Maintaining the Stability of Trilinos Dev

Stable vs Experimental Code

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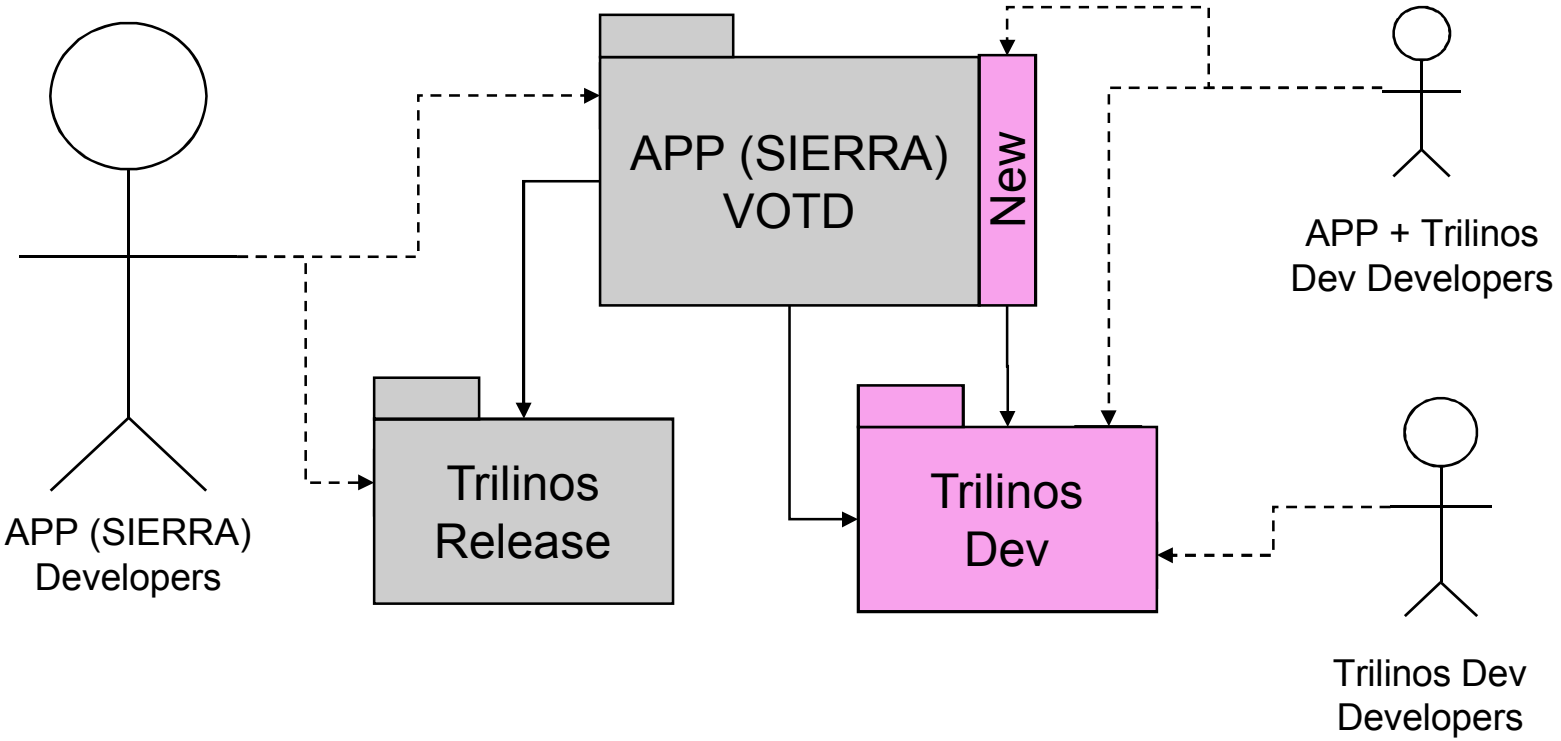
Motivations for Improving Stability of Trilinos Dev

