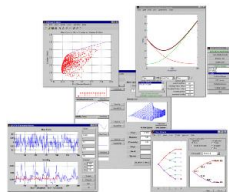


Using MATLAB to Develop and Deploy Financial Models

Financial Products Group



Allen Schweitzer Account Manager
Kas Sharma Applications Engineer
Rob Quinn Technical Marketing

Topics

- Introduction
- Application Examples
- Overview of MATLAB
 - Data I/O
 - Data Analysis
 - Modeling
- Break
- Algorithm Deployment and Reporting
- Distributed Computing
- Wrap up

The MathWorks at a Glance

 **Headquarters:**
Natick, Massachusetts USA

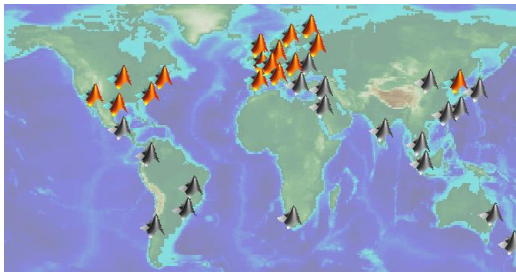
 **USA:**
California, Michigan,
Washington DC, Texas

 **Europe:**
UK, France, Germany,
Switzerland, Italy,
Spain, Benelux, Nordic

 **Asia-Pacific:**
Korea

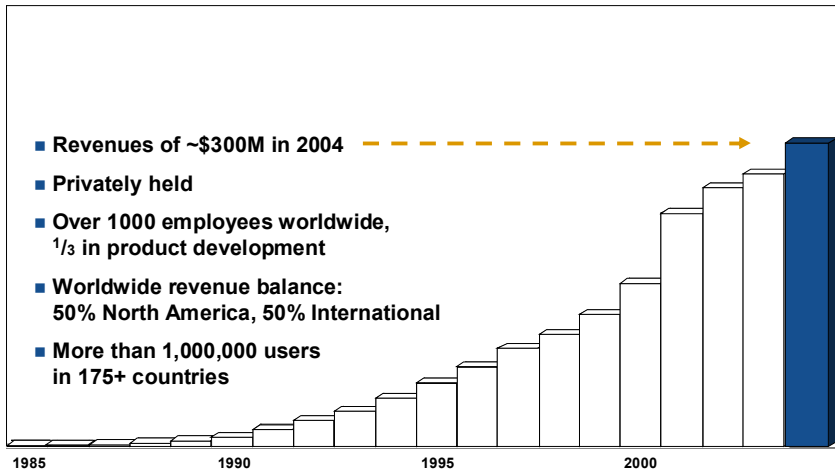
 **Worldwide training
and consulting**

 **Distributors in 20 countries**



Earth's topography on an
equidistant cylindrical projection,
created with the MATLAB Mapping
Toolbox

The MathWorks Today



Business Challenges

- **Development time**
- **Computational speed**
- **Deployment time**

Lost opportunity or added risk

Customer Quote

*"MathWork's products have saved us significant time in developing our return forecast models. MATLAB, coupled with the deployment capabilities available, **enables us to distribute sophisticated models to portfolio managers and researchers much quicker than we could have with other solutions.**"*

Eric Kisslinger
Barclays Global Investors

Customer Quote

*“MATLAB can **reduce programming time by about 75 percent**. In some cases it would be weeks before we could run the calculations in C++.”*

“MATLAB is virtually the only program that can handle the large-scale problems that we model. It is a powerful tool that provides a very flexible Environment in which to build models rapidly.”

**Alexander Eydeland
Mirant**

Customer Quote

*By using MATLAB as the computation engine for our Excel models, we have been able to significantly improve the accuracy of our simulations and **reduce computing time by up to 95%.***

Don Mango
American Reinsurance

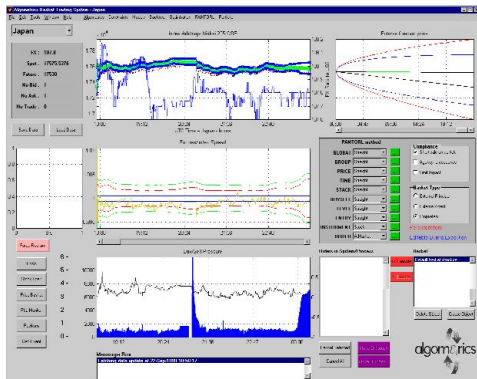
Customer Quote

*“We found the development cycle in MATLAB to be **10 times shorter than in C++**, dramatically reducing project costs without any significant penalties to computation speed.”*

Zaf Bhuia
Credit Suisse First Boston

Trading Application

A statistical arbitrage trading system for a London hedge fund



High speed data analysis and trading application

- Custom Reuters datafeed
- Read and analyze data
- Estimate risks
- Execute trades

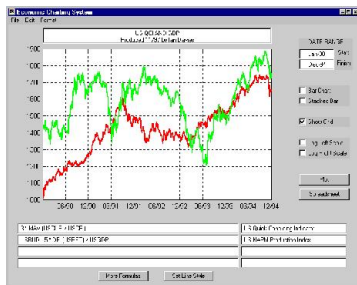
ROI

Developed for 20% of their expected cost in only 3 months.

Data Analysis Applications

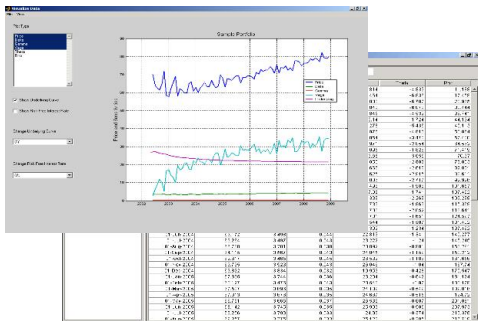
Economic charting system for a major insurance company

- Macro economic trending tool for economists
- Read data from a databases
- Filter using custom user interface
- Report using either Microsoft Excel or Word



Analysis and reporting tool for energy trading companies

- Customized database access routines
- Extensive use of object oriented programming
- Hierarchical structure for books, deals, derivatives, etc...
- Distribution of nightly position reports to senior management via their intranet.
- Display of market curves, sensitivities, etc...



