## Appendix

## 1. User directions

(To be appended)

## 2. Source Code and stock data formats of input files

(To be appended)

## 6. Conclusions

This work shows to us that:

- The importance to make use of existing(well-developed) visualization environment in the parallel programming environment;

- A distributed parallel computing environment with scientific data visualization can be achieved through the use of AVS;

- A highly portable interactive graphic tool for the option price modeling on parallel computers such as DECmpp-12000 can be implemented with relatively small programming effort, provided that AVS be the visualization environment and the parallel programming environment supports multi-paradigm programmings at compiler level.

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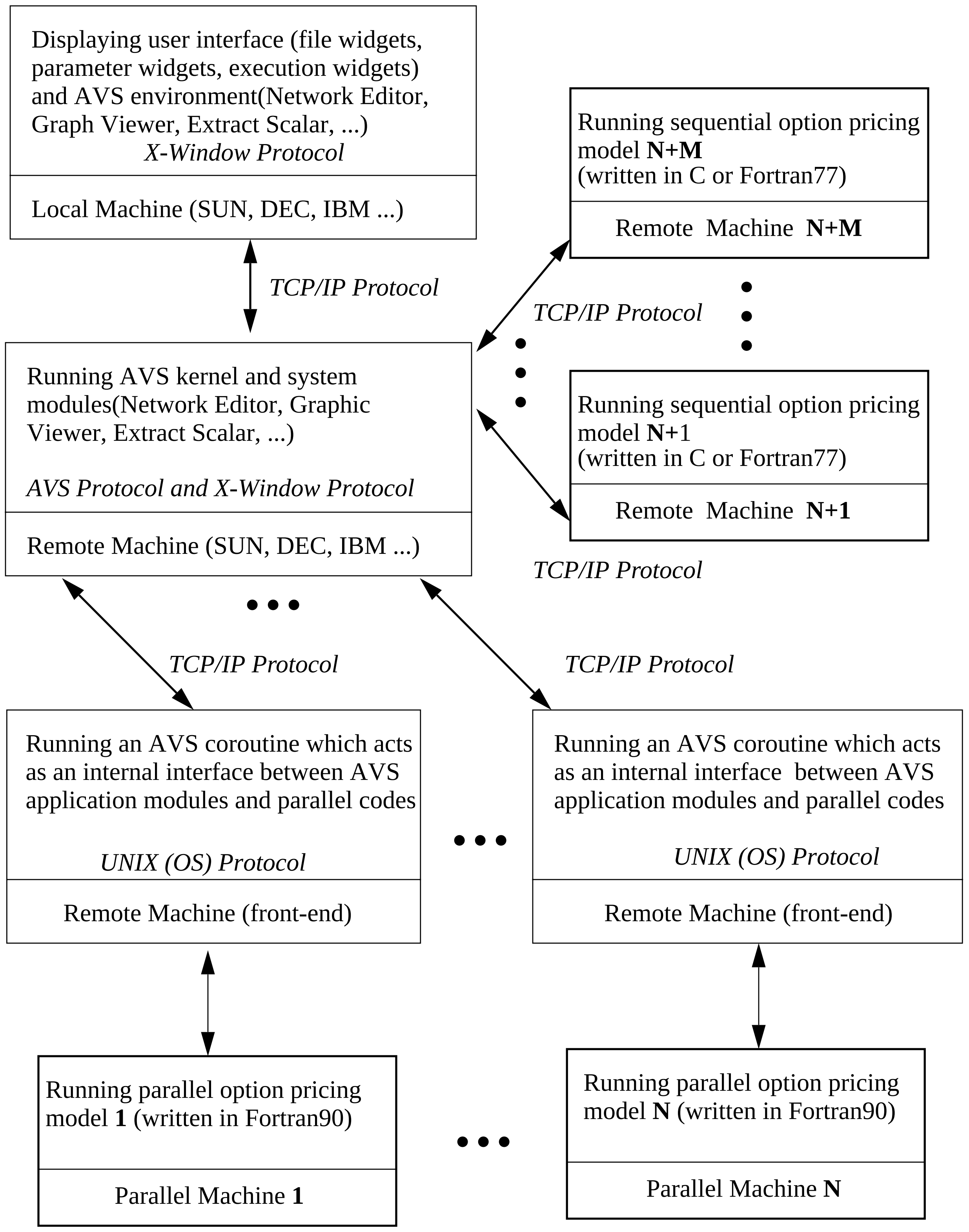
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Figure 4 A complete distributed environment for a large application problem requiring scientific data visualization

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In this study, we choose DECmpp-12000 to be the parallel machine running the option price models. As it becomes obvious from the above discussion, it will be very easy to port this tool to any other parallel machines. AVS and Fortran90 help us to achieve this goal. It is not impossible that using AVS we can achieve a complete high level heterogeneous distributed computing environment for a large application problem which requires data visualization, as illustrated in Figure 4, where each option pricing model can be thought as a relatively independent component in a large application problem domain.

But, as found in the practice of this study, the current parallel programming environment is far from flexible and complete to facilitate such a computing environment. Originally, our option price codes are implemented in Fortran-90 (MP-fortran)[4]. The DECmpp-12000 programming environment does not support a mechanism to call MPfortran subroutines from a front-end C program or Fortran77 program at the front-end. It does provide a way to call MPL functions from C. MPL is a C-like programming language with parallel extensions on DECmpp-12000[5] which is not portable to other parallel machines. To integrate our model into AVS modules which is written in C, we have to rewrite all parallel models in MPL. This reduces the portability of this tool, though our models have Fortran90 versions. This also brings us another parallel programming environment issue that because so far the parallel programing environments on parallel machines are far less rich than those on sequential machines as their front-ends, there should be a flexible mechanism to provide the multi-language mixed programming environment, at least on the compiler level such that subroutines(functions) written in different programming languages can be called each other.

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● a system module "Extract Scalar" ---- extract from the vector data generated by the coroutine a specified model's data for output.

