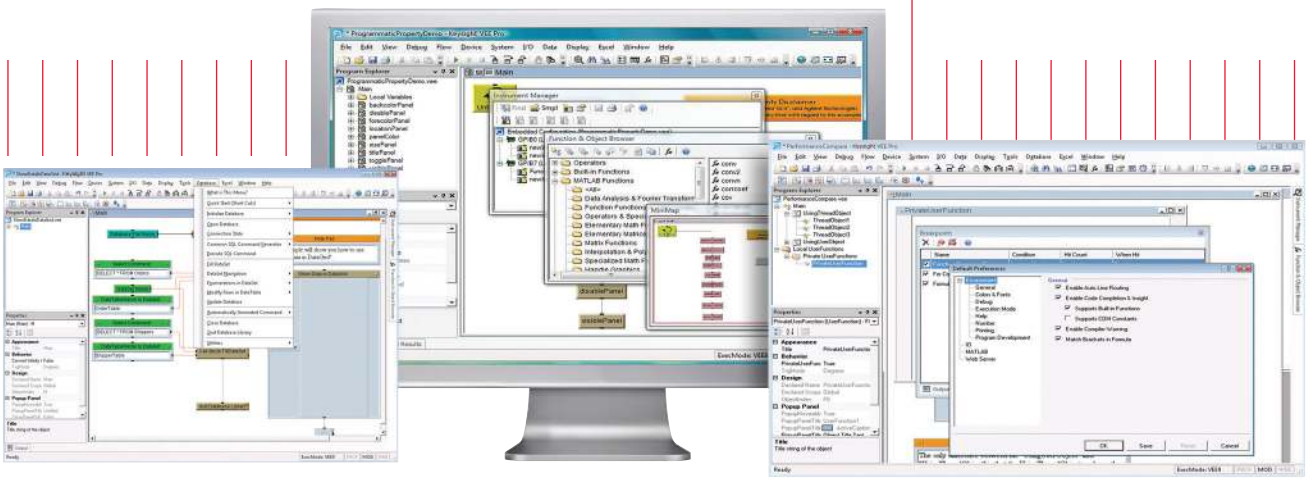
Keysight Technologies
Multithreading in Keysight VEE 9.0

White Paper



KEYSIGHT TECHNOLOGIES

Multithreading in Keysight VEE 9.0

In today's technological environment where test and measurement requirements become increasingly stringent, the need for enhanced software performance is critical. One proven method to address this need is through the use of multithreading, which has its roots in parallel processing or parallel computing.

Since 1958, when parallelism calculations are first proposed in computers*, parallel computing is gaining more popularity with computers now taking advantage of multiprocessor technology that has been developed around 50 years ago. Usage of parallelism in a single process is called multithreading where it is a concept of problem solving by dividing a task into several threads that can be executed in parallel rather than in a linear fashion. Speed of a single process running on a single processor, is restricted by the speed of light. Therefore, to increase the speed of that process further, it has to be broken down into threads and execute it with multiple processors in parallel.

*IBM employees John Cocke and Daniel Slotnick first proposed parallelism in computers. (Cocke, J.; Slotnick, D.S., (1958) 'Use of parallelism in numerical calculations', Research memorandum; No. RC-55, Retrieved October 10, 2008 from http://www.computerhistory.org/collections/accession/102635119)

Fast forward to the year 2008, the Keysight Technologies, Inc. VEE 9.0, a well-known visual and dataflow programming software, now allows users the option of using multithreading in their solutions. Combined with intuitive, graphical drag and drop programming, multithreading is made easier and less time-consuming.