- Support deep stacks of vertically integrated Trilinos packages with production APPs
  - Algorithm Integration Project
  - Many others ...
- Support tighter coupling and co-development with production APPs
  - SIERRA toolkit packages (STK_Mesh, STK_IO, ...)
  - Replace SIERRA framework code with Trilinos code (Teuchos::ParameterList, ...)
- Support more frequent, safer, higher quality, lower risk releases of Trilinos
- Improve overall development productivity and software quality

See:

Trilinos/doc/DevGuide/TrilinosSoftwareEngineeringImprovements.doc

Challenges of APP + Trilinos Release and Dev Integration



Problems

- APP developers sometimes break APP + Trilinos Dev New
- APP + Trilinos Dev inherits instability of APP and Trilinos development lines

Improvements

- Make Trilinos Dev backward compatible with Trilinos Release
  - => Minimize need to refactor and ifdef
- Improve stability of Trilinos Dev
- Improve stability of APP VOTD

SIERRA + Trilinos Integration: Opportunities and Challenges

- SIERRA Framework Developers would like to consider tighter integration with Trilinos:
  - Move new SIERRA toolkits packages into Trilinos
    - STK_Mesh
    - STK_IO?

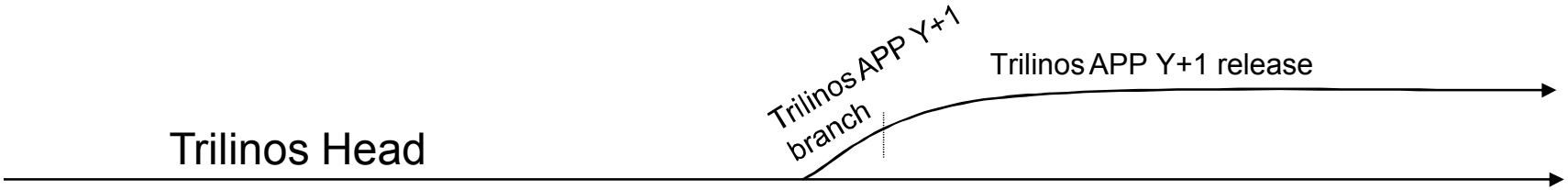
    => Make these available for rapid production and other projects
  - Develop the FEI through Trilinos instead of a SIERRA TPL

    => Allow FEI to be updated more frequently
  - Replace SIERRA code with Trilinos code:
    - Teuchos::ParameterList
    - Intrepid
    - Phalanx

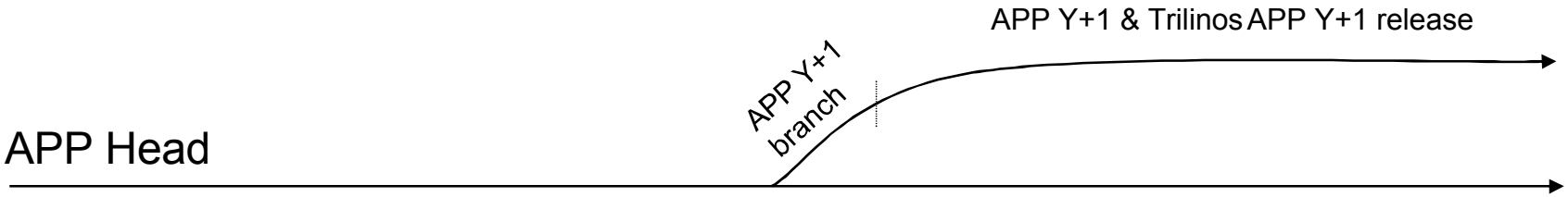
    => Reduce duplication and increase Trilinos impact

- Challenge: Tighter integration of APP and Trilinos does not fit well into current APP + Trilinos Release and Dev model!