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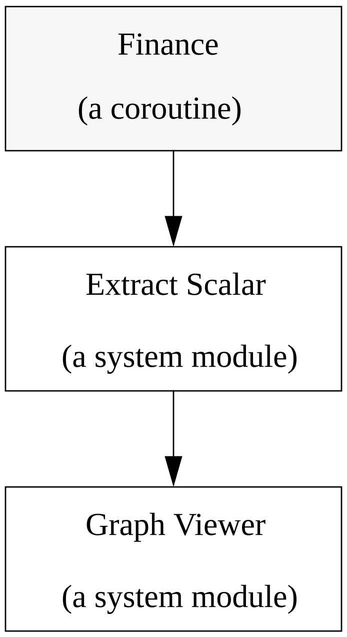

Figure 2 module diagram

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- to temporarily pause the modeling process to have a detailed view of the animated pictures or change model parameters;
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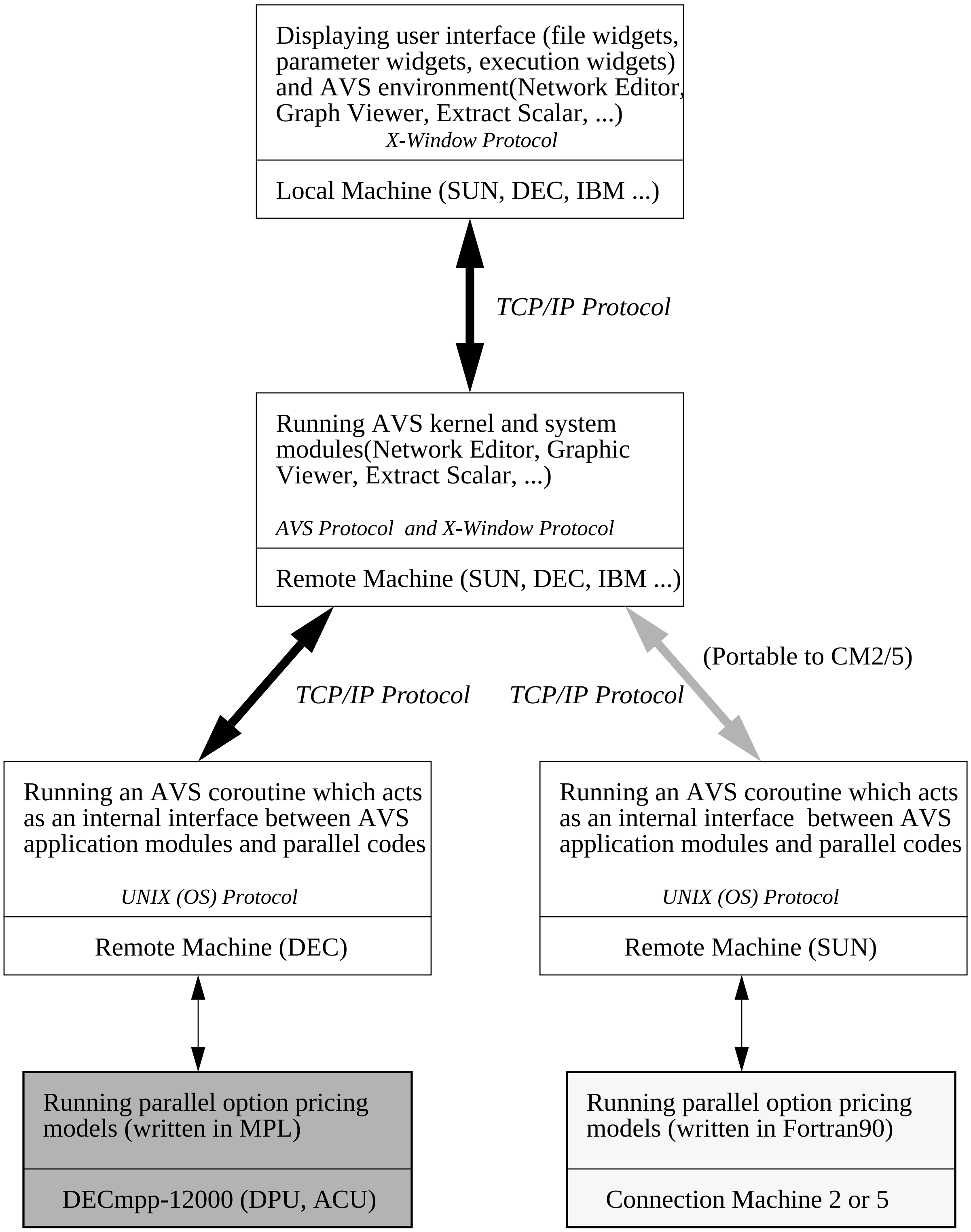
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For detailed functionality about AVS, refer to [3].

## 4. Integrating the Option Price Modeling on DECmpp-12000 into AVS

There are two alternatives for data visualizations on parallel machines. One is to use the display or image processing library provided by the parallel machine’s programming environment, such as MPDDL on DECmpp-12000, CMX11 on CM5. This can be very efficient as they fetch the data to be visualized directly from each processor element but it generally requires particular hardware like framebuffer which can not be shared by other users. The other way is to make use of the well-developed conventional graphics environment such as X-window Toolkit, OSF/Motif, AVS on sequential machines which are usually connected to the parallel machines as front ends.

Based on the following observations, we choose AVS as front-end visualization environment to implement our tool:

The characteristics of the option price modeling on DECmpp-12000 requires not only scientific data visualization but also dynamic interaction with the modeling itself. The MPDDL on DECmpp-12000 provides very limited facilities to support the graphic interaction with the running program.

Our tool is designed to be portable to any parallel machines which can run the option price models. AVS is now available on the major UNIX-based workstation and visualization systems. These include computer systems from Convex Computer Corporation, Cray Research Inc., Digital Equipment Corporation, Evans and Sutherland, Hewlett-Packard, IBM Corporation, Kubota Pacific Computer Inc., Set Technology Corporation, Sun Microsystems, and Wavetracer.

Our data visualization does not necessarily require fetching data to be visualized directly from PE nodes. So there would be no significant performance problem to display the scalar (2D) data from the front-end.

In order to illustrate the portability and extensibility of this tool, and also to overcome an unknown AVS system problem (probably a memory problem) that the repeated invocations of the Graph Viewer on the same machine as the invoking module will lead to system crash, we use a distributed environment to implement the tool. Figure 1 shows the configuration of this environment.

while allowing model parameters either estimated by some optimization method(function) or given by interactively parameter input at run-time, or by both.

