Quick! Drop Your VI Execution Time!

General-purpose techniques to speed up your VIs

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Before we get started

All of my presentations (including this one) are available at:

dnatt.org

(slides, demos, and links to video recordings)

This presentation's link: https://bit.ly/slowvis

Download link for ZoomIt

Outline

- Why I’m talking about this stuff
- Stuff I’m not going to talk about
- Stuff I’m going to talk about
- **Real-world** demos that show the stuff I talked about

Why am I giving this presentation?

- About once a month, somebody comes to me with a slow VI and asks me to make it run faster.
- These slow VIs reside in a wide variety of LabVIEW applications.
  - …but are usually of the type “do something with a big chunk of data”.
- Over the years I have accumulated a toolbox of **simple**, **general-purpose** techniques for improving VI execution time.
- I am sharing those techniques with you today.

Stuff I'm **not** going to talk about

- Desktop Execution Trace Toolkit
- Show Buffer Allocations
- Profile Buffer Allocations
  - The coolest LabVIEW feature you've never heard of
- Benchmarking techniques
  - http://bit.ly/brainlesslabview
- How the LabVIEW compiler works
  - Introduction to the LabVIEW Compiler
  - LabVIEW Compiler Under the Hood
- Real-Time/FPGA

Stuff I'm going to talk about

- **VI Profiler**
  - The good, the bad, and the ugly
- VI Settings
  - Enabled debugging, Priority, Inlining, etc.
- Parallel For Loops
- Programming Patterns for Performance
- Sets and Maps

- Illustrative **real-world** demos

Disclaimer

- There are times when we have to do **silly things** to eke out more performance from our VIs.
- If code readability and maintainability is our #1 goal, we shouldn't do these things.
- If code performance is our #1 goal, we may have to.
- Items marked as "!" in this presentation denote these situations.

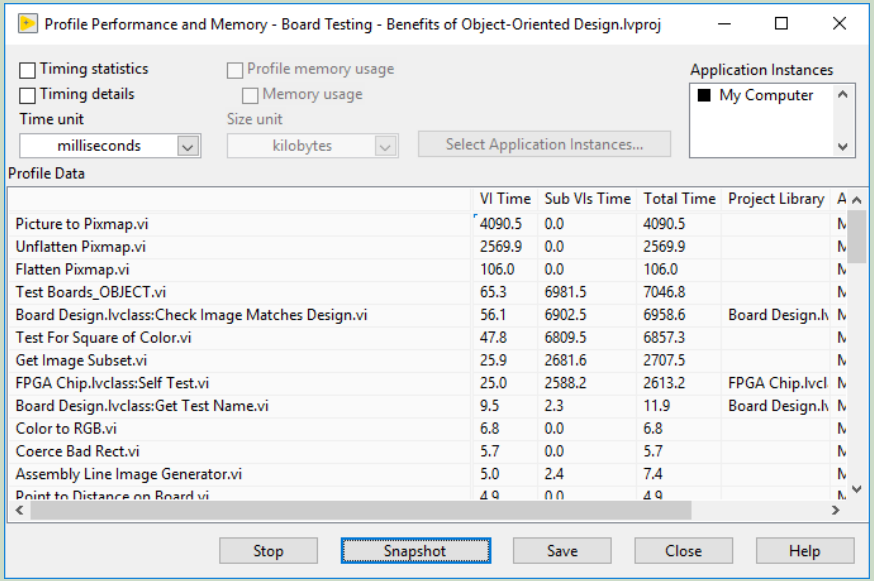
- *"Make it work, make it right, make it fast."* – Kent Beck

  ...then make sure it still works.