APP developed only against Trilinos Dev



Future of SIERRA + Trilinos Integration?



Testing: APP VOTD + Trilinos Dev

Supported with continuous integration testing!

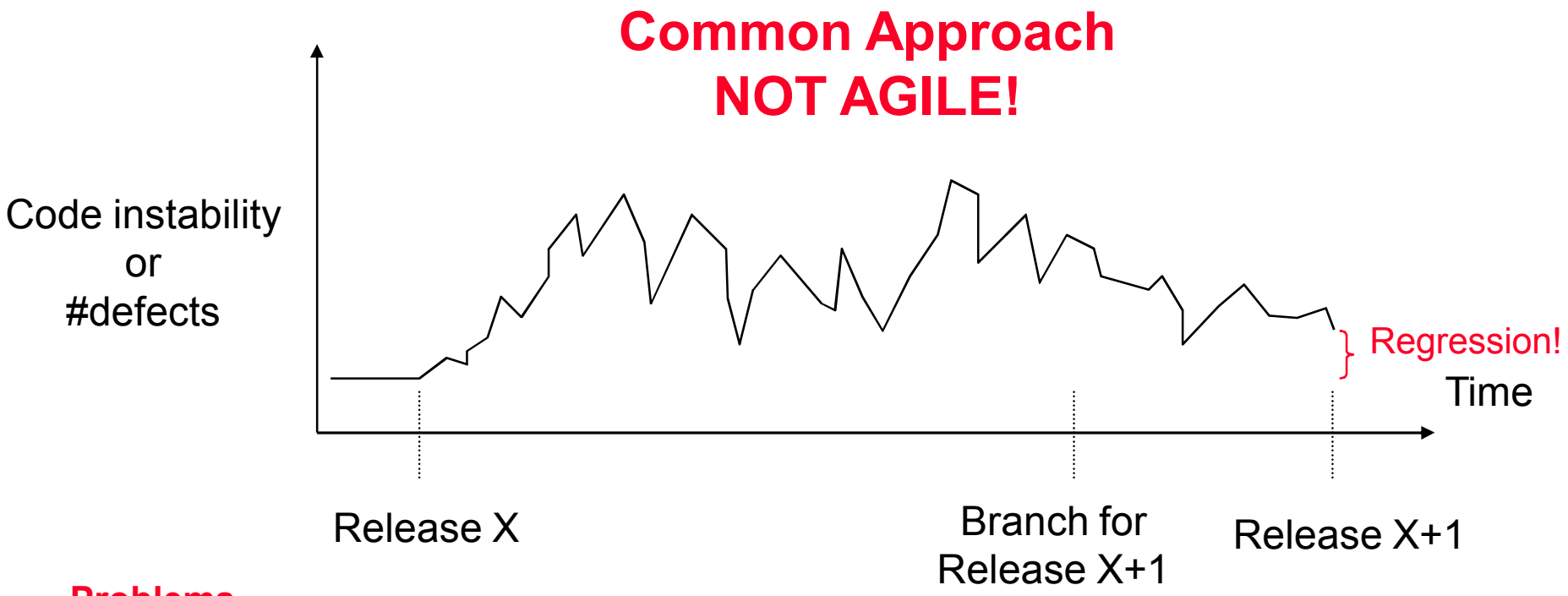
- All changes are tested in small batches
- Low probability of experiencing a regression
- Less computing resources for testing
- Regressions and flagged immediately by APP developers
- Can support tighter integration efforts
- Supports rapid development of new capability from top to bottom
- Requires Trilinos to be more stable
- Other issues arise as well

Lean/Agile Software Engineering Principles

- High quality software is developed in small increments and with sufficient testing in between sets of changes.
- High quality defect-free software is most effectively developed by not putting defects into the software in the first place (i.e. code reviews, pair programming etc.).
- High quality software is developed in short fixed-time iterations.
- Software should be delivered to real (or as real as we can make them) customers is short intervals.
- Ruthlessly remove duplication in all areas.
- Avoid points of synchronization. Allow people to work as independently as possible and have the system set up to automatically support this.
- Most mistakes that people make are due to a faulty process/system (W. Edwards Deming).
- Automation is needed to avoid mistakes and improve software quality.