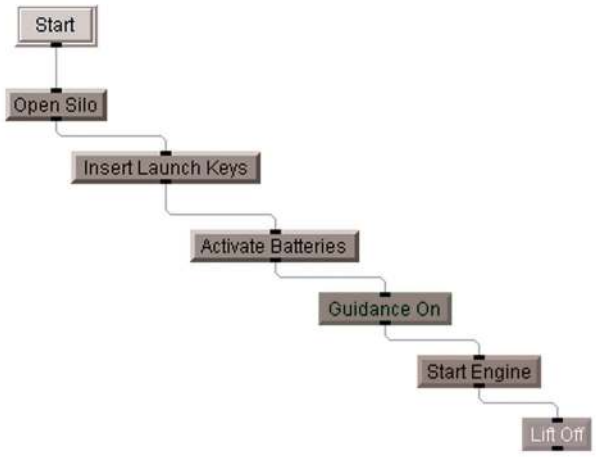


Figure 1: Sequential programming in Keysight VEE

Next, the user needs to group sub-tasks into groups of code, and identify independent codes that do not have any dependencies. Let's say there are two dependencies in the missile launch example, 'Lift Off' cannot be started unless 'Start Engine' is completed and 'Start Engine' is dependent on the completion of all the other tasks. As 'Open Silo', 'Insert Launch Keys', 'Activate Batteries' and 'Guidance On' are tasks independent of any inputs or outputs from other sub-tasks, hence they can be safely multithreaded.

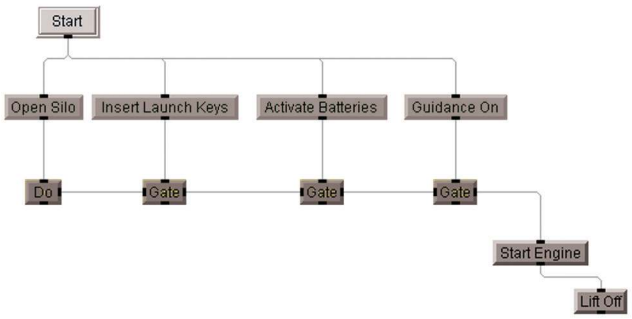


Figure 2: Multithreading tasks in a missile launch program using Keysight VEE

Not all applications can be multithreaded. For example, if the task is to program a robot to cross the road, the sub-tasks would be: 'Turn head left', 'Turn head right', 'Stop', 'Analyze traffic', 'Cross the road'. In this case, each sub-task has its dependencies:

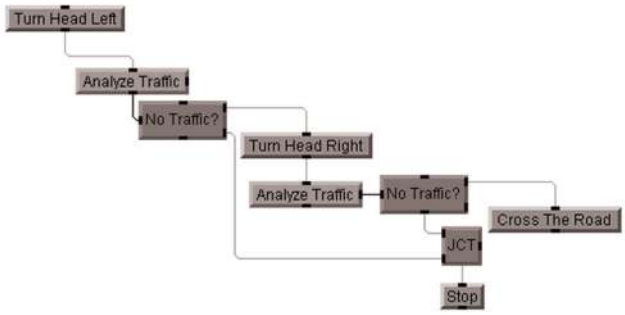


Figure 3: Dependency of sub-tasks in a program to control a robot using Keysight VEE

Deadlock

Trying to multithread a sub-task with dependencies would result in a deadlock, also known as race condition if there are no control procedures. A simple example of a deadlock is Process A waits for Process B while Process B waits for Process A, and thus continues into an infinite loop. Modern, real-time software and operating systems use synchronization methods such as file locking, semaphore, mutex and message passing to allow multithreading of dependent processes to overcome this deadlock. A simple analogy for synchronization would be akin to using a timetable to control shared usage of a railroad track. Without the timetable, trains might collide with each other on the track.

Benefits of multithreading

How would multithreading improve performance in real-world measurement applications? One significant benefit is the ability to operate multiple instruments simultaneously. For example, the following solution in Figure 4 has five instruments, each needing 10 seconds to initialize and calibrate, before the start of measurement.

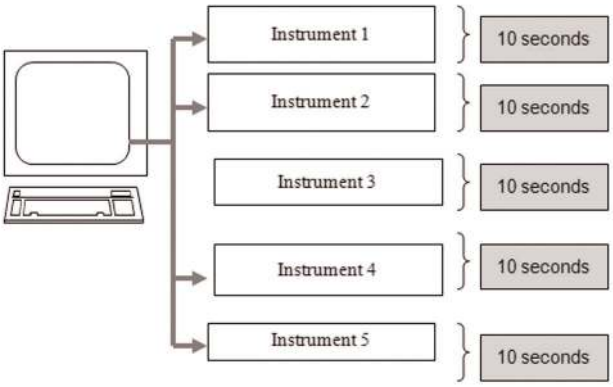


Figure 4: Multithreading to improve performance of multiple instruments operation.

Running them in linear sequence would take 50 seconds. However, running them in parallel using multithreading would result in only 10 seconds of initialization for all five instruments.