Through AVS(Application Visualization System), this tool integrates the parallel option pricing models into an interactive, user-friendly graphic interface and provide the model users and researchers with a dynamic visualization for model verification and optimization.

This work also investigates the feasibility to use AVS as a data visualization tool in parallel programming environment. It further suggests that a complete, high-level distributed computing environment with a comprehensive visualization environment can be achieved through AVS, in which heterogeneous parallel machines and workstations may be integrated all together to accomplish a large application problem which requires scientific data visualization.

This paper discusses the design issues and implementation details of this tool.

## 2. Option Pricing Models on DECmpp-12000

The parallel option pricing models in our study are binomial approximation models which incorporates stochastic volatility and American call[1]. Another two sequential models assuming constant volatility are used for the purpose of comparison. After a large scale comparison of these models with historical market data[2], we found that a few key model parameters have significant impact on the model performance of (parallel) stochastic models. These parameters are:

- stock initial volatility
- variance of stock volatility
- correlation between stock price and its volatility

The determinations of the parameters are based on many factors in real stock market situations. They are generally unable to be observed directly but must be estimated either from historical data or by financial expertise. They are the major concerns in the model optimization. The model optimization requires more computing time than the model themselves, even on parallel machines. In the comparison of the models running on DECMPP-12000, we use some criteria, most of them are plain data, to evaluate the model performance of a whole stock over a 1-month or 6-month time. In the run of the comparison, we are unable to interact with the modeling process and it will take relatively long time to visualize a parameter’s impact on the model performance, which is done statically, due to the lack of an interactive visualization tool.

## 3. The AVS environment

Advanced Visual System’s Application Visualization System(AVS) is a comprehensive visualization environment which incorporates the latest advances in visualization software, graphics, networking, high performance systems, and industry standards.

Modules are the building blocks of AVS. A module is an independent computing element (C or

# An Interactive Graphic Tool For The Option Price Modeling On DECmpp-12000 Using AVS

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*Abstract*

*An interactive graphic tool has been implemented for the option price modeling on DECmpp-12000. Through the use of AVS, it integrates the parallel option pricing models on DECmpp-12000 into an interactive, user-friendly graphic interface which visualizes the modeling process dynamically while allowing model parameters input at run-time by the user.*

*This paper discusses design issues and implementation of this tool. The feasibility of a distributed parallel computing environment with a comprehensive data visualization environment is also investigated.*

## 1. Introduction

A set of (parallel) option pricing models have been implemented, which can run efficiently on parallel machines such as DECmpp-12000, CM2 and CM5. After a large-scale comparison of the option price models on DECmpp-12000 using historical market data[2], we evaluated that a group of models, namely, “stochastic volatility model”, provide more accurate option price estimates than another group of “conventional” models. We also found that the “stochastic volatility models” are highly sensitive to a couple of model parameters, such as volatility of stock price and variance of the volatility. Those parameters can not be observed directly and can only be estimated either from historical data through some optimization method or from financial expertise.

To further evaluate and optimize the models, a visualizing tool for interacting with the models running on parallel machines would be very useful. An interactive graphic tool for the option price modeling is then implemented on DECmpp-12000 in this study. It visualizes the modeling process

## Appendix

### 1. User directions

(To be appended)

### 2. Source Code and stock data formats of input files

(To be appended)

## 6. Conclusions

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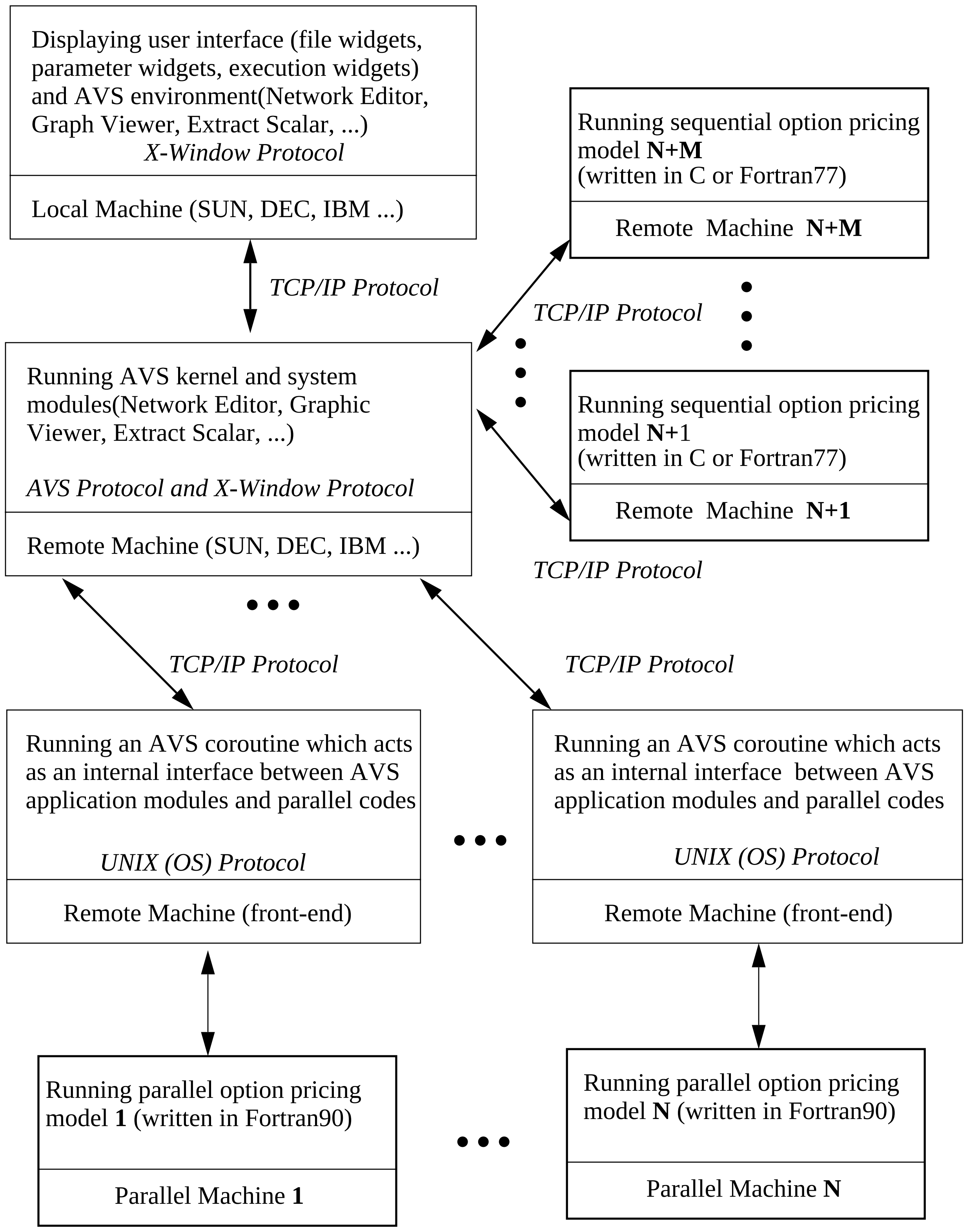
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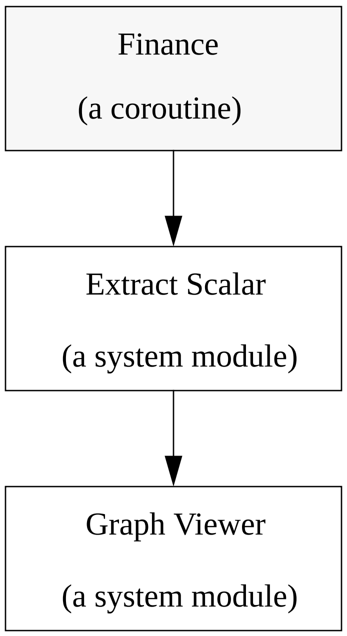

