Successful VSIPL Software Application Migration
A Case Study:
NATO Seasparrow Illumination Radar Signal Processing

Dan Averill
Avatar Engineering, Inc.
Phone: (410) 271-3630
Fax: (410) 267-0642
Email: dan.averill@avatarengineering.com

An embedded weapon system signal processing software application involving 10K SLOC was converted from vendor proprietary middleware to that vendor's VSIPL implementation, deployed aboard US Navy surface combatants, and then ported without modification to a less expensive hardware platform using a different vendor's commercially available VSIPL product. This successful episode of software portability offers an opportunity to assess the utility of VSIPL in the context of a production military application, and yields user and vendor strategies and forecasting information for similar future efforts to cost-effectively leverage the products of this research community.

The NATO Seasparrow ship self defense missile is guided to a maneuvering high velocity inbound target by a ship based 10.125 GHz illumination radar. At 43 Hz, the radar receiver time series is digitized and processed for tracking data products. Inbound targets manifest as Doppler shifted energy spikes in the frequency spectrum. A conically scanned receive antenna scheme imparts amplitude modulation across the time series for off-center targets. A 2 KHz carrier frequency modulation smears the Doppler shift of a target over multiple frequency bins as a function of range. The Naval Research Laboratory (NRL) developed a modest set of signal processing algorithms modeled in MatLab to yield track velocity, traverse and elevation angle errors, estimated range, and audio-video spectral representations given the input time series. The software implementation of these algorithms served as the study case for this VSIPL application migration effort.

Before the VSIPL migration, the legacy implementation of this algorithm set was hosted on a Sky Computers SkyBolt II Excalibur. The source code contained approximately 300 vector library calls to 68 distinct Sky Standard Math Library (SML) functions, including single precision 4K complex FFTs, a 7:1 FIR filter decimation, and several 64 point forward and inverse FFTs. The migration target hardware selected by the design agent is a Motorola MVME5100 single board computer with an Altivec PowerPC processor. The MPI Softtech VSI/Pro product provides a VSIPL compliant vector library compatible with Wind River Systems vxWorks in that hardware architecture. Significant production unit cost savings per radar system are realized by replacing the legacy hardware and software architecture with the migration target architecture, but only if the engineering cost of the migration is minimized. A two stage risk averse strategy was adopted: first convert the algorithm set to VSIPL on the legacy platform and verify equivalent numeric results, and second recompile the validated VSIPL application for the migration target platform and again verify equivalent numeric results.

The presentation of this case explores the object management challenge presented when converting software from an "operate on bare memory" paradigm to the persistent object paradigm presented by VSIPL. Brief examples instantiating certain subtle implications of the VSIPL standard when applied in a real time embedded software environment are offered, as well as a systematic scheme for identifying and implementing the minimal set of objects necessary to convert an arbitrary legacy signal processing application to VSIPL. The "hints" that would have accelerated the effort under study had they been available before the effort began are offered for the benefit of similar future efforts.

The presentation provides quantitative code growth and performance impact measurements for the studied application in the legacy hardware. Also provided are measured engineering level of effort and schedule as a function of pre-migration source size, for at least the studied case. Since the only tangible product of a successful first stage effort is slower performance, the presentation offers observations on the programmatic benefits (deferred gratification) of conversion to VSIPL. The presentation encourages the managers of similar military application systems to migrate their software to VSIPL.

The second stage of the effort surfaced VSIPL implementation compatibility and relative maturity data. It is gratifying to report that the application ultimately initialized and iterated with acceptable performance and accuracy and without any algorithm modification. The configuration management advantages of this fact are significant to all fielded configurations of the studied weapon system. Result precision, numerical accuracy, and implemented function inventory all emerge as factors when porting a legacy application to a new platform. The utility of the VSIPL development version to the porting effort was limited; such a tool seems likely to be of greater value to an initial implementation. Vendor product support plays an important role at both ends of a port, and user regression testing of an already validated application can yield valuable benefits back to the VSIPL library vendor. The presentation offers vendors an insight into the VSIPL end user experience, permitting a more competitive vendor offering to such users.

This abstract asserts the relevance of the studied case to the topics of "Middleware Libraries and Application Programming Interfaces" and "Case Study Examples of High Performance Embedded Computing". It has summarized the involved application and the software implementation of that application, highlighted the specific subjects explored by the offered presentation, and identified notional benefits of the presentation to a cross section of the research community. The HPEC technical committee is respectfully requested to consider including the offered presentation in the workshop.