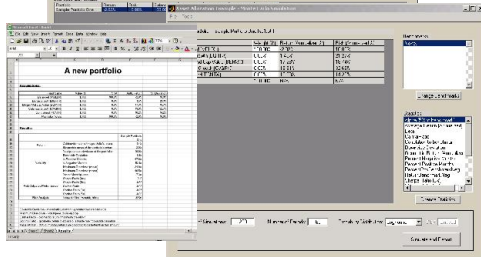
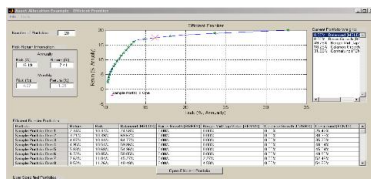
Asset allocation Application

Analysis tool for Privately managed investment company

- An environment for detailed analysis of their holdings.
- Analysis includes:
 - Visualizing efficient frontiers
 - Monte-Carlo simulation
 - Performance reporting

Final application provided:

- Asset and group constraints.
- Statistic calculation against benchmarks
- Reporting back to Excel
- Extensibility

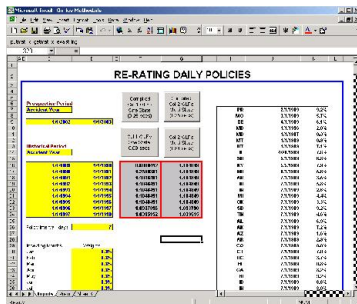


Pricing and risk tool for major re-insurance company

- Used Excel as front end user interface
- Needed access to several databases
- Analysis includes:
 - Statistical routines
 - Monte-Carlo simulations
 - Cash flows

ROI

- Calculation time reduced from 2 hours to 3 minutes
- Won \$130M order due to quick response time



Securities Trading Application

Analysis and development tool for major investment banking

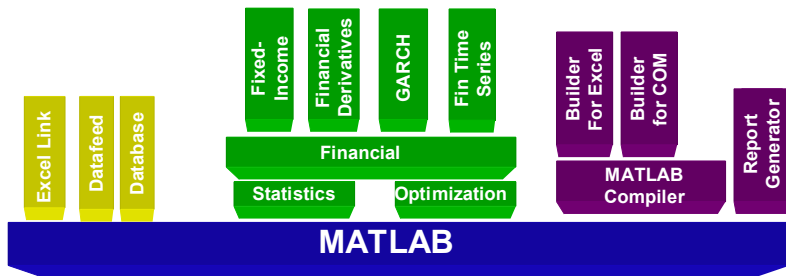
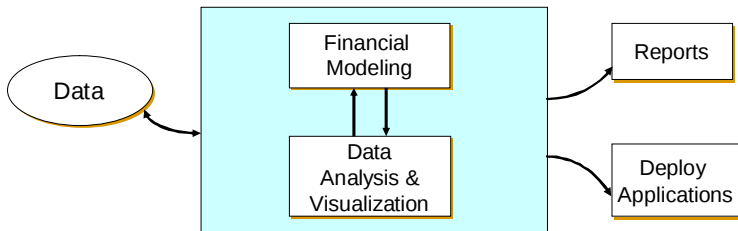
- Application to analyse large volumes of data to determine daily trading strategies
 - Implement new strategies
 - Link to Excel
 - Link to trading platform

ROI

- Reduce model execution time from 10 hour to 2.5 minutes
 - Analyze 500 stocks, up from 150
- Increase trading volume from £30million to £120million
- Pilot study, using Consulting Services and implemented in 3 days, paid for itself in 2 trading days.

Overview of MATLAB and Toolboxes

Typical Process Flow



The Power of MATLAB

MATLAB is both

A Computational Environment:

Financial professional develop complex financial models using MATLAB and its family of toolboxes

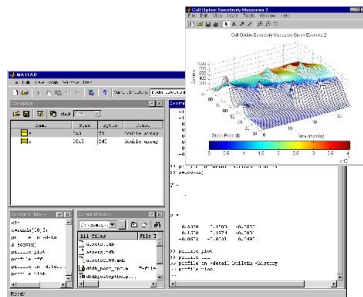
and

An Application Development Environment:

Models developed in MATLAB by financial professionals are translated into components using the MATLAB Compiler and distributed as stand-alone applications or quickly integrated into new or existing legacy applications by Information Technology Engineers

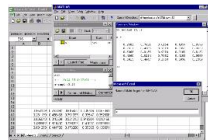
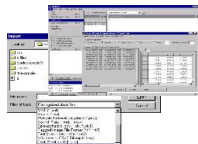
Why MATLAB?

- Quick Prototyping environment
 - Less Programming
 - Matrix Based
 - Easy Syntax (no overhead)
 - 1000's Math & Graphics
- Fast computational engine
- Work with various data sources
- Integrate with other programs
 - Excel, VB, & C/C++



Data I/O Overview

- Data importing functions
- Support for ODBC and JDBC compliant database
- Interface with data providers
- Many Interfaces to Excel

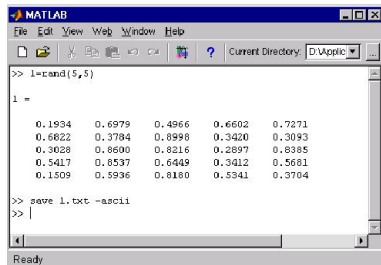


Core MATLAB Data I/O functionality

- Save and load command
- Low-level file I/O functions
- COM/ActiveX
- DDE function
- textscan
- xlsread