References: http://www.cs.sandia.gov/~rabartl/readingList.html

Lean/Agile Methods: Development Stability

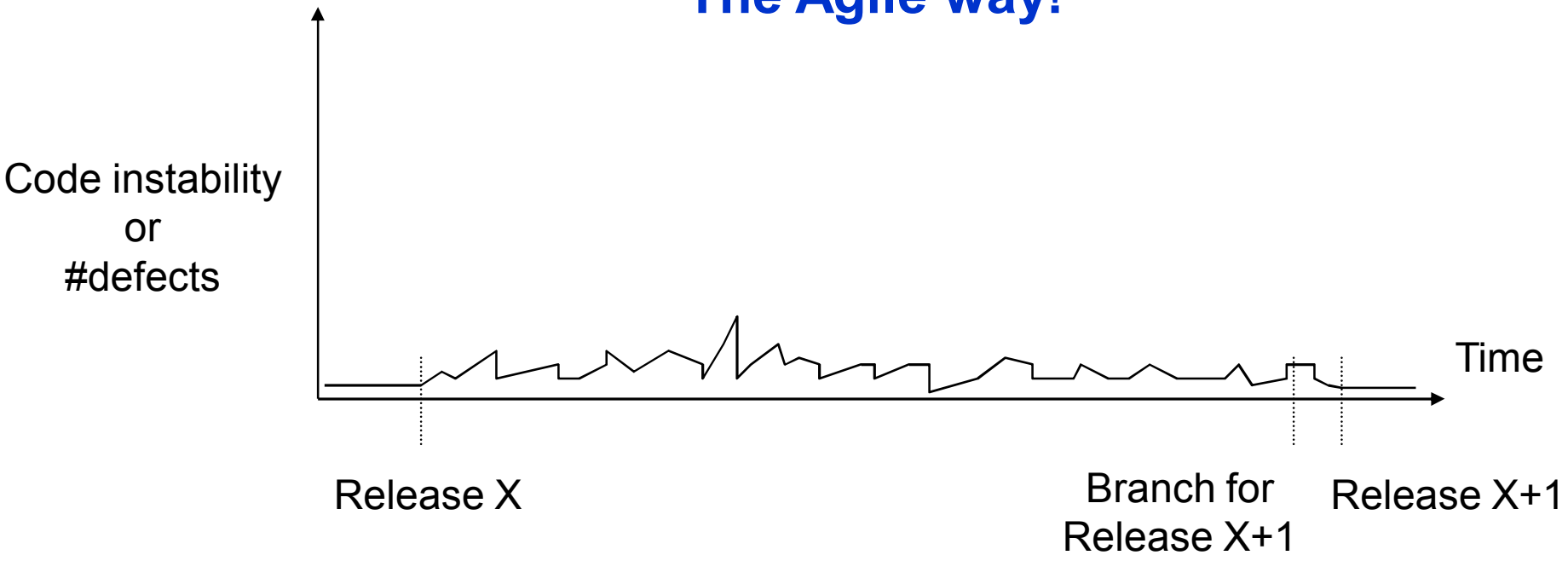


Problems

- Cost of fixing defects increases the longer they exist in the code
- Difficult to sustain development productivity
- Broken code begets broken code (i.e. broken window phenomenon)
- Long time between branch and release
  - Difficult to merge changes back into main development branch
  - Temptation to add “features” to the release branch before a release
- High risk of creating a regression

Lean/Agile Methods: Development Stability

The Agile way!