VI Profiler

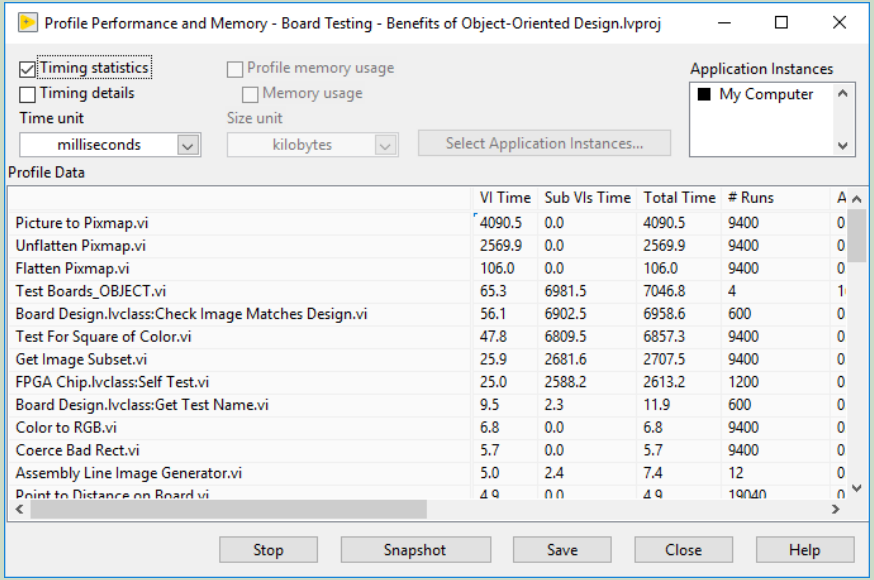
VI Profiler

- Official name: “Profile Performance and Memory”
- *Tools > Profile > Performance and Memory*
- Has been around forever
- Gives information on execution time of VIs, along with optional info on memory usage



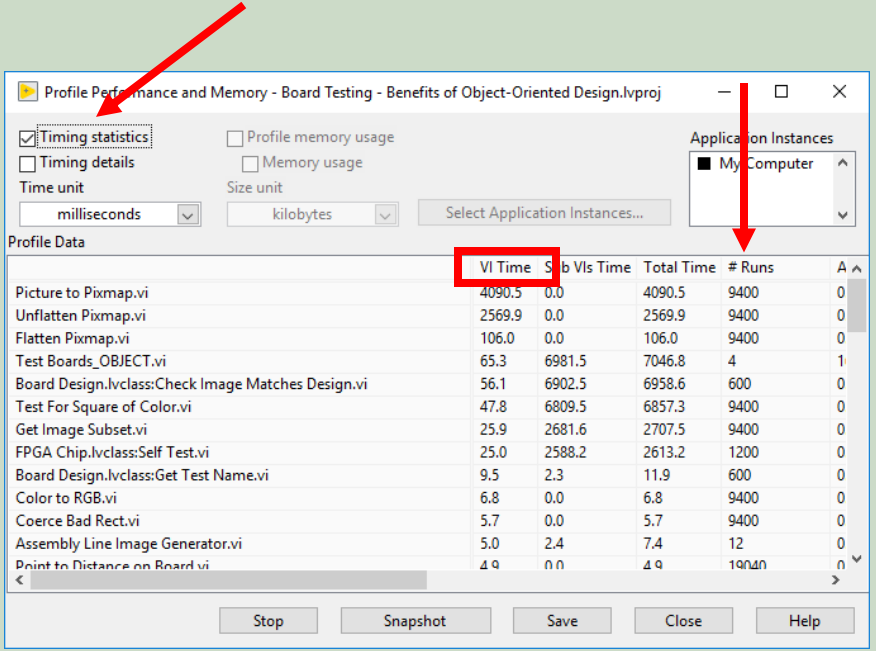
VI Profiler – Simple Usage Procedure

1. Launch *Tools > Profile > Performance and Memory*
2. Check ‘Timing statistics’
3. Click *Start*
4. Run your code
5. Click *Snapshot*
6. Interpret Results



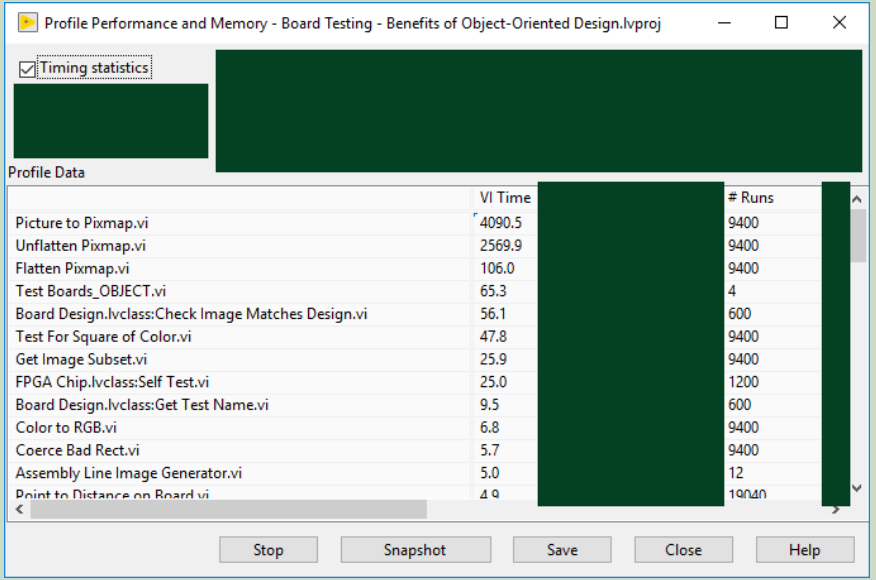
VI Profiler – The Good

- **Very low barrier to entry**
- **Very easy to interpret results**
- Automatically sorts by VI Time
  - Sortable columns (but VI Time is almost always what I want to sort by)
- Enabling “Timing statistics” shows the “# Runs” column
  - Useful when deciding if inlining makes sense



