Sustainable Software Practices in Developing MATLAB

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MathWorks as Producer and Consumer of Scientific Software

- MATLAB is a technical computing environment providing scientific software to our customers and also a platform for development of scientific software

- Many MathWorks products also sit on top of third-party scientific software libraries
  - BLAS, LAPACK, FFTW, UMFPACK, HSL_MA57, … and many more

I'll talk today about ways we've addressed sustainability challenges in developing and in using scientific software

Disclaimer: Following are my opinions and do not necessarily reflect those of MathWorks

Sustainability is our Business

- MathWorks around since 1984
  - MATLAB, even longer---late 1970s
  - ~5000 employees, ~55--60% are in Development
- Not everything is MATLAB…
  - MathWorks makes *a lot* of products---around 123 in total
  - Almost all of them require MATLAB
- Many customers have suites of MATLAB code/Simulink models
  - We need good software practices to build software serving internal and external customers alike

Company Decisions that have helped Sustainability

- Conversion to C
  - First MATLAB that shipped was PC-MATLAB implemented in C
- The Quality Initiative
  - Natural expression of Core Values, particularly Continuous Improvement
- Foundational Expression of QI: Fixed Time between releases
  - Since 2004, MATLAB (and all products) have been released roughly every six months
  - We have a well-defined release cycle
    - Active Dev is 8 iterations ~ 26 weeks with Freeze milestones
    - End-game ~ 3 months

The Quality Initiative

- Phased approach to improving our software
  - Focus on defect reduction, tracking, reporting
  - Consider sources of bugs in all phases of software lifecycle
  - *With emphasis on process improvement to eliminate defects and their sources*
- Targeted metrics
  - Bugs/Dev
  - Categorized bugs ← emphasis on the most severe bugs
  - Compiler warning reduction
- Began in earnest roughly ***20 years in***

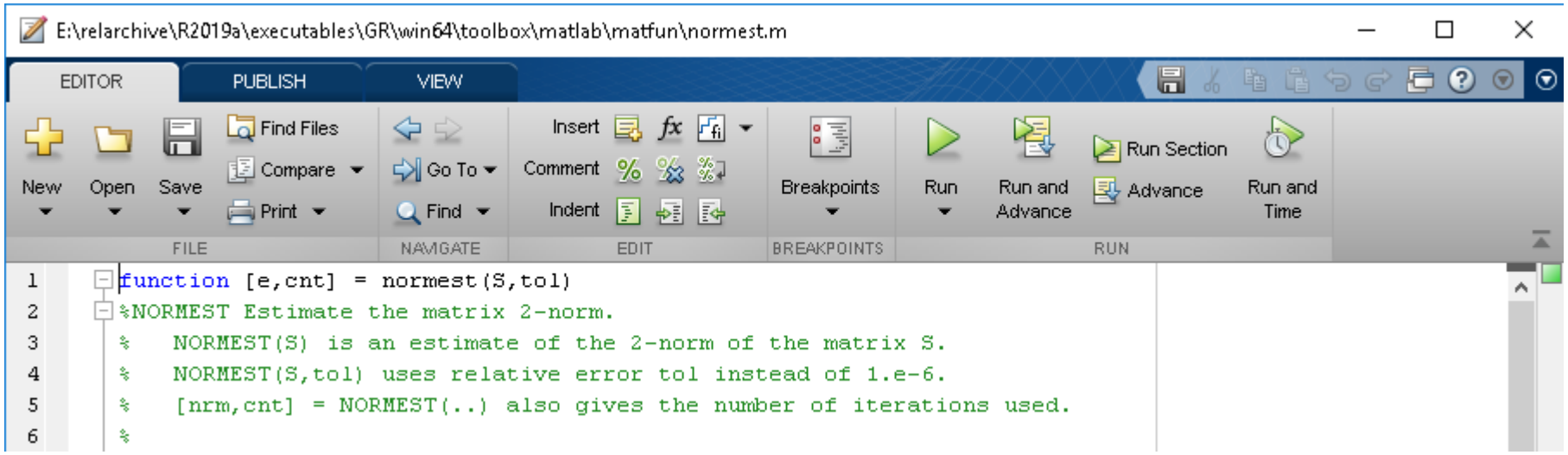
Testing and Integration

- Code organized into clusters in a system called BaT (Build and Test)
  - Clusters run tests charted to file changes for every submission; rejected if failures
  - Build and test code on all platforms (with some processor variants)
  - Continuous integration up the chain into main
- Testing occurs as part of build and as part of test
  - pkgtests and unittests built/executed with C++ modules
  - MATLAB Unit tests run during Test phase
  - Performance regression tests run 3 times weekly
- Company wide bashes are held
  - Defect reporting/enhancement requests rewarded!

Implementation strategies

- Define or adopt a coding standard and use tooling to enforce it
  - Minimally, compile at the highest warning level you can and at least consider lint
  - Lots of choices (C++ Core Guidelines, Google, C++ Coding Standards book)
  - Also, use standard libraries and stay off the bleeding edge

- MATLAB includes a Code Analyzer that automatically runs in the Editor



Light's green, code's clean

Refining Designs

- Bugs introduced at ***design time*** are the most expensive to eliminate

- Codified our software design process
  - Templates provided, revisited, and revised to make sure that they are still serving us
  - New hires are trained within the first 6—8 weeks
  - Local teams empowered to influence the process and templates
  - Codified how we do design review
  - Every customer visible MATLAB API goes through extensive design review

- Effect: Simpler designs with less surface area
  - True for both C++ and MATLAB APIs
  - Mileage varies across products

Managing Complexity and Adding Value with Layers of APIs

- Some APIs offered in MATLAB language (as .m)
- Which then use builtins from some shared library
- Which may depend on another shared library with almost all of the MathWorks-ish dependencies stripped out
  - Can be used by other products in a variety of ways
- Which then may depend on some 3rd party library

- At every level, expose only what is necessary

- Examples
  - `fft, decomposition, rand`

Speaking of third party libraries…

Questions we ask of Software we use in MATLAB

- Doc? Is it comprehensive and understandable?
- Test? Does any exist?
- Build? make, Cmake, autotools?
- Who do we run to with problems? Can we track resolution of our problems?
- Do you run on our supported platforms (Win, Linux, Mac)?
- How do you manage
  - Memory
  - Errors
  - Threads
  - Globals
  - And how much of that can we control and how?

Questions we ask of Software we use in MATLAB (continued)

- Under what circumstances are you reproducible?
- Numerically, what guarantees do you give?
- What about nonfinite/subnormal handling?
- How about recursion?
- What about messages you might want to dump to stdout? Can we suppress that easily?
- What are your dependencies and do we have conflicts?
- What about the license? Can we redistribute? Can we modify the code?

Before we go, a word about Backwards Compatibility

Keep the old code running---Backwards Compatibility

- Almost never throw anything away
  - Leverage "Discourage Use" process through doc and tooling
  - Keep around former code paths as undocumented package functions
    - Continue to test them, to some extent
  - Our big customers standardize on releases and don't move often (maybe every 3—6 years)

- Reproducibility
  - Guarantee run-to-run reproducibility under very strict circumstances
    - Same OS
    - Same MATLAB version
    - Same number of threads
    - Same inputs
  - Otherwise, it's a bug

Wrap Up

- Leverage build and test for continuous integration
- Track bugs, squash them, and report to your customers
- Adhere to standards, but stay away from the bleeding edge
- Spend time on design to design out bugs

- Observation: This wanted to be a talk about Technical Approaches but possibly turned out to be more cultural…

Thank you!