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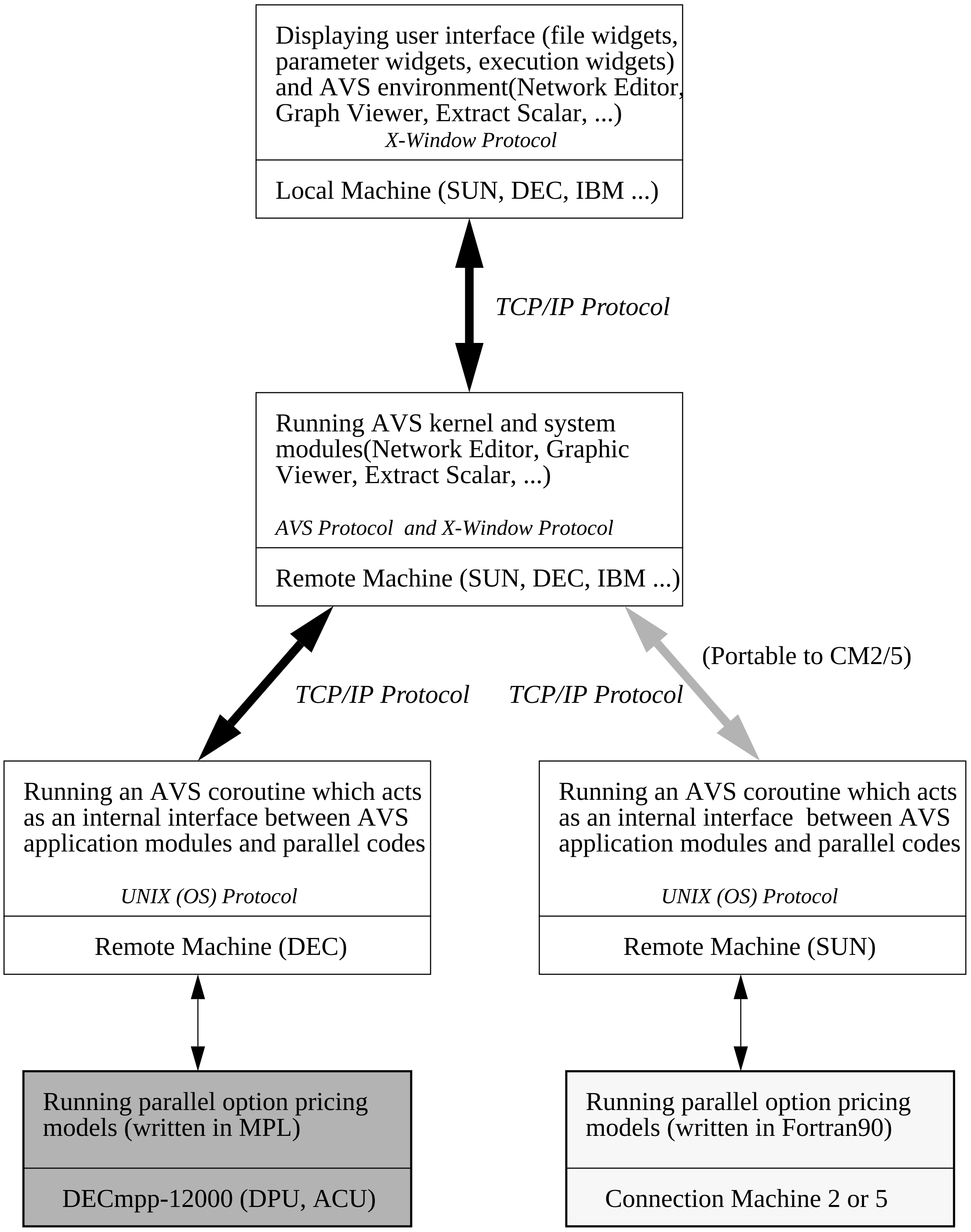
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# An Interactive Graphic Tool For The Option Price Modeling On DECmpp-12000 Using AVS

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*An interactive graphic tool has been implemented for the option price modeling on DECmpp-12000. Through the use of AVS, it integrates the parallel option pricing models on DECmpp-12000 into an interactive, user-friendly graphic interface which visualizes the modeling process dynamically while allowing model parameters input at run-time by the user.*