VI Profiler – The Bad

- C-based feature
  - No LabVIEW-based extensions ☹
- Inline VIs do not show up
- Lots of mostly distracting info

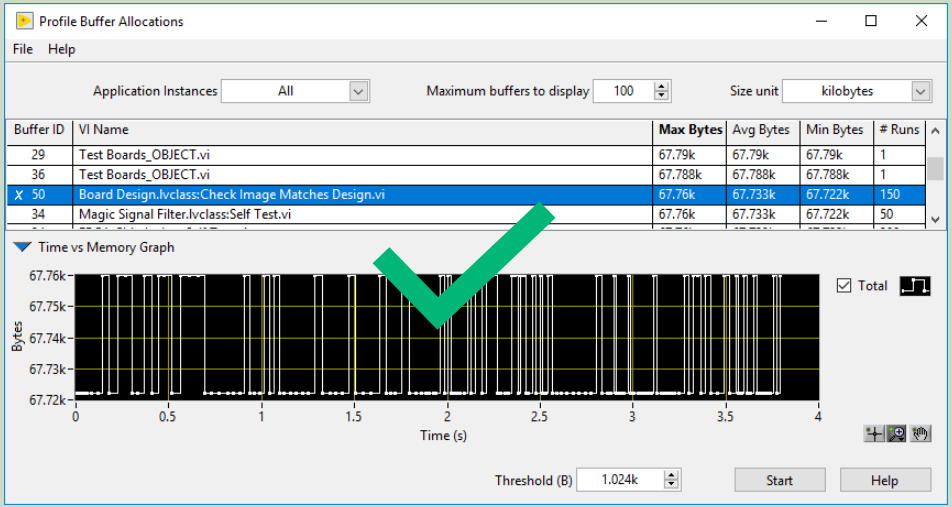


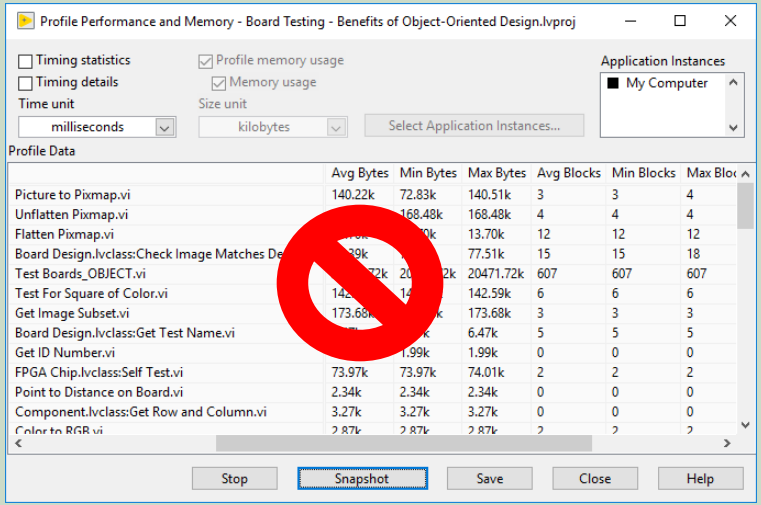
VI Profiler – The Ugly

- Absolute time values are often **unexpected**
  - A VI that takes 10 seconds to run might show ‘VI Time’ values that sum to something completely different
  - One reason is that parallel operations are summed
    - A VI with two parallel loops that run within 1 second will show a profile time of 2 seconds
  - Another reason is because “LabVIEW-friendly sleep time” is not included
    - LabVIEW-friendly sleep: Wait functions, Event Structure, TCP, Queues
    - LabVIEW un-friendly sleep: OS-level (e.g. driver functions, DLL calls)
- Use VI Time value as a **relative metric**
  - Focus on the big numbers
  - Ignore the small numbers
  - You’re making progress if the big numbers get smaller and your VI execution time decreases

VI Profiler – What about Memory?