In previous versions of Keysight VEE, there are UserObjects where users can easily create function-type sub-procedures. Now, Keysight VEE 9.0 comes with ThreadObject (an extension of the UserObject), a thread where users can place their non-dependent thread-safe codes. A simple example in Figure 5 below compares two ThreadObjects against two UserObjects executing at the same time. The execution time of the ThreadObjects is twice as fast as that of the UserObjects as shown in the Timer.

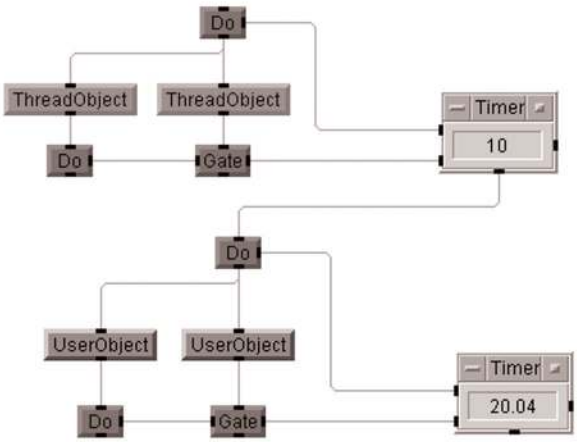


Figure 5: ThreadObjects executing twice as fast as UserObjects in Keysight VEE

Pipelining

Pipelining is another process that can benefit from multithreading. It is a common practice used for mass-production in assembly plants where sub-processes of a stream of inputs are queued. The output of a single sub-process is continuously fed into the next sub-process, while it receives another input from the stream queue. Consider the following example of a banana juice production process. A banana needs 30 seconds to be converted into a packet of juice — see Figure 6.

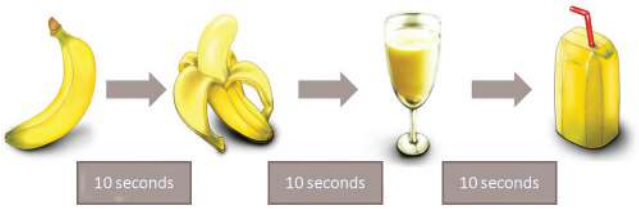


Figure 6: Banana juice production process

What if there are five bananas to be converted into five packets of juice?

A sequential linear flow would require a total of 150 seconds to complete the process:

5 x 30 seconds = 150 seconds.

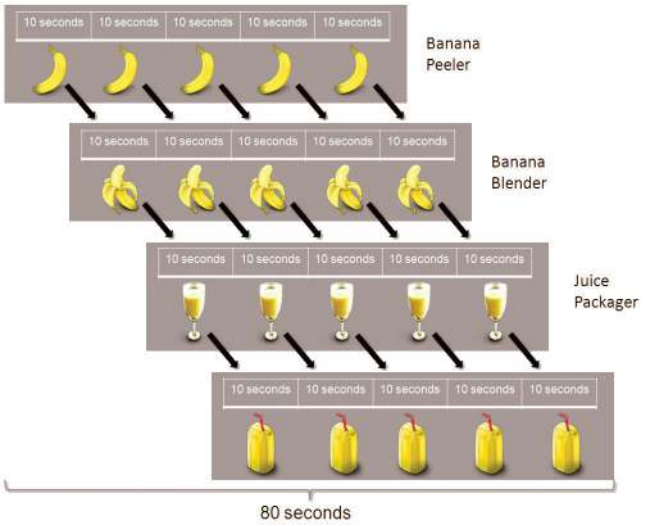


Figure 7: Implementing pipelining in production of five packets of banana juice

In ideal conditions for the process in Figure 7, implementing pipelining in the solution improves the performance by 80% — only 80 sec compared to 150 sec using the sequential linear method. However, not all solutions will have significant benefits from pipelining. For example, if the banana peeler sub-process in the example above takes 100 seconds, then the whole pipeline would be mostly idle waiting for the banana peeler to complete its task.The improvement will only be from 600 seconds to 530 seconds (theoretically around 13% improvement).To optimize the pipeline performance, users should ensure execution time for all sub-processes is more or less of equal length.

The availability of parallelism in Keysight VEE 9.0 software in the form of multithreading is very useful and powerful in terms of performance optimization. This improvement will directly translate into increased productivity and shorter time to market.

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Published in USA, July 31, 2014
5990-3540EN
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