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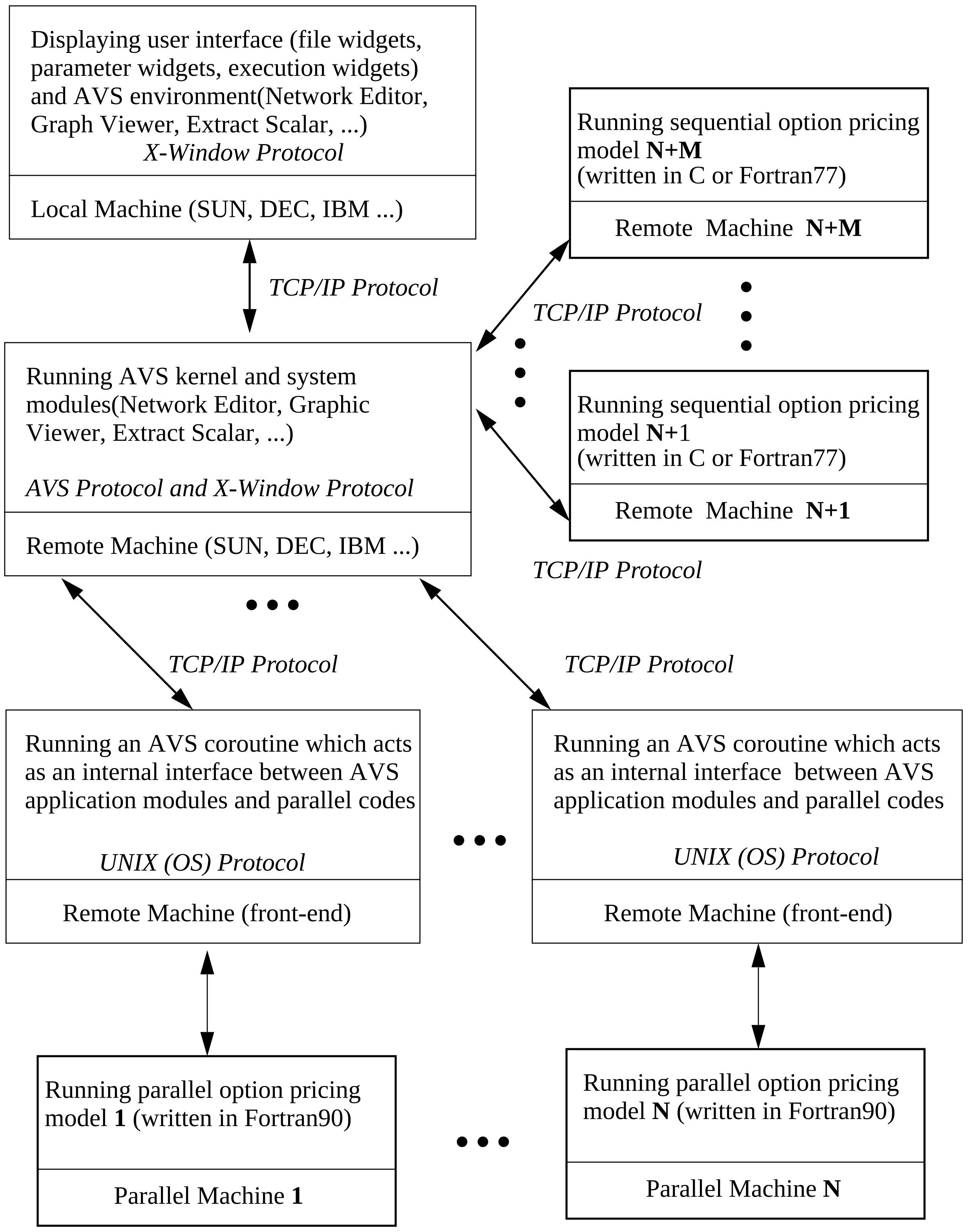
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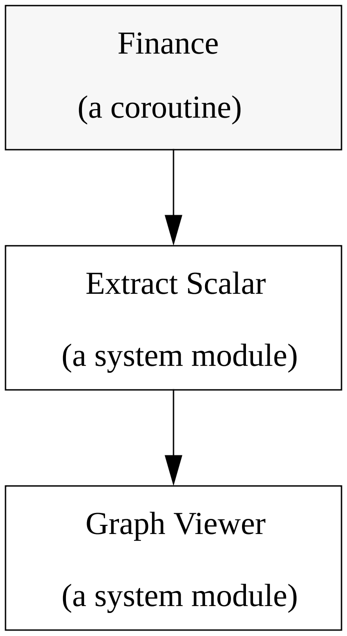

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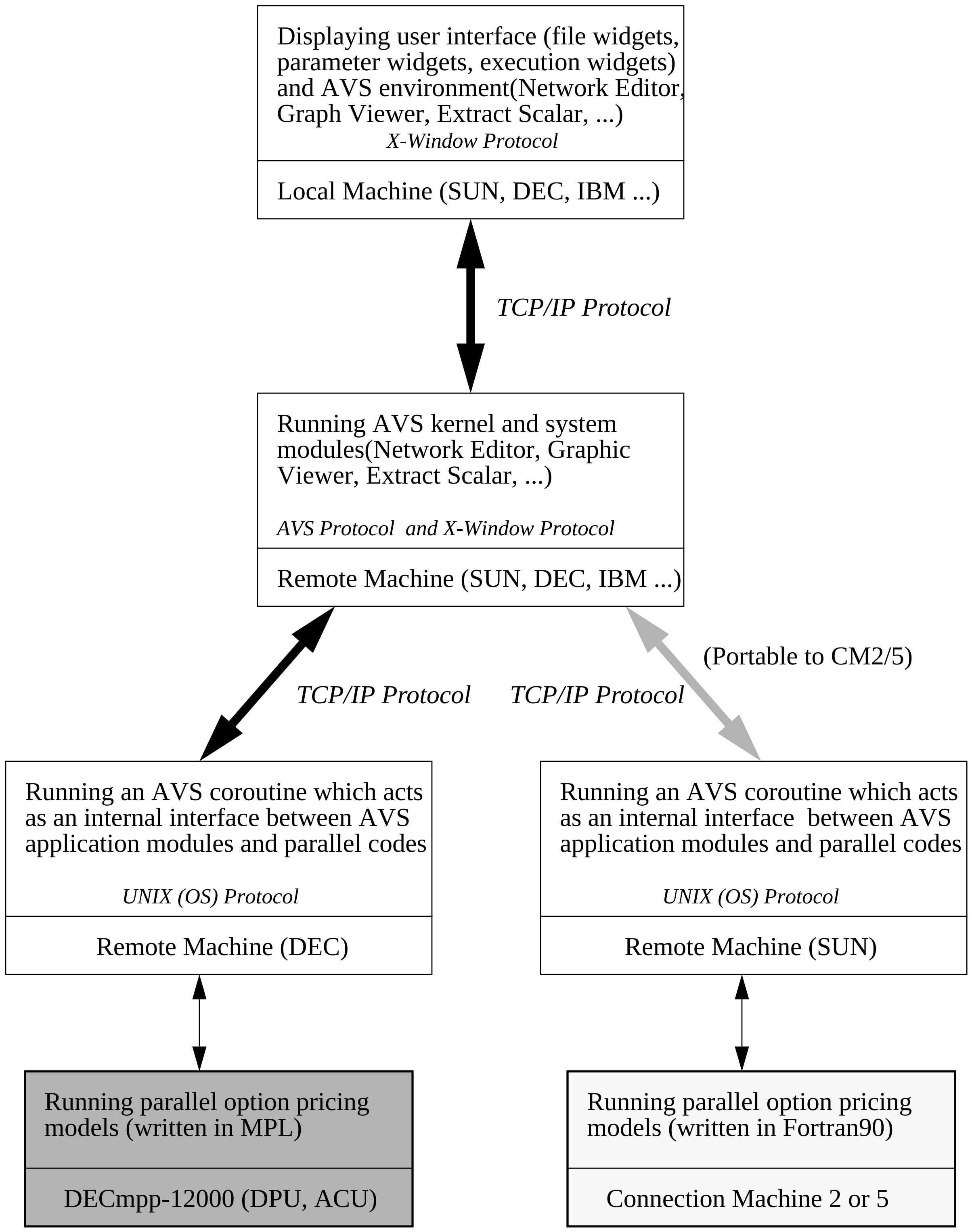
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For detailed functionality about AVS, refer to [3].