Save options

- 8-digit or 16-digit ASCII format
- Delimits with tabs or spaces
- Text data (ASCII)
- Binary data (MAT-file)



```

MATLAB
File Edit View Web Window Help
[Icons] Current Directory: D:\Applic...
>> l=rand(5,5)

l =

    0.1934    0.6979    0.4966    0.6602    0.7271
    0.6822    0.3784    0.8998    0.3420    0.3093
    0.3028    0.8600    0.8216    0.2897    0.8385
    0.5417    0.8537    0.6449    0.3412    0.5681
    0.1509    0.5936    0.8180    0.5341    0.3704

>> save l.txt -ascii
>>
Ready
    
```

Connections to Data Providers

- Supported connections:

Bloomberg, FactSet,
Financial Times Interactive Data (IDC)
Yahoo, and Hyperfeed

- Potential connections

Reuters and Datastream

- GUI Tool (DFTOOL)

- Need connection/license



Database Connections

- ODBC or JDBC compliant database
 - ODBC and JDBC on PC
 - JDBC on UNIX
- Data types are preserved
- Retrieval of large/partial data sets
- Access multiple connections (same or different DB)
- Database connections remain open



Microsoft Access
The Office XP database solution

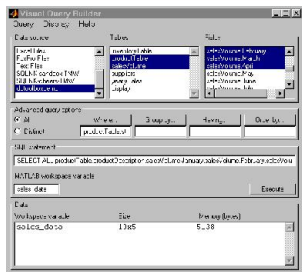


Microsoft
SQL Server



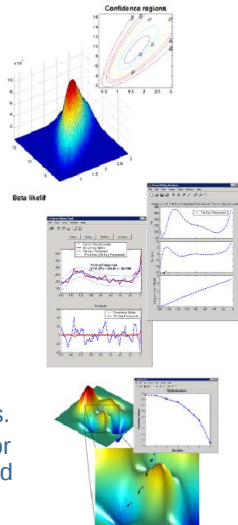
Visual Query Builder

- Access data without knowing SQL
 - Scroll through tables and fields
 - Customize your query using Where/Group
- Built-in visualization tools
 - Plotting and charting
 - Creating HTML reports
 - Handling date strings
- Reuse SQL statements in your own program



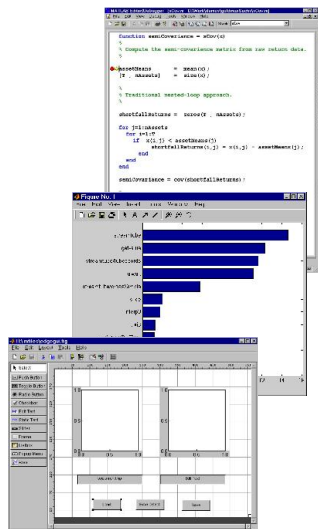
Data Analysis in MATLAB (library of functions)

- **Statistics**
 - analyzing historical data, modeling data, simulating systems, and developing statistical algorithms.
- **Curve Fitting**
 - routines for preprocessing data, as well as creating, comparing, analyzing, and managing models.
- **Optimization**
 - proven algorithms for general and large-scale optimization
 - linear programming, quadratic programming, nonlinear least-squares, and nonlinear equations.
 - Genetic algorithm tools with numerous options for creation, fitness scaling, selection, crossover, and mutation
- **Signal Processing, Neural Networks, Wavelets ..**



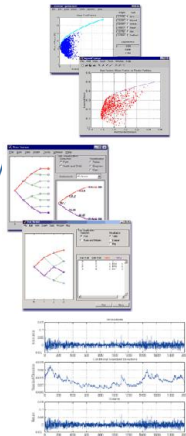
Complete Development Environment

- MATLAB Editor/Debugger
 - Capture work from history
 - Color coded
 - Break points
- Performance Tools
 - Profiler
 - M-Lint
- GUI Builder
 - Drag and drop graphical user interface
- Multi-platform Support
 - Windows, Unix, Linux, & Mac



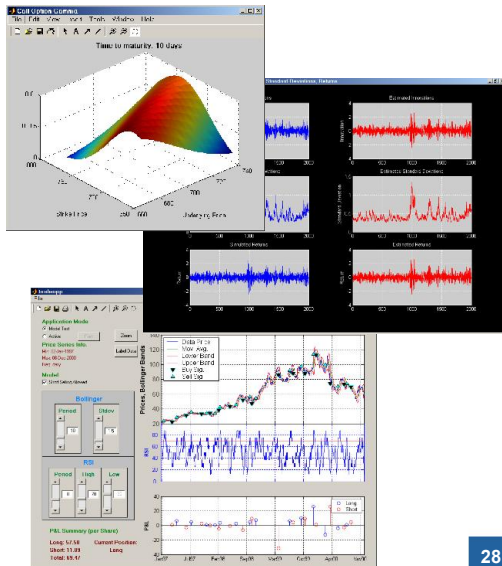
Financial Modeling with MATLAB (library of functions)

- **Financial**
 - perform portfolio optimizations, risk analyses, asset allocations, fixed income pricing, and much more
- **Fixed Income**
 - determine the price, yield, and cash flows for many types of fixed-income securities including mortgage-backed
- **Financial Derivatives**
 - analyzing and modeling equity and fixed-income derivatives and securities contingent on interest rates
- **GARCH**
 - perform Monte Carlo simulation of univariate returns, perform pre- and post-estimation diagnostic and hypothesis testing, estimate parameters of general ARMAX/GARCH models



Examples

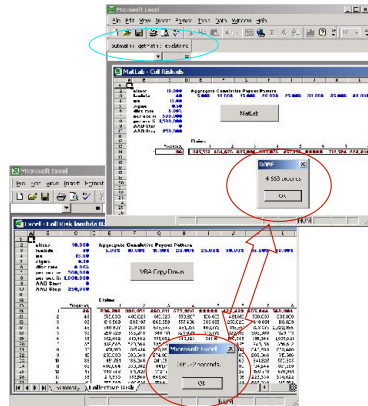
- Option modeling
- Fixed Income Analysis
 - Interest rate curves
- Volatility modeling
- Monte Carlo Simulations
 - Value at Risk (VaR)
 - Credit Risk
- Technical Analysis



Faster Simulation Times

Spread Sheet Applications

- MATLAB Excel Link can be the computational engine behind your Excel applications
- Faster scalable solution



Collective Risk Model
4.6 Seconds v.s 204.2 Seconds

Why MATLAB?



