Unit and Integration testing
in modularized Julia package eco-systems

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Development Workflow

- Writing code
- Writing tests
- Git commit & git push
- Open pull request
- Automatic testing
CI Tests

- **Review required**
  New changes require approval from someone other than the last pusher.
  [Learn more about pull request reviews.](#)

  1 pending reviewer

- **No unresolved conversations**
  There aren't yet any conversations on this pull request.

- **Some checks were not successful**
  1 failing and 3 successful checks

  - **✗** Build and Deploy Documentation / build (pull_request)  Failing after 3m
  - **✓** formatter / formatter (pull_request)  Successful in 1m
  - **✓** [ci/gitlab/gitlab.com](#) — Pipeline passed with warnings on GitLab
  - **✓** [ci/gitlab/gitlab.com/run_integration_tests](#) — Pipeline passed on GitLab
CI Pipeline

Upstream
- unit-test
  - unit_tests nightly
  - generate_integration_tests
  - unit_tests_releases: [1.6]
  - unit_tests_releases: [1.7]
  - unit_tests_releases: [1.8]
  - unit_tests_releases: [1.9]

generate_integration_test
- generate_integration_tests

run_integration_test
- run_integration_tests

verify-unit-test-deps
- verify-unit-test-deps_julia1.9

Test
- IntegrationTestQED
- IntegrationTestQEDfields
- IntegrationTestQEDprocesses
CI Pipeline

Integration Tests

Unit Tests
CI Pipeline

Integration Tests

Unit Tests

Disclaimer

- Concepts are language independent
- Implementation is Julia specific
- Building up a CI is not a trivial job
CI Pipeline

Unit Tests

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Example QEDbase.jl
- 8 different CI jobs
- 200 LoC yaml configuration
- 2 CI tools (400 LoC + tests)
Unit Tests (for PkgA)
Dependencies in our Project

PkgB

using PkgA

New feature
Unit Tests

PkgA/src.jl

```julia
module PkgA
    foo(i) = i + 3
end
```

PkgA/test/runtest.jl

```julia
using PkgA
using Test
@testset "PkgA.jl" begin
    @test PkgA.foo(4) == 7
end
```
Unit Tests: New Feature

- Testing if the functions of PkgA still working after a code change.

**PkgA/src.jl**

```julia
module PkgA

foo(i, j) = i + j + 3

end
```

**PkgA/test/runtest.jl**

```julia
using PkgA
using Test

@testset "PkgA.jl" begin
    @test PkgA.foo(4, 2) == 9
end
```
Dependencies in our Project

- Distinguished between own dependencies and third party dependencies
- Own dependencies are developed by ourselves
- Third party dependencies developed by other developers
Unit Tests Steps

1. Clone PkgA with code changes
2. Set own dependencies to dev branches
3. Run tests
Integration Tests (for PkgA)
Integration Tests

→ Test if PkgB is still working if we change a function in PkgA.
→ The Unit test of PkgB is the integration test of PkgA.

PkgB/src.jl

```julia
module PkgB
using PkgA

bar() = PkgA.foo(3)
end
```

PkgB/test/runtest.jl

```julia
using PkgB
using Test

@testset "PkgB.jl" begin
    @test PkgB.bar() == 6
end
```
Integration Tests Steps

• Integration tests are executed in the CI pipeline of PkgA
Integration Tests Steps

• Integration tests are executed in the CI pipeline of PkgA

1. Determine which package use PkgA -> e.g. PkgB
2. Generate for each depending package own CI job
3. Each integration test job clones the dependent package
4. Use pull request version of PkgA as dependency
5. Execute tests of PkgB
QED.jl Graph

Use the dependency graph of the Project.toml
QED.jl Graph

Use the dependency graph of the Project.toml
QED.jl Graph

QED.jl

QEDprocesses.jl

QEDevents.jl

QEDfields.jl

QEDbase.jl

QEDfields.jl modified
QED.jl Graph

QED.jl

QEDfields.jl

QEDevents.jl

QEDprocesses.jl

QEDbase.jl

QEDfields.jl modified

Dependent packages:

Visited
- QEDbase.jl
QED.jl Graph

QED.jl

QEDprocesses.jl

QEDevents.jl

QEDfields.jl

QEDbase.jl

QEDfields.jl modified

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QEDfields.jl modified

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Visited
- QEDbase.jl
- QEDprocesses.jl
- QEDfields.jl
- QEDevents.jl
Integration Test of PkgA failed

Code Change → Pull Request → Unit Test ✓

PkgA

PkgB
Integration Test of PkgA failed: requires Change in PkgB

Code Change → Pull Request → Unit Test ✓ → Integration Test ×

PkgA

PkgB
Integration Test of PkgA failed: New Code in PkgB

Code Change ➔ Pull Request ➔ Unit Test ✓ ➔ Integration Test ×

PkgA

———

PkgB

Code Change ➔ Pull Request
Integration Test of PkgA failed: fix Unit Test of PkgB
Integration Test of PkgA failed: fix Unit Test of PkgB

Code Change → Pull Request → Unit Test ✓ → Integration Test ×

Set via commit message

Code Change → Pull Request → Unit Test ✓ → Integration Test ✓
Integration Test of PkgA failed: fix Integration test of PkgA

Code Change → Pull Request → Unit Test ✓ → Integration Test × → Integration Test ✓

Set via commit message

PkgA

PkgB

Set via commit message

Code Change → Pull Request → Unit Test ✓ → Integration Test ✓
Integration Test of PkgA failed: fix Integration test of PkgA

Code Change → Pull Request → Unit Test ✓ → Integration Test ✗ → Integration Test ✓ → Merge

Set via commit message

PkgA

PkgB

Code Change → Pull Request → Unit Test ✓ → Integration Test ✓
Finish PkgB Pull Request

Code Change -> Pull Request -> Unit Test ✓ -> Integration Test ✗ -> Integration Test ✓ -> Merge

Set via commit message

PkgA

Code Change -> Pull Request -> Unit Test ✓ -> Integration Test ✓ -> Unit Test

Set via commit message

PkgB

Code Change -> Pull Request -> Unit Test ✓ -> Integration Test ✓ -> Unit Test Depends ✗
Finish PkgB Pull Request

1. Code Change
2. Pull Request
3. Unit Test ✓
4. Integration Test ×
5. Integration Test ✓
6. Merge

- PkgA
- PkgB

Set via commit message

- Code Change
- Pull Request
- Unit Test ✓
- Integration Test ✓
- Integration Test ✓
- Unit Test Depends ×
Finish PkgB Pull Request

1. Code Change
2. Pull Request
3. Unit Test ✓
4. Integration Test ×
5. Integration Test ✓
6. Merge

PkgA

PkgB

Set via commit message

Code Change → Pull Request → Unit Test ✓ → Integration Test ✓ → Integration Test ✓ → Merge

Set via commit message

Code Change → Pull Request → Unit Test ✓ → Integration Test ✓ → Unit Test Depends ✓
Finish PkgB Pull Request

Code Change → Pull Request → Unit Test ✓ → Integration Test × → Integration Test ✓ → Merge

Set via commit message

PkgA

PkgB

Code Change → Pull Request → Unit Test ✓ → Integration Test ✓ → Unit Test Depends ✓ → Merge
Lessons Learned

- Start implementing (automatic) testing as early as possible
- Think about your development workflow
- Develop your CI pipeline incrementally
- Prepare yourself that your CI concept has gaps

**Update:** The algorithm for searching for package dependencies becomes a separate package: https://github.com/QEDjl-project/IntegrationTests.jl
QED Graph

- Avoid duplicated package
- Avoid cycles in the graph
- Restrict search depth
- Handle third party dependencies