## 4. Integrating the Option Price Modeling on DECmpp-12000 into AVS

There are two alternatives for data visualizations on parallel machines. One is to use the display or image processing library provided by the parallel machine's programming environment, such as MPDDL on DECmpp-12000, CMX11 on CM5. This can be very efficient as they fetch the data to be visualized directly from each processor element but it generally requires particular hardware like framebuffer which can not be shared by other users. The other way is to make use of the well-developed conventional graphics environment such as X-window Toolkit, OSF/Motif, AVS on sequential machines which are usually connected to the parallel machines as front ends.

Based on the following observations, we choose AVS as front-end visualization environment to implement our tool:

The characteristics of the option price modeling on DECmpp-12000 requires not only scientific data visualization but also dynamic interaction with the modeling itself. The MPDDL on DECmpp-12000 provides very limited facilities to support the graphic interaction with the running program.

Our tool is designed to be portable to any parallel machines which can run the option price models. AVS is now available on the major UNIX-based workstation and visualization systems. These include computer systems from Convex Computer Corporation, Cray Research Inc., Digital Equipment Corporation, Evans and Sutherland, Hewlett-Packard, IBM Corporation, Kubota Pacific Computer Inc., Set Technology Corporation, Sun Microsystems, and Wavetracer.

Our data visualization does not necessarily require fetching data to be visualized directly from PE nodes. So there would be no significant performance problem to display the scalar (2D) data from the front-end.

In order to illustrate the portability and extensibility of this tool, and also to overcome an unknown AVS system problem (probably a memory problem) that the repeated invocations of the Graph Viewer on the same machine as the invoking module will lead to system crash, we use a distributed environment to implement the tool. Figure 1 shows the configuration of this environment.

while allowing model parameters either estimated by some optimization method(function) or given by interactively parameter input at run-time, or by both.

Through AVS(Application Visualization System), this tool integrates the parallel option pricing models into an interactive, user-friendly graphic interface and provide the model users and researchers with a dynamic visualization for model verification and optimization.

This work also investigates the feasibility to use AVS as a data visualization tool in parallel programming environment. It further suggests that a complete, high-level distributed computing environment with a comprehensive visualization environment can be achieved through AVS, in which heterogeneous parallel machines and workstations may be integrated all together to accomplish a large application problem which requires scientific data visualization.

This paper discusses the design issues and implementation details of this tool.

## 2. Option Pricing Models on DECmpp-12000

The parallel option pricing models in our study are binomial approximation models which incorporates stochastic volatility and American call[1]. Another two sequential models assuming constant volatility are used for the purpose of comparison. After a large scale comparison of these models with historical market data[2], we found that a few key model parameters have significant impact on the model performance of (parallel) stochastic models. These parameters are:

- stock initial volatility
- variance of stock volatility
- correlation between stock price and its volatility

The determinations of the parameters are based on many factors in real stock market situations. They are generally unable to be observed directly but must be estimated either from historical data or by financial expertise. They are the major concerns in the model optimization. The model optimization requires more computing time than the model themselves, even on parallel machines. In the comparison of the models running on DECMPP-12000, we use some criteria, most of them are plain data, to evaluate the model performance of a whole stock over a 1-month or 6-month time. In the run of the comparison, we are unable to interact with the modeling process and it will take relatively long time to visualize a parameter’s impact on the model performance, which is done statically, due to the lack of an interactive visualization tool.

