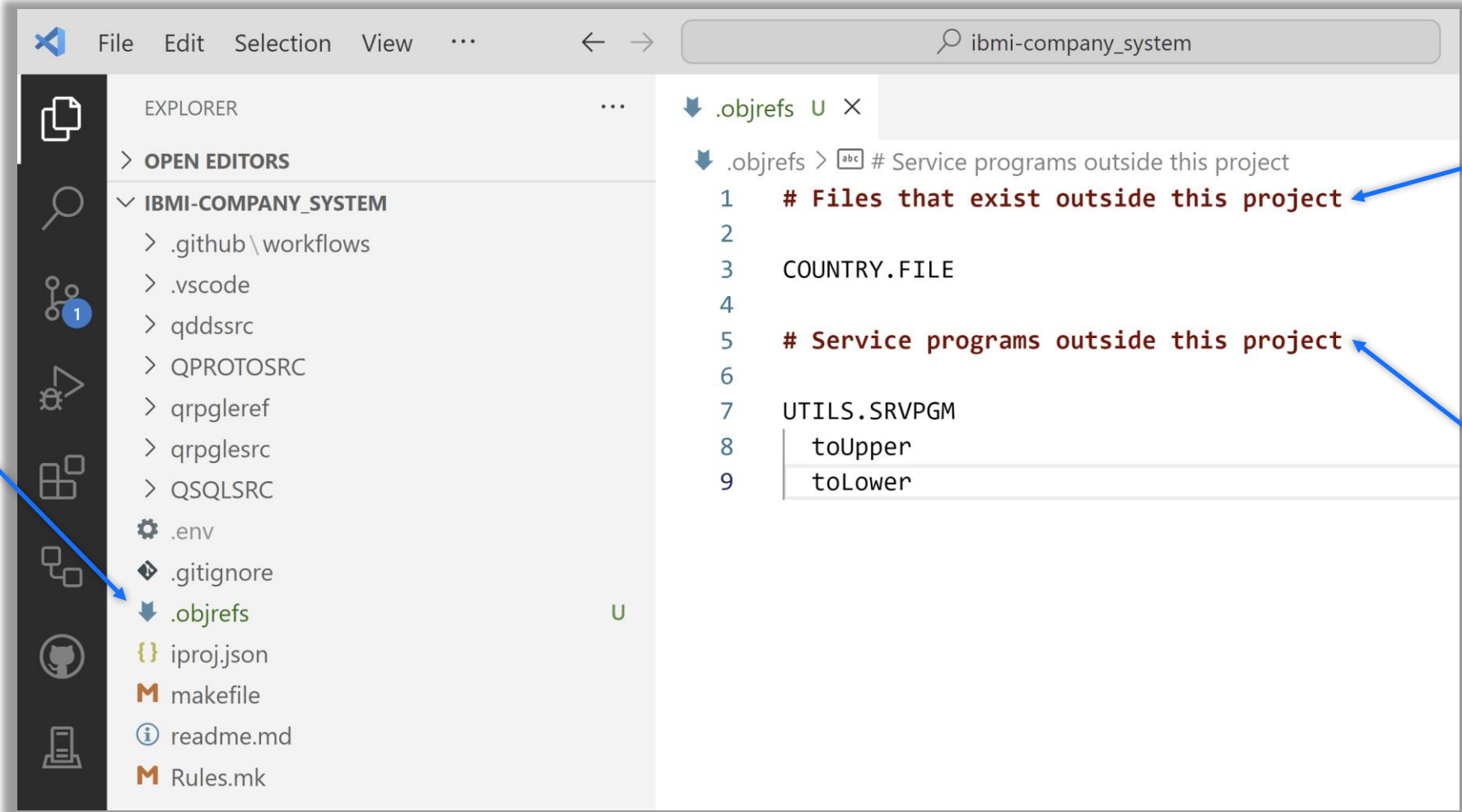
Source name	Resulting object	Note
abcd.rpgle	ABCD.MODULE	No change
ab_cd.pgm.rpgle	AB_CD.PGM	No change
thisIsASuperLongName.pgm.clle	TIASLN.PGM	First character plus following capitals
FetchUserData.cmd	FUD.CMD	All capitals from file name
ua_fetchUserData.sqlrpgle	UAFUD.MODULE	Prefix, followed by first post-prefix character plus following capitals
ART200D- Work_with_Article.DSPF	ART200D.FILE	Support for ibmi-bob file name

# Source Code Rules – Unresolved Objects

Source Orbit will complain about unresolved objects

```
no object found for reference 'COUNTRY'
```