- The VI Profiler gives memory usage info on a **per-VI** basis
- **Profile Buffer Allocations** gives memory usage info on a **per-node** basis
  - (most of the time)





VI Profiler – More Granular Information

- Use **Edit > Create SubVI** to create temporary subVIs of suspect code (!)
  - Workaround for the lack of per-node execution time
- These subVIs will appear in the VI Profiler to help you narrow down issues

Profile Data

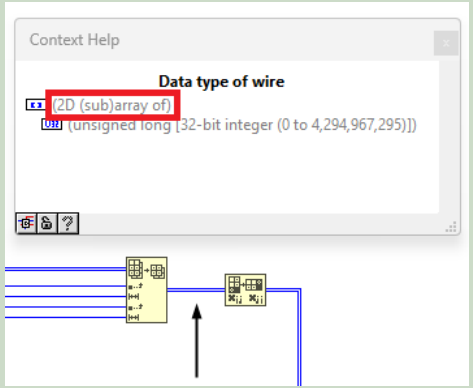
	VI Time	Sub VIs Time	Total Time	# Runs
Waveform Time to Date Time String.vi	8014.5	0.0	8014.5	2500000
WriteToCSV.vi	5719.9	8014.5	13734.4	1

VS.

Profile Data

	VI Time	Sub VIs Time	Total Time	# Runs
Waveform Time to Date Time String.vi	8160.7	0.0	8160.7	2500000
Untitled 3 (SubVI)	4803.7	8160.7	12964.4	25
Untitled 1 (SubVI)	1374.8	0.0	1374.8	25
Untitled 2 (SubVI)	353.3	0.0	353.3	25
WriteToCSV.vi	194.5	14692.6	14887.1	1

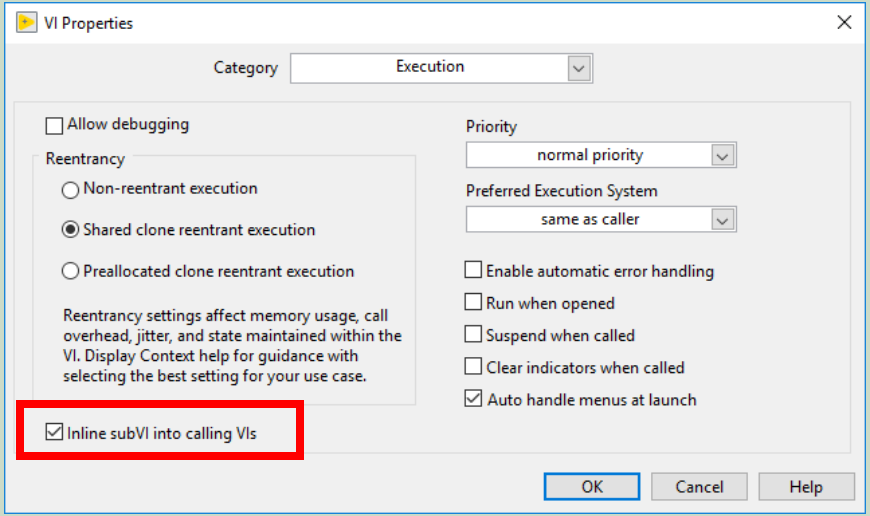
Watch out for sub-arrays!



VI Settings

VI Settings

- **Inline VIs** that run a lot
  - Removes subVI overhead
  - Opens up potential optimizations when subVI boundaries are removed
    - Dead code elimination, Constant folding, etc.
- Don't worry about *Priority* or *Preferred Execution System*
- Save copies of vi.lib VIs to inline and optimize them (!)
  - Give them a different icon
  - Document the caller VI



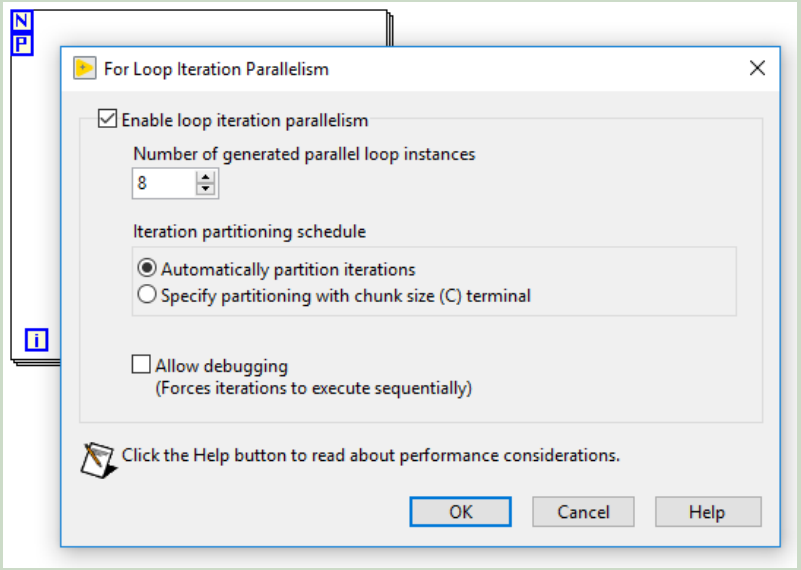
VI Settings – When to apply them

- Inline VIs don't show up in the VI Profiler ☹
- Mark as inline after you're done profiling to get that last speed boost
- **Turn off debugging** on non-inline VIs after you're done profiling
  - (Debugging setting doesn't matter for non-debug outputs like EXEs and PPLs)