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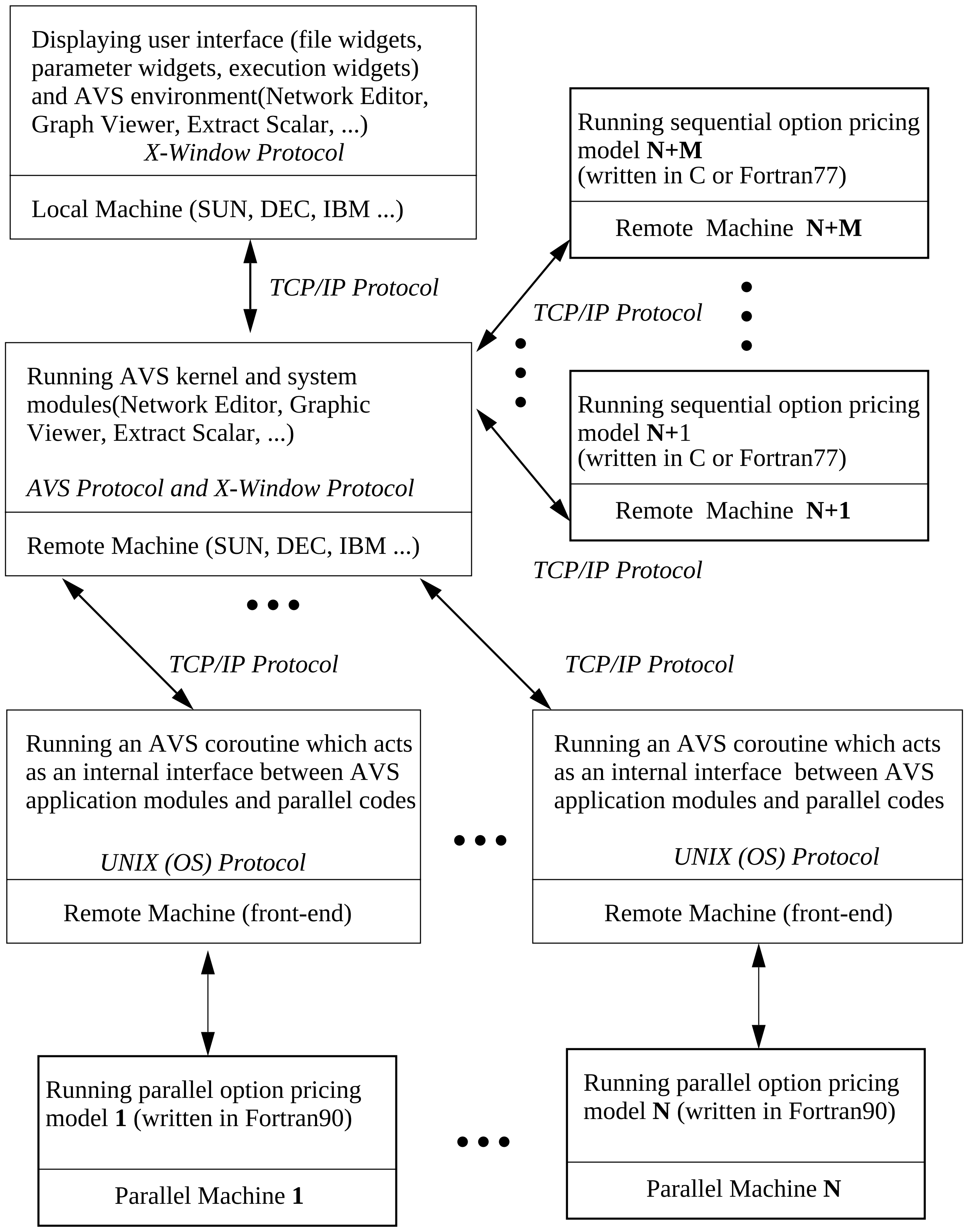
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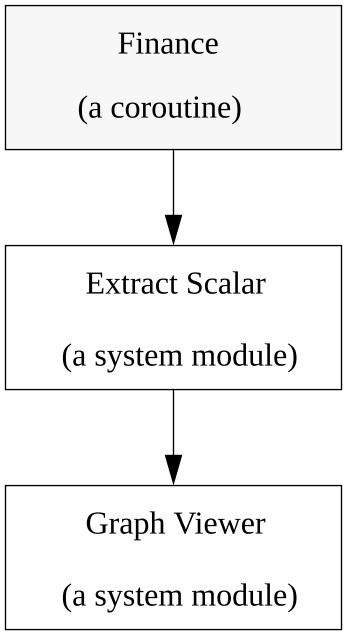

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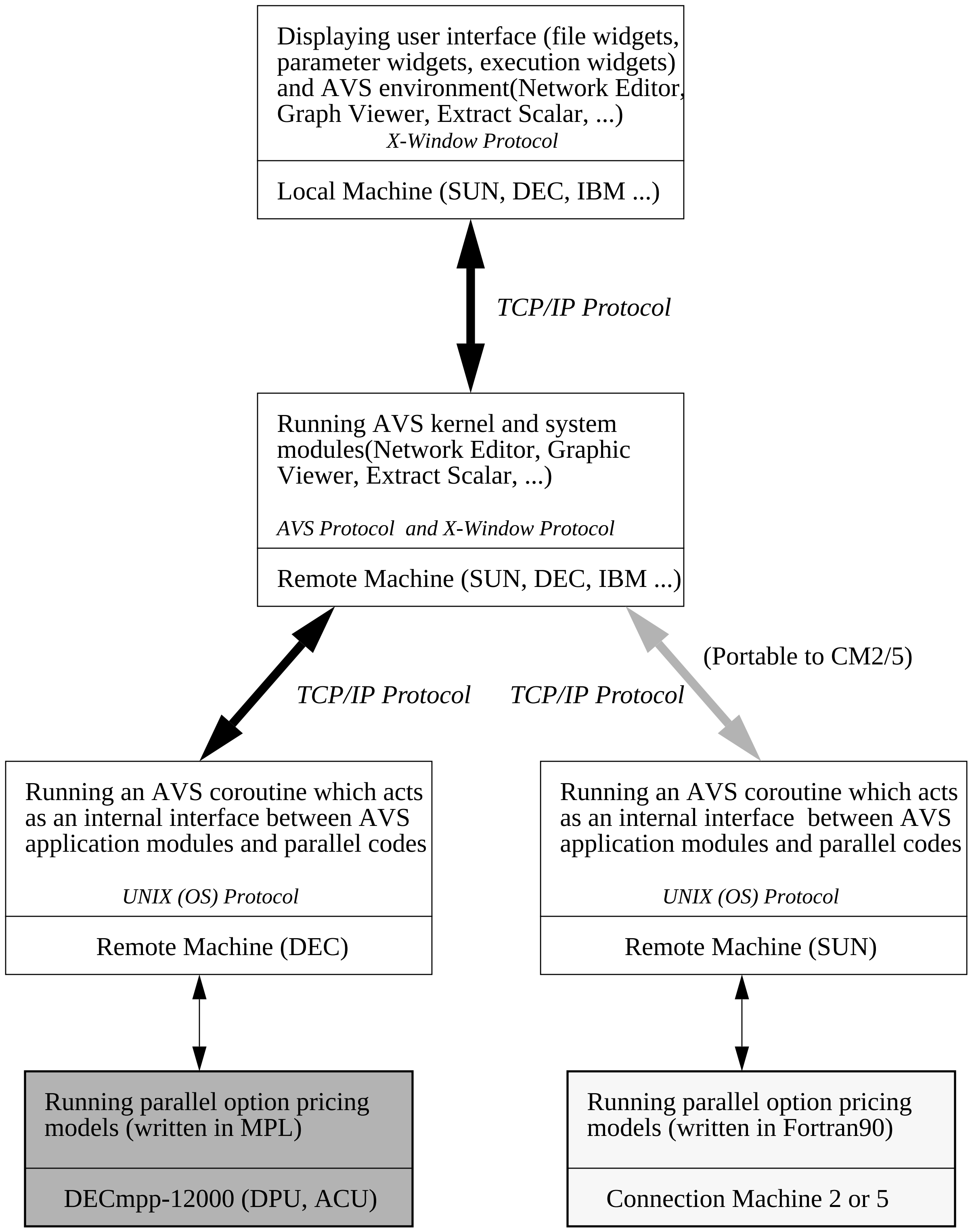
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For detailed functionality about AVS, refer to [3].