Advantages

- Defects are kept out of the code in the first place
- Code is kept in a near releasable state at all times
- Shorten time needed to put out a release
- Allow for more frequent releases
- Reduce risk of creating regressions
- Decrease overall development cost

Trilinos Framework ⇔ Package Responsibilities

- Analogy: United States of America
  - Federal Government vs State roles and responsibilities

- Trilinos Analogy
  - Services provided by the framework (federal) for the packages (states)
  - Other services packages (states) provide for themselves

  => This as been described as a one-way street! Framework => Packages

- What about package responsibilities to the framework and other packages?

- Analogy: United States of America
  - Federal government imposes standards and requirements on States
    - Example: States can not deny voter rights in local elections
  - States have to support other states and the federal government
    - Example: States have to pay taxes to support the federal government
    - Example: If Florida is invaded by Cuba, all states will provide soilders

- Trilinos package developers have extra responsibilities by being in Trilinos!

  => We need a two-way street! Framework ⇔ Packages

Trilinos "Stable" vs "Experimental" Code: Defined

- "Stable" Code and Tests:
  - "Stable" code meets one or more of the following criteria:
    - Represents an important capability being used by an existing customer in a release of Trilinos, or
    - Represents a new capability that the authors are willing to stand behind (as defined below) and is being targeted for the next release
  - "Stable" code/tests are expected to be kept working at all times. There should be little excuse for breaking "Stable" code on the primary development platform(s).
  - "Stable" code should be developed from the start and maintained to be highly portable.
  - "Stable" code should be maintained at the highest quality as defined by Lean/Agile software engineering principles.
- "Experimental" Code and Tests:
  - By definition, all remaining code that is not "Stable" code.
  - Represents fundamental research and may be developed with informal low-quality software practices.
  - Any code that has a direct and mandatory dependency on any "Experimental" code must also be considered to be "Experimental" code.
  - Developers should try to avoid depending on other "Experimental" code because it is likely to be unstable and break frequently.
  - "Experimental" code should be protected behind ifdefs with macos that must be defined in order to be built.

Trilinos "Stable" vs "Experimental" Code: Goals

- Allow crazy and impulsive algorithms research with "Experimental" Code
  - Conducted within Trilinos
  - Benefit from ready to use "Stable" building blocks
  - Take advantage of everything the Trilinos environment has to offer
- Maintaining "Stable" core allows:
  - Other "Experimental" research efforts can remain highly productive because their foundation is not constantly breaking
  - New requirements from "Stable" code needed to drive "Experimental" research code development can be rapidly developed and integrated in real time
- Partitioning off "Experimental" code from "Stable" code
  - Avoid the problem of a top-heavy overly strict environment which does not allow for rapid research investigations.
- By keeping "Stable" code in a near releasable state, we allow for fast and frequent releases of Trilinos.
- Summary: We can have our cake and eat it too!

Trilinos "Primary Stable" vs "Secondary Stable" Code

- Sub-categorizations of "stable" code based on dependencies:
  - "Primary Stable" code is "Stable" code that only depends on:
    - C, and C++ compilers
    - Fortran 77 compiler
    - BLAS and LAPACK
    - MPI
  - "Secondary Stable" code is "Stable" code with additional dependencies such as:
    - SWIG/Python (i.e. PyTrilinos)
    - Fortran 2003+ (i.e. ForTrilinos)
    - External direct sparse solvers like UMFPACK, SuperLU, etc. (i.e. Amesos adapters)
    - ...
- "Stable" code in one package can only depend on "Stable" code in other packages.
- "Stable" code should by default only build "Primary Stable" code.
- Enabling "Secondary Stable" code should require explicit configure-time options.