Create file in project root



The screenshot shows the Visual Studio Code interface. On the left, the Explorer sidebar shows the project structure for 'ibmi-company\_system'. The file '.objrefs' is highlighted in the sidebar. In the center editor, the '.objrefs' file is open, showing a list of service programs and files. The content includes comments and references to files and service programs outside the project.

```
.objrefs U X
.objrefs > # Service programs outside this project
1 # Files that exist outside this project
2
3 COUNTRY.FILE
4
5 # Service programs outside this project
6
7 UTILS.SRVPGM
8   toUpper
9   toLower
```

List objects/source that are in another repository or already exist in a library

For service programs, list exports by indenting after reference



# Practical Use Cases

## Create New Pull Request...

## Open a pull request

The change you just made was written to a new branch named `fix/text_colour`. Create a pull request below to propose these changes. [Learn more about diff comparisons here.](#)

base: main

compare: fix/text\_colour

✓ Able to merge. These branches can be automatically merged.

Add a title

Update emps.dspf

Add a description

Write

Preview

H B I

A simple update to function key description text from blue to white.

Reviewers

No reviews

Assignees

No one—[assign yourself](#)

Labels

None yet

Projects

None yet

Milestone

No milestone

Development

Use [Closing keywords](#) in the description to automatically close issues

Helpful resources

[GitHub Community Guidelines](#)

1 commit

1 file changed

1 contributor

Commits on Nov 12, 2023

Update emps.dspf

worksofliam committed now

Verified

cac56e7

<>

# Trigger a Workflow...

## Update emps.dspf #20

Open worksofliam wants to merge 1 commit into `main` from `fix/text_colour`

Conversation 0

Commits 1

Checks 0

Files changed 1

worksofliam commented now Member

A simple update to function key description text from blue to white.

Update emps.dspf Verified ✗ cac56e7

Add more commits by pushing to the `fix/text_colour` branch on `IBM/ibmi-company_system`.

**Some checks were not successful** Hide all checks  
1 queued and 1 action required checks

**Source Orbit Impact Report / so-impact (pull\_request)** *Queued — Waiting to run this check...* Details

**DCO** Action required after 1s — DCO Details

**This branch has no conflicts with the base branch**  
Merging can be performed automatically.

Merge pull request

You can also [open this in GitHub Desktop](#) or view [command line instructions](#).

**GitHub Actions:** Speed up build times with [larger GitHub-hosted runners](#) ✕

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# Post a Comment...

Conversation 1

Commits 1

Checks 2


Files changed 1





worksofliam commented on Nov 12, 2023


Member ...


A simple update to function key description text from blue to white.






 Update emps.dspf

Verified  cac56e7




github-actions bot commented on Nov 12, 2023

...

 A new change report is available based on this PR being created.

[See summary here.](#)



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# View Impact Analysis....

← Back to pull request #20

✓ Update emps.dspf #8

Re-run all jobs

...

Summary

Jobs

✓ so-impact

Run details

Usage

Workflow file

Triggered via pull request 2 minutes ago

Status

Total duration

Artifacts

worksofliam opened #20 `fix/text_colour`

Success

18s

—

so-impact summary

...

Impact Analysis

Touched objects:

- `EMPS.FILE : qddssrc/emps.dspf`

EMPS.FILE

- `EMPS.FILE ( qddssrc/emps.dspf )`
  - `EMPLOYEES.PGM ( qrpglesrc/employees.pgm.sqlrpgle )`
    - `DEPTS.PGM ( qrpglesrc/depts.pgm.sqlrpgle )`

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Actions

Wiki

Security

Insights

Actions

All workflows

Impact analysis

Source Orbit Impact Report

Source Orbit Impact Report

Management

Caches

Deployments

Attestations

Source Orbit Impact Report

41 workflow runs

Event	Status	Branch	Actor
Refactor build and deploy commands	Success	feature_label_changes	18 hours ago 35s
Update nemp.dspf	Success	txc	2 days ago 30s
Source Orbit Impact Report	Failure	marcin-ogon:small_improveme...	last week Startup failure
Update emps.dspf	Success	lugdemoa	2 weeks ago 34s
Added setup instructions & object list, updated the Rules.mk	Failure	ravisankar-PIO:main	last month 22s
1st line on vscode	Failure	ravisankar-PIO:dev	2 months ago 31s
Change label and change action	Success	feature/ocean2024_demo	3 months ago 35s
Change the label and the colour	Success	feature/italy2	4 months ago 32s

# Demo

# Any Questions?



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