## 4. Integrating the Option Price Modeling on DECmpp-12000 into AVS

There are two alternatives for data visualizations on parallel machines. One is to use the display or image processing library provided by the parallel machine's programming environment, such as MPDDL on DECmpp-12000, CMX11 on CM5. This can be very efficient as they fetch the data to be visualized directly from each processor element but it generally requires particular hardware like framebuffer which can not be shared by other users. The other way is to make use of the well-developed conventional graphics environment such as X-window Toolkit, OSF/Motif, AVS on sequential machines which are usually connected to the parallel machines as front ends.

Based on the following observations, we choose AVS as front-end visualization environment to implement our tool:

The characteristics of the option price modeling on DECmpp-12000 requires not only scientific data visualization but also dynamic interaction with the modeling itself. The MPDDL on DECmpp-12000 provides very limited facilities to support the graphic interaction with the running program.

Our tool is designed to be portable to any parallel machines which can run the option price models. AVS is now available on the major UNIX-based workstation and visualization systems. These include computer systems from Convex Computer Corporation, Cray Research Inc., Digital Equipment Corporation, Evans and Sutherland, Hewlett-Packard, IBM Corporation, Kubota Pacific Computer Inc., Set Technology Corporation, Sun Microsystems, and Wavetracer.

Our data visualization does not necessarily require fetching data to be visualized directly from PE nodes. So there would be no significant performance problem to display the scalar (2D) data from the front-end.

In order to illustrate the portability and extensibility of this tool, and also to overcome an unknown AVS system problem (probably a memory problem) that the repeated invocations of the Graph Viewer on the same machine as the invoking module will lead to system crash, we use a distributed environment to implement the tool. Figure 1 shows the configuration of this environment.

while allowing model parameters either estimated by some optimization method(function) or given by interactively parameter input at run-time, or by both.

Through AVS(Application Visualization System), this tool integrates the parallel option pricing models into an interactive, user-friendly graphic interface and provide the model users and researchers with a dynamic visualization for model verification and optimization.

This work also investigates the feasibility to use AVS as a data visualization tool in parallel programming environment. It further suggests that a complete, high-level distributed computing environment with a comprehensive visualization environment can be achieved through AVS, in which heterogeneous parallel machines and workstations may be integrated all together to accomplish a large application problem which requires scientific data visualization.

This paper discusses the design issues and implementation details of this tool.

## 2. Option Pricing Models on DECmpp-12000

The parallel option pricing models in our study are binomial approximation models which incorporates stochastic volatility and American call[1]. Another two sequential models assuming constant volatility are used for the purpose of comparison. After a large scale comparison of these models with historical market data[2], we found that a few key model parameters have significant impact on the model performance of (parallel) stochastic models. These parameters are:

- stock initial volatility
- variance of stock volatility
- correlation between stock price and its volatility

The determinations of the parameters are based on many factors in real stock market situations. They are generally unable to be observed directly but must be estimated either from historical data or by financial expertise. They are the major concerns in the model optimization. The model optimization requires more computing time than the model themselves, even on parallel machines. In the comparison of the models running on DECMPP-12000, we use some criteria, most of them are plain data, to evaluate the model performance of a whole stock over a 1-month or 6-month time. In the run of the comparison, we are unable to interact with the modeling process and it will take relatively long time to visualize a parameter’s impact on the model performance, which is done statically, due to the lack of an interactive visualization tool.

## 3. The AVS environment

Advanced Visual System’s Application Visualization System(AVS) is a comprehensive visualization environment which incorporates the latest advances in visualization software, graphics, networking, high performance systems, and industry standards.

Modules are the building blocks of AVS. A module is an independent computing element (C or

# An Interactive Graphic Tool For The Option Price Modeling On DECmpp-12000 Using AVS

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*Abstract*

*An interactive graphic tool has been implemented for the option price modeling on DECmpp-12000. Through the use of AVS, it integrates the parallel option pricing models on DECmpp-12000 into an interactive, user-friendly graphic interface which visualizes the modeling process dynamically while allowing model parameters input at run-time by the user.*

*This paper discusses design issues and implementation of this tool. The feasibility of a distributed parallel computing environment with a comprehensive data visualization environment is also investigated.*

## 1. Introduction

A set of (parallel) option pricing models have been implemented, which can run efficiently on parallel machines such as DECmpp-12000, CM2 and CM5. After a large-scale comparison of the option price models on DECmpp-12000 using historical market data[2], we evaluated that a group of models, namely, “stochastic volatility model”, provide more accurate option price estimates than another group of “conventional” models. We also found that the “stochastic volatility models” are highly sensitive to a couple of model parameters, such as volatility of stock price and variance of the volatility. Those parameters can not be observed directly and can only be estimated either from historical data through some optimization method or from financial expertise.

To further evaluate and optimize the models, a visualizing tool for interacting with the models running on parallel machines would be very useful. An interactive graphic tool for the option price modeling is then implemented on DECmpp-12000 in this study. It visualizes the modeling process