Quick Prototyping environment

- Less Programming
 - Matrix Based
 - Easy Syntax (no overhead)
 - 1000's Math & Graphics

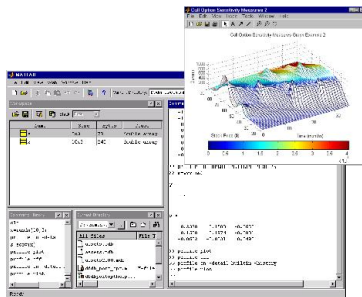


Fast computational engine



Work with various data sources

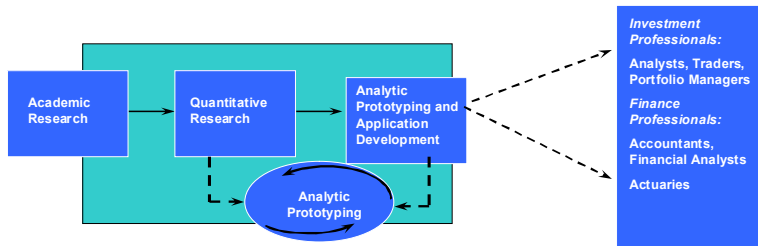
- Integrate with other programs
 - Excel, VB, & C/C++



Break

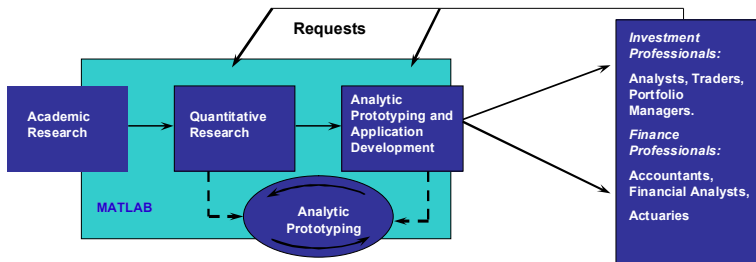
Application Deployment

Model Development Process



	Strength	Weakness
Excel	▪ Ease of use	▪ Limited functionality
Excel, C/C++, VB	▪ Deployment	
Application Specific Software	▪ Functionality	▪ Learning curve ▪ Deployment

MATLAB Prototype to Production



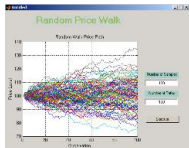
Traditional prototype to production system port
... development timeline **2 weeks ~ 6+ months**

MATLAB prototype to production system
... single command at the command line



The MATLAB Compiler

**Your
MATLAB
App**

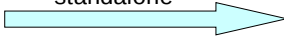


**Your
MATLAB
Functions**

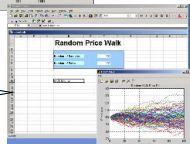
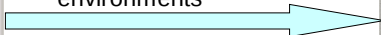
```

1 % Random Price Walk
2 % This function generates a random price walk.
3 % It takes the number of steps and the number of trials as input.
4 % It returns the price path and the average price.
5
6 % Check for correct input arguments
7 if nargin < 2
8     error('Not enough input arguments.')
9 end
10
11 % Generate random price paths
12 [pricePath, avgPrice] = randomPriceWalk(steps, trials);
13
14 % Display the results
15 figure;
16 plot(pricePath, 'b');
17 hold on;
18 plot(avgPrice, 'r');
19
20 % Check for correct output arguments
21 if nargout > 2
22     error('Too many output arguments.')
23 end
24
25 % Check for correct output arguments
26 if nargout < 2
27     error('Not enough output arguments.')
28 end
29
30 % End of function
    
```

Deploy as a
standalone



Integrate into other
environments



- Works with C/C++ compilers (Microsoft Visual Studio)
- Creates executables, components, or libraries
- Supports the entire MATLAB language (OOP's, JAVA, EVAL, ActiveX)
- Deploy applications at no cost



The Distributed MATLAB Application

- MATLAB Compiler command issued at the command prompt creates an executable, COM, or Lib

- **Create a stand-alone executable**

```
mcc -m yourapp.m
```

- **Integrate with other applications (.dlls, .so, etc)**

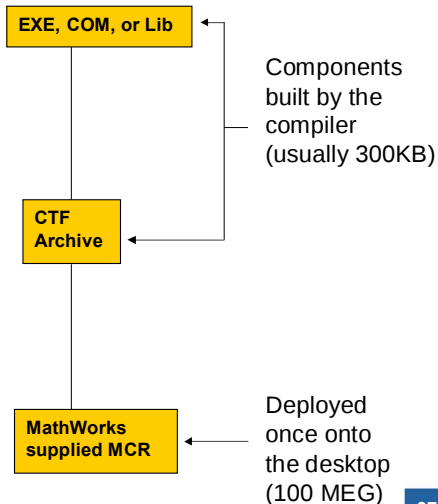
```
mcc -W lib:libfunction -T link:lib  
yourfunc1.m, yourfunc2.m
```

- MATLAB does not need to be available on the target user's desktop
- Generated binary, CTF, and MCR can be packaged and freely distributed to the target user's desktop