Synchronous Continuous Integration : Defined

"Synchronous Continuous Integration": Software is integrated and tested locally before it is checked in by performing the following in rapid succession:

- Do a VC update
- Rebuild all affected code
- Rerun the "precheckin" test suite
- If there are *any* failing tests
  - Fix the code, or
  - Investigate why the code fails, or
  - Do something else to make sure it is okay to check in.
  - Don't just check in broken code and/or broken tests!
- If all the affected code and tests build and pass
  - Quickly check in the changes using one atomic checkin

Asynchronous Continuous Integration : Defined

Asynchronous Continuous Integration": Software is integrated and tested on a CI server after it is checked in by performing the following:

- Developers do basic/incomplete testing (i.e. without doing full "synchronous continuous integration")
- Developers check in code
- Continuous integration (CI) server periodically runs:
  - Does VC update (on a fixed schedule or when changes are detected)
  - Does a full integration build and runs the integration test suite
- If the build or any tests fail
  - An email notification is sent out to some group of people alerting them

- Developers fix problems ASAP!

General Practices Related to "Stable" Code

- Stability and portability as the highest goals
- Maintained in a "done" (i.e. close-to-releasable) state
  - up-to-date tests, examples, documentation
- Compiled with high warning levels and treat warnings as errors
  - Portability of the software!
  - Many users want to compile their codes with this and Trilinos is a problem
- Backward compatibility (one major release or more) is a high priority
- Every Trilinos developer's responsibility to help maintain stability and integrity
- Built every night on a variety of different platforms & compilers
  - High priority on fixing broken builds first and then on fixing broken tests
- 100% passing test policy for all "Stable" code on our primary development platforms!
  - Primary development platforms include:
    - Linux + gcc ??? (high warning levels and warnings as errors)
    - Mac OSX + gcc ??? (lesser warning levels?)
- Goal of 100% passing tests on other auxiliary platforms as well
  - Efforts to fix failing builds and tests on auxiliary platforms will take place in an auxiliary development loop that runs behind the efforts on the primary development platforms
  - Examples of auxiliary platforms: Intel compilers, PGI compilers, IBM compilers, Pathscale compilers, SUN compilers, ...

General Practices Related to “Experimental ” Code

- Other Trilinos developers have little-to-no direct responsibility to maintain “Experimental” code
  - However, should still consider the impact their changes will have *before* they check in
  - Example: Use a script to automatically change the name in all source files

- Remove “Experimental” code segments and even entire files for releases

Promotion of “Experimental” Code to “Stable” Code

TBD

“Stable” vs “Experimental” Code: Continuous Integration

- “Primary Stable” code
  - => Use “synchronous continuous integration” before every checkin
    - Steps can be skipped based on developer discretion
  - => Provide driver tools to make this easy!

- “Secondary Stable” code
  - => Use “synchronous continuous integration” for any “Primary Stable” code
  - => Rely on “asynchronous continuous integration” for testing other “Secondary Stable” code
    - Respond to failed builds/tests ASAP!
  - => Or, build and test on Central Build Server to test affected “Secondary Stable” code before checkins

- “Experimental” code
  - => No pre-checkin procedure for “Experimental” code
  - => Use “synchronous continuous integration” for any “Primary Stable” code

Synchronous Continuous Integration Checkin Procedure

A) Start filling out the checkin checklist message in a temporary text file

B) Do a VC update to get all current changes

C) Configure Trilinos to enable all "Primary Stable" code that depends on your code:

- Without any "Secondary Stable" or "Experimental" code enabled
- Test serial + debug (-pedantic), and mpi + optimized (high warning levels and warnings as errors)

D) Rebuild and rerun the "pre-checkin" test suite (high working levels and warnings as errors)

- If there are *any* tests fail, fix the code, investigate why the tests are failing, etc ...
- DO NOT UNDER ANY CIRCUMSTANCE EVER CHECK IN CODE THAT DOES NOT BUILD!

E) Finish filling out the checkin checklist message (while rebuilt/retest is running).