Parallel For Loops

Parallel For Loops

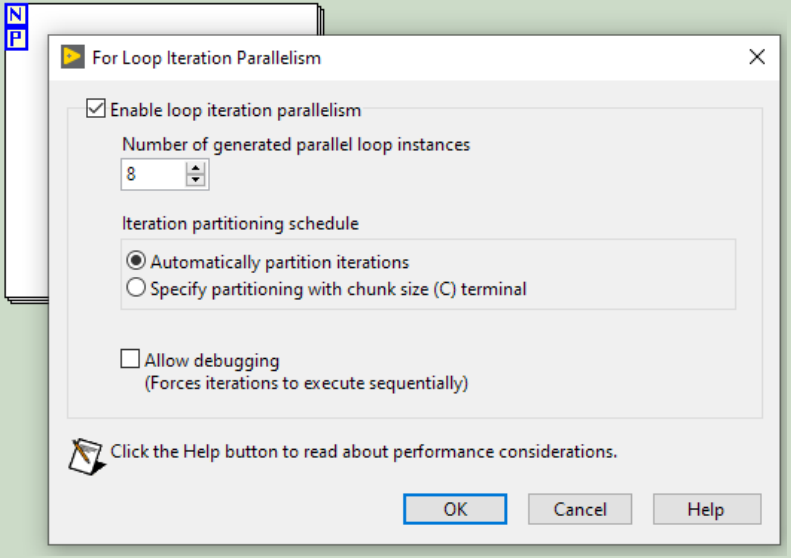
- **Easiest** way to speed up existing For Loop code
  - The **first thing** I look for when I get a “slow VI”
- Parallelize the outer-most loop
  - Don’t parallelize nested loops
    - (with rare exception)
- VI will become broken if the loop cannot be parallelized



Parallel For Loops – How many loop instances?

- Don’t wire ‘P’ (see guidance below)
- ‘Number of generated parallel loop instances’ specifies the **maximum** number of parallel instances the LabVIEW compiler will generate
- “Just use 8”
  - (unless you know for sure you’ll need more)

-1: Use value in dialog
0 (unwired): Use the most available logical processors (up to configured value)
1 or greater: Use wired value (up to configured value)



Programming Patterns for Performance

Programming Patterns for Performance part 1

- Control and Indicator terminals always on the top-level diagram (of subVIs)
- Remove decision points from diagrams if you can
  - Like error case structures
- Basic string primitives vs. “newer” stuff like JSON (!)
- Consolidate class accessors in tight loops (!)
  - …or get the data out of classes before the tight loop starts (!)

Programming Patterns for Performance part 2

- Modifying cluster and array elements
  - If you need the original element value, use In Place Element Structure
  - If you don’t, use Bundle By Name or Replace Array Element
    - NEVER delete/index from array then rebuild
- If you see multiple branches of a (large) array wire, you *may* need a DVR
  - Or if you have the large array in a promiscuous functional global variable
  - When refactoring for performance, DVRs should be a last resort

Sets and Maps

Good/Gooder/Better/Betterer/Best/Bester

- Good – Search 1D Array
  - Gooder – Search Unsorted 1D Array.vim
- Better – Custom binary search
  - Betterer – Search Sorted 1D Array.vim
- Best – Variant Attributes
- Bester – **Sets and Maps**

Performance Benefits of Maps

Maps **eliminate the data type conversion** required to store variant attribute keys as strings and values as variants. Plus, they're an actual API and not a hack. ☺

Variant attributes are comparably performant **if** your keys are already strings and your values are already variants. (!)

If you find yourself dropping a Search 1D Array or a Build Array, ask yourself if you should be using Sets or Maps instead.

See my **All About Collection Data Types** presentation for more info:
https://bit.ly/dnattcollections

Real-world Demos

Thanks for attending!

Remember, you can download the presentation here:

bit.ly/slowvis

Parallelize your loops. Inline your subVIs. Profile your VIs. Write fast code.

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