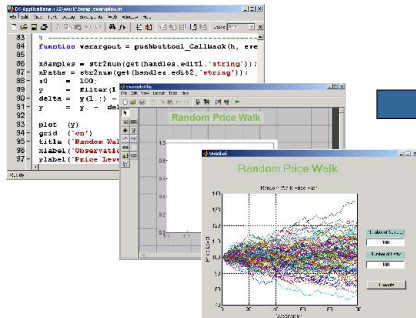
Compiler architecture ... 3 Components

1. Executable, Component or Library
2. Component Technology File (CTF)
 - CTF file contains all supporting m files, mex files, java files, MAT files, etc. that are needed to allow application to run.
 - Enables customers to protect their IP due to new encryption model used in building the CTF archive.
3. MATLAB Component Runtime (MCR)

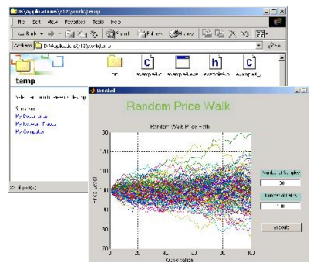


A Stand-alone Example

MATLAB Editor/GUI Builder



Stand-alone application

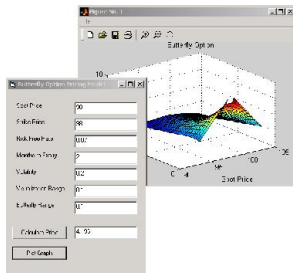


>> mcc -m rwalk2a.m

Integration With Other Environments



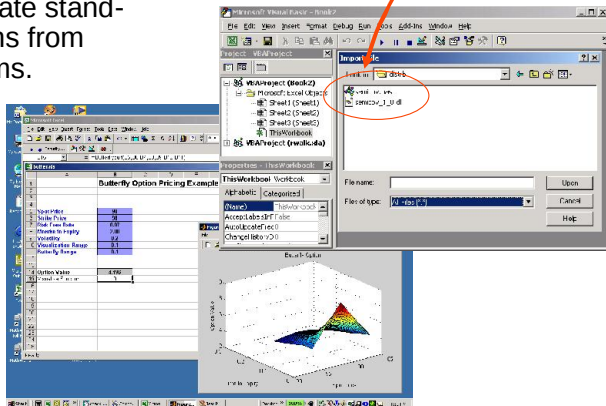
- MATLAB Compiler generated shared libraries (lib and DLL's) may be integrated with...
 - C/C++
 - Visual Basic
 - Excel



MATLAB Builder for Excel

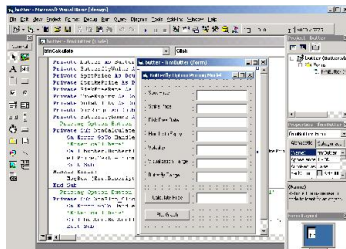
MATLAB Builder for Excel works with the MATLAB Compiler to generate stand-alone Excel add-ins from MATLAB algorithms.

VBA wrapper & .dll file

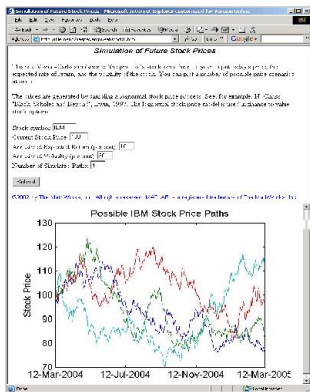


MATLAB Builder for COM

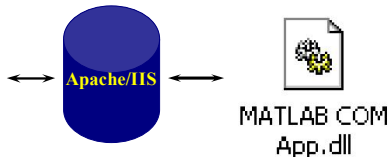
MATLAB Builder for COM works with the MATLAB Compiler to automatically generate COM wrappers for MATLAB algorithms.



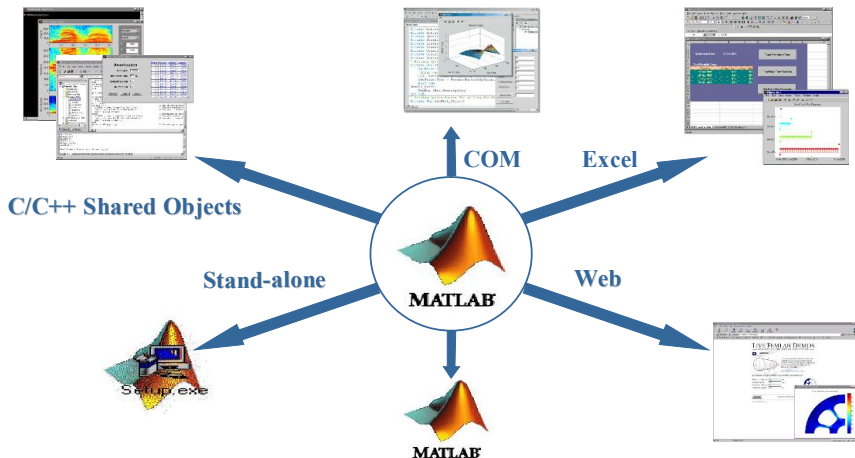
Web Deployment with MATLAB Builder for COM



MATLAB Builder for COM enables the development and distribution of Web-based MATLAB applications via ASP.



Deploying with MATLAB



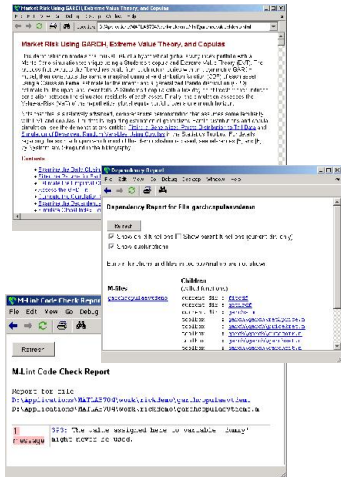
Reporting

- Documents for compliance and model verification
- Generating custom daily/nightly reports