F) If the rebuild/restest passes and (i.e. all tests pass, 0 test fail), then:

- Quickly do a 'cvs –nq update –dP' to see if there are any new changes
  - If you see changes that are worrisome, go back to step 'B' and repeat.
- Otherwise, go ahead and check in
  - Do checkin in one global atomic checkin using the checkin with 'cvs commit –F checkin_message'.

G) Otherwise, abort the checkin and then do either:

- Backup your changes to keep them safe (e.g. using 'tar –czvf Trilinos.date.tar.gz Trilinos' or something and 'scp' the file to another machine).
- Or, Try to resolve the problems and get the code to build and get all of the tests to pass.

NOTE #1: Any and all of the above steps can be bypassed by the developer

NOTE #2: A tool (Cmake-based) must be available to perform all of the above steps

NOTE #3: The fallback is to rely on "asynchronous continuous integration"

NOTE #4: Changes that break down-stream code are immediately caught *before* checkin

“Stable” vs “Experimental” Code: Daily Integration Testing

- Testing of “Primary Stable” Code
  - Tested on primary testing servers
  - Tested on other auxiliary platforms (as many as we can get)
  - Results reported to “Primary Stable” code dashboard section
  - Tested as part of APP + Trilinos Integration testing (i.e. Charon, SIERRA, Alegra, ...)
- Testing of “Secondary Stable” Code
  - All “Secondary Stable” code with all dependencies tested on a central testing server
  - Targeted subsets of “Secondary Stable” code tested on targeted auxiliary platforms
  - Tested as part of APP + Trilinos Integration testing (i.e. Charon, SIERRA, Alegra, ...)
- Nightly testing of “Experimental” code
  - Performed entirely on package teams computing resources
  - Takes advantage of easy-to-create testing drivers (i.e. Cmake/CTest)
  - Results posted to central dashboard separate from “Stable” code results
  - Tested as part of APP + Trilinos Integration research testing (i.e. Charon, SIERRA, Alegra, ...)

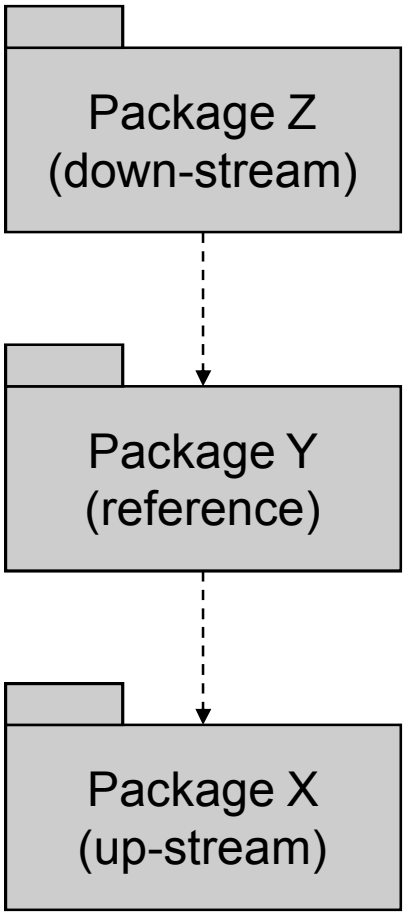
“Stable” Code: 100% Passing Test Policy

- All “Stable” code should have 100% passing tests 100% of the time on the primary development platforms as the norm instead of the exception.

- Achieving 100% passing tests on auxiliary development platforms is also a priority but is done in a secondary development loop.

- A failing test on any testing platform should be addressed and be made to pass or be disabled using the following algorithm:
  - Fix the test in the strongest way possible
  - Or, loosen the “strength” of test to get it pass on that specific platform (i.e. by loosing a platform-specific tolerance)
  - Or, disable the test and submit a new item to the sprint or product backlog (e.g. Bugzilla bug report) so that it can be prioritized and fixed later
  - Or, remove the test and all of the associated code related to it

Motivations for a 100% Passing Test Policy for "Stable" Code



Why is 100% passing tests important?