Compliance and Model Verification

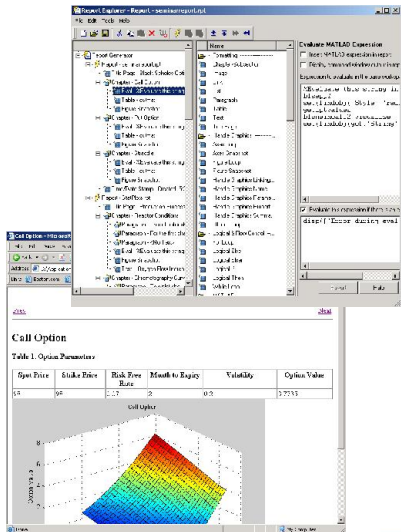
Presentation Quality Reports

- Documentation of code
 - Display code and comments
 - Headings, links, and fonts
 - Graphics
 - Multi –output formats
 - HTML, XML, Word, LaTeX, PowerPoint
- Create dependency reports
 - Understand parent/child relationships
- Performance reports
 - Recommendations for improvements
 - Check unused variables



Custom Report Generation

- Template based report design
 - Develop report outline
 - Reusable templates
- Scripting features
 - Chapters
 - Text, tables, links, graphs, code, etc
- Multiple output formats
 - HTML
 - XML
 - RTF



Distributed Computing

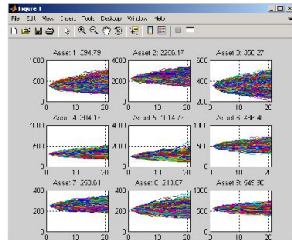
Applications for Distributed Computing

Address the need to solve computationally intensive problems:

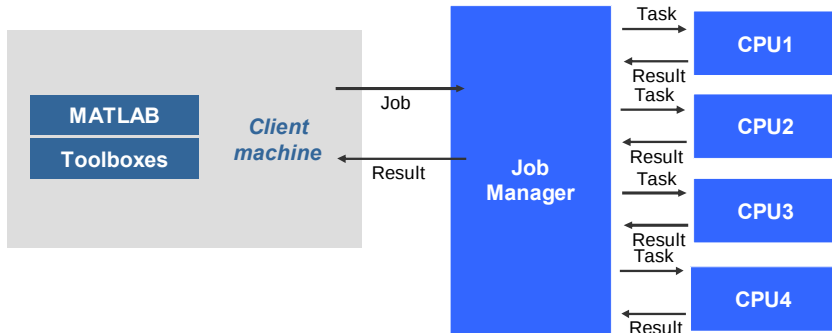
- Enhance productivity
- Improve performance

Examples: (Monte Carlo simulations)

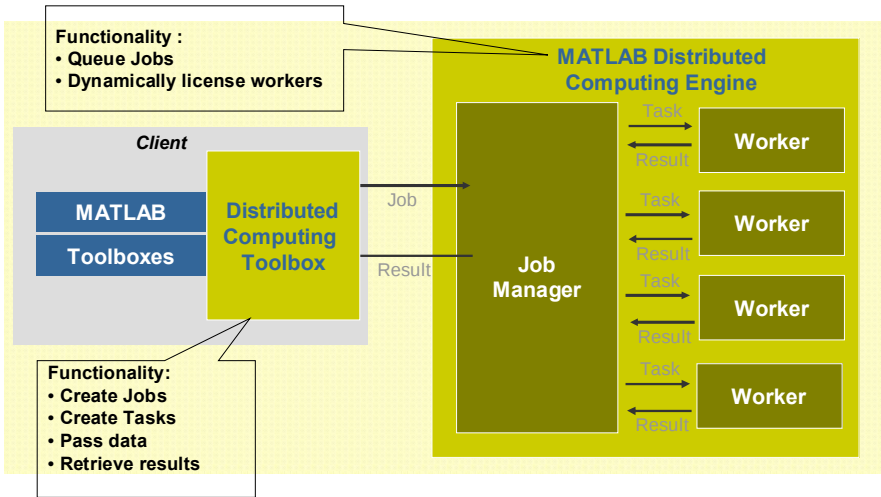
- Risk management simulations
- Derivatives pricing simulations
- Portfolio optimization problems



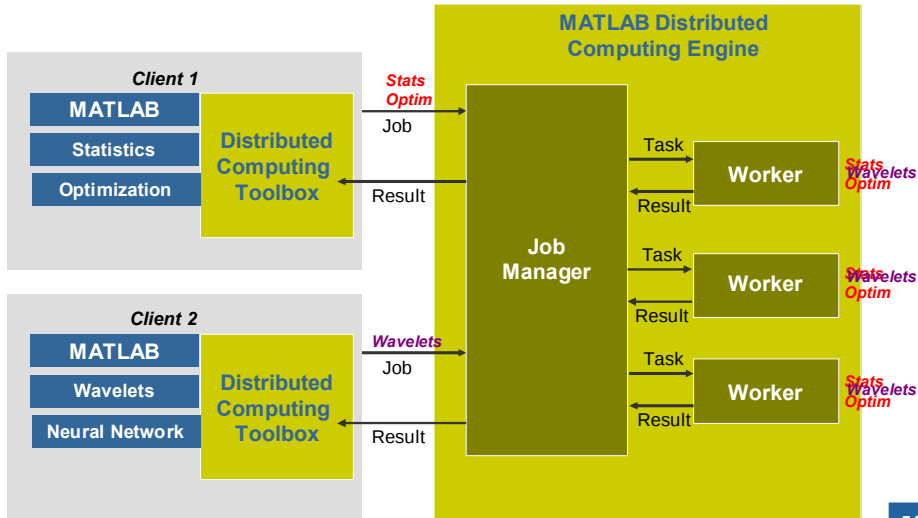
Coarse-grained Distributed Computing



Coarse-grained Distributed Computing Solution

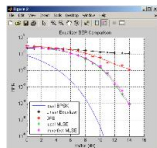


Dynamic Licensing

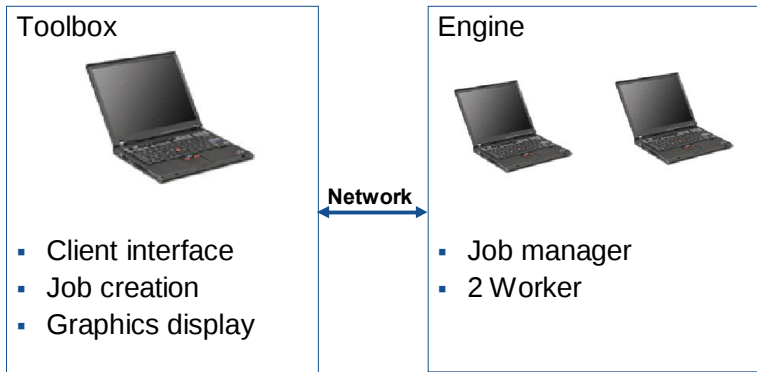


Key Features

- Dynamic licensing
 - Engine is the only product required in the cluster
 - Eliminates the need to buy multiple toolboxes licenses for worker nodes
- Access to single or multiple clusters by single or multiple users
- Distributed processing on both homogeneous and heterogeneous platforms
- Support for both synchronous and asynchronous operations
- Control of the distributed computing process via a function-based or object-based interface

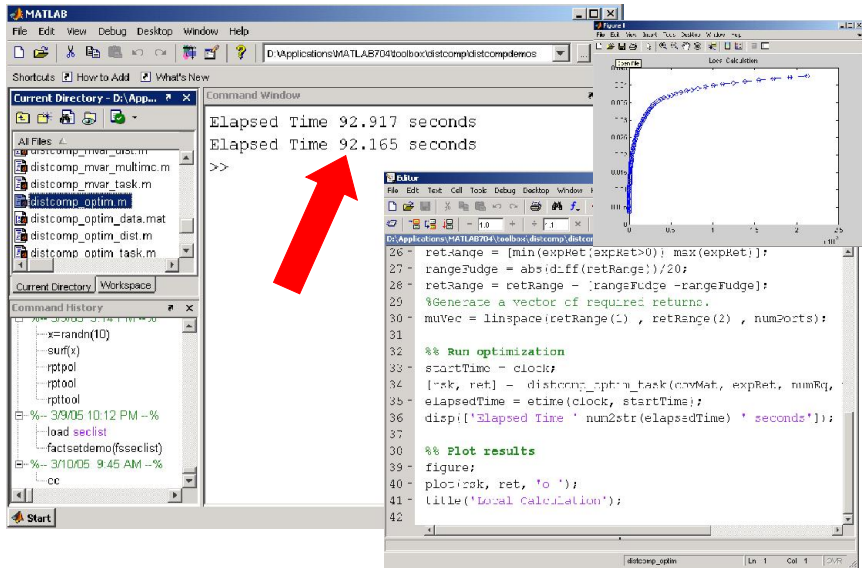


Demonstration



- **Functional interface**
- **Object interface**
- **Single CPU**
- **Multi-CPU**

Portfolio Optimization (non-distributed)



The screenshot displays the MATLAB environment with the following components:

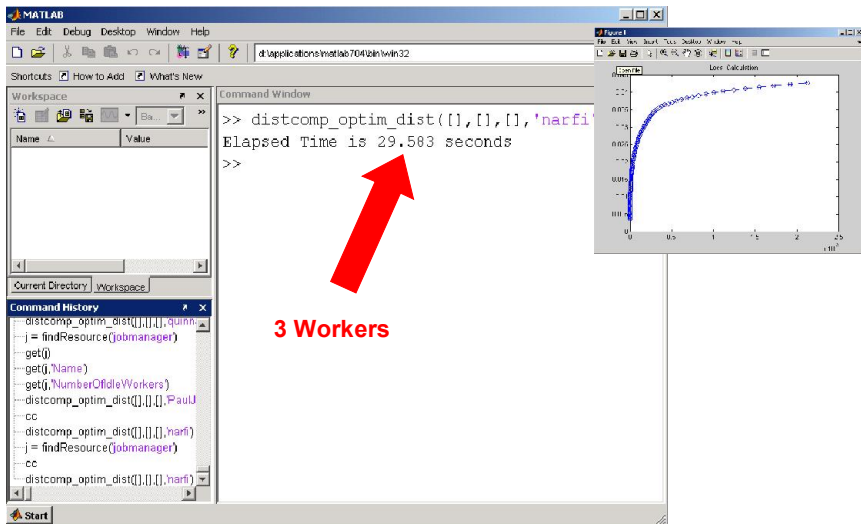
- Current Directory:** Shows files in the path `D:\Applications\MATLAB704\toolbox\distcomp\distcomp\demo`. The file `distcomp_optim.m` is selected.
- Command Window:** Displays the execution results:


```
Elapsed Time 92.917 seconds
Elapsed Time 92.165 seconds
>>
```

 A red arrow points from the Command Window to the Editor window.
- Editor:** Shows the MATLAB script `distcomp_optim.m` with the following code:


```
26- retRange = [min(expRet(expRet>0)) max(expRet)];
27- rangeFudge = abs(diff(retRange))/20;
28- retRange = retRange - [rangeFudge -rangeFudge];
29- %Generate a vector of required returns.
30- muVec = linspace(retRange(1), retRange(2), numPorts);
31
32- %% Run optimization
33- startTime = clock;
34- [ask, ret] = distcomp_optim_task(omyMat, expRet, numRq,
35- elapsedTime = etime(clock, startTime);
36- disp(['Elapsed Time ' num2str(elapsedTime) ' seconds']);
37
38- %% Plot results
39- figure;
40- plot(ask, ret, 'o ');
41- title('Local Calculation');
```
- Figure Window:** Displays a plot titled "Local Calculation" showing a curve of required returns (ask) versus expected returns (ret). The x-axis ranges from 0 to 2.5, and the y-axis ranges from 0 to 0.02.
- Command History:** Shows the sequence of commands executed, including `x=randn(10)`, `surf(x)`, `rptool`, `load seclist`, `factsetdemo(fsseclist)`, and `cc`.