- Package Y (reference package):
  - "Broken Window" Phenomenon
    => One broken test begets others
  - Zero (0) is singularly different that 1 or X failing tests
    => People take notice of "all passed" vs "failed"
  - 'M' failing tests is not much different that 'N' failing tests
  - 100% passing tests clear measure of the code health
  - 100% passing test suite is unbiased criteria for code checkins
  - 100% passing test suite is an unbiased measure for if any code has been broken after a checkin
  - Code coverage less meaningful when there are failing tests
- Package X (up-stream package being used by Package Y)
  - 100% passing test suite for Package Z provides a clear means to determine if changes in Package X break anything.
- Package Z (down-stream package that uses Package Y)
  - 100% passing test suite for Package Y gives Package Z developers confidence that they can depend on and trust the code in Package Y.
- Bottom Line:
  - 100% passing test suites help to build trust between developers
  - 100% passing test suites help to avoid unnecessary communication
  - 100% passing test suites help to avoid synchronization points

Specific Areas where Trilinos Needs Improvements

- Reduce compilation times to speed rebuilds
  - Take all standard C++ headers out of Package_ConfigDefs.hpp and use only where needed
  - Make greater use of forward class declarations
  - Take greater advantage of the pImpl idiom for many more classes
  - Use explicit instantiation for as much templated C++ code as we can (i.e. templated on Scalar)
  - Exploit shared libraries (with Cmake build system)
- Create different categories of tests that get built and run for different purposes:
  - “Unit” tests (i.e. TDD tests)
  - “Basic integration” tests (i.e. pre-checkin tests)
  - “Regression” tests (i.e. nightly tests)
  - “Performance” tests
  - “Scalability” tests
  - “User-like” tests (i.e. backward compatibility tests)
- Improve installation testing:
  - Configure, build and install Trilinos, then reconfigure Trilinos tests and examples to build against installed Trilinos headers
- Improve the exception safety of our C++ codes (See Item 29 “Strive for exception-safe code” in “Effective C++ 3rd Edition”)
- Improve backward compatibility (tools, processes, policies, testing, ...)
- Nightly testing on more platforms (i.e. SCICO LAN Linux compilers, Sun, ...)
- Improve release process

Trilinos Release Process Improvements

- Things to do before the branch for the release is created:
  - Implement all functionality for the upcoming release
  - Keep all documentation and examples for “Stable” code up to date after each change
  - Put all “Experimental” code behind ifdefs so that it will not be included in the next release.
  - The “Stable” code for each package should almost always be in a releasable state
    => No reason to branch or tag individual packages separately before release branch creation
  - “Stable” code produces clean tests on all of the test platforms well before the release date
  - Perform at least one round of ports and acceptance tests with Trilinos Dev against all major customer platforms and applications a few weeks before the targeted release branch date.
- Things to do after the branch for the release is created:
  - Run automated scripts to automatically strip out all “Experimental” code and tests (This removes a lot of the need for complex tarball logic).
  - No changes are made to the branch except what are absolutely necessary to address serious defects.
  - Do (what should be) a final round of ports and acceptance tests against all major customer platforms and applications.
    - Resolve any new problems that have come up since the previous round of ports and tests conducted a few weeks prior. (Experience with SIERRA + Trilinos Integration shows that very few new issues come up.)
  - Change the version numbers inside of Trilinos. (NOTE: We need a more automated and uniform way of updating version numbers.)
  - Create the final tag.
  - Release the code.

Summary

- Partitioning of “Stable” and “Experimental” Code:
  - “Stable” Code and Tests:
    - Represents an important capability being used by an existing customer
    - Expected to be kept working at all times
  - “Experimental” Code and Tests:
    - All remaining code that is not “Stable” code
    - Represent fundamental research with informal low-quality software practices
- Goals for “Stable” and “Experimental” Code partitioning:
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  - Maintaining “Stable” core allows:
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