Portfolio Optimization (distributed)



Distributed Computing Tools Summary

- Execute independent MATLAB algorithms models in a computer cluster
 - Performance improvement
 - Enhanced productivity
- This is the first release of a milestone product
 - Supports coarse-grained applications
- Trial versions are now available!



Wrap Up

MATLAB for Business Applications

Business Tools on the Desktop

- Excel
- Word
- Browsers

- Live Market Data

- Databases
 - Oracle
 - Microsoft Access
 - Microsoft SQL Server
 - Sybase SQL Server
 -

MATLAB Tools

- Excel Link & Data Import Tool
- Publisher, copy figure
- Publisher and Report Generator

- Datafeed Toolbox

- Database Toolbox
 - ODBC & JDBC
 - ...

Benefits of MATLAB

- Interactive environment
- An extensive library of viewable code that can be used “as is” or modified to incorporate business models
- Matrix based — handle and manipulate large data sets
- First rate graphics engine
- A considerably shorter application development process resulting in rapid delivery of model to the end user desktop

The MATLAB Advantage

- **Develop models faster**
- **Run large scale simulations**
- **Reduces the costs of model integration**

Representative Customers

- **Federal Reserve Bank**
- **Goldman Sachs**
- **J.P. Morgan Chase**
- **State Street**
- **Salomon Smith Barney**
- **Merrill Lynch**
- **Ernst & Young**
- **Deloitte & Touche**
- **Lehman Brothers**
- **Putnam Investments**
- **Prudential Securities**
- **Bank of America**
- **Freddie Mac**
- **Fannie Mae**
- **Moody's Investors**
- **Scudder Investment**
- **Price Waterhouse
Coopers**

Insurance and Energy Trading Companies

- Allstate Insurance
- American RE
- AXA
- Element RE
- John Hancock
- Kemper RE
- Liberty Mutual
- New York Life
- Zurich RE
- Williams Energy
- Reliant Energy
- TXU
- Mirant
- ExxonMobil
- Entergy Koch
- Constellation Power Source
- Sempra Energy
- Allegheny Energy
- Dominion Energy

Representative U.K. & US Business Schools

- **Judge Institute, University of Cambridge**
- **Cornell University, Johnson School of Business**
- **Sloan School (MIT)**
- **Carnegie Mellon University**
- **London Business School**
- **Harvard Business School**
- **Imperial College, Centre for Quantitative Finance**
- **Warwick Business School**
- **University of California at Berkeley**
- **University of Chicago, GSB**
- **Cass Business School**

Support and Community



 The MathWorks
Consulting Services

- Engineering expertise and deep product knowledge, specializing in:
 - Application development using MATLAB
 - Model-based design using Simulink and Stateflow
 - Embedded-system development
 - Enterprise-wide integration of MathWorks products into engineering process and systems
 - Jumpstart services
- Project-based services for a growing number of industries, including Aerospace and Defense, Automotive, Communications, Power and Marine, and Financial Services



Three ways to get training

- **Public Training**
 - Offered throughout the world
 - Schedule and course information at <http://www.mathworks.com/training>
- **On-Site Training**
 - Bring training to your site, with course customization available
- **Web-Based Training**
 - Instructor-led e-learning
 - Train at work or at home, with flexible dates and times

Financial Modeling and Analysis

Course Name	Length
MATLAB Fundamentals and Programming Techniques for Financial Applications	2 days
MATLAB Based Optimization Techniques	1 day
Statistical Methods in MATLAB	1 day
MATLAB for Application Integration and Distribution	1 day
Advanced MATLAB Programming Techniques	1 day
MATLAB for Building Graphical User Interfaces	1 day



File exchange and newsgroup access for MATLAB and Simulink users

- 130,000 visits per month
- Over 2,800 files in the exchange
 - General-purpose functions, industry- and application-specific tools and examples
 - 100 new submissions per month
 - 5,000 downloads per day
- 5,000 posts to “CSSM” (comp.soft-sys.matlab) per month, 60% routed through MATLAB Central

 The MathWorks
Connections Program

Over 300 add-on products and services from partners that complement and extend MathWorks products

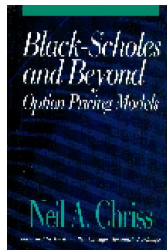
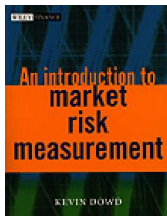
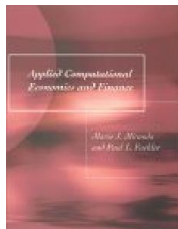
- Specialized third-party toolboxes for MATLAB
- Interfaces to partners' software and hardware products
- Specialized training courses and consulting services
- System integrators and suppliers that incorporate MathWorks products

 The MathWorks
Book Program

www.mathworks.com/books

750+ textbooks for educational and professional use, in 20 languages

- An Introduction to Market Risk Measurement
- Applied Computational Economic and Finance
- Pricing Derivatives Securities
- Black Scholes and Beyond



Technical Support

• Technical Support

- 90% of problems solved in 24 hours
- 60+ Application Engineers on staff, ½ with Masters Degrees

• World Wide Web (www.mathworks.com)

- 24x7 self-service technical support
- over 9,000 technical solutions
- software archive (ftp.mathworks.com)
- MATLAB Digest – electronic newsletter

• Newsgroup (comp.soft-sys.matlab)



Further information

- Stay for questions
- Visit MATLAB Central for some of the tools you've seen today
- Trials, onsite demonstrations, technical literature:

John.Cunningham@mathworks.com

508.647.7122 or visit:

<http://www.mathworks.com/products/industry/finance>

- Company and product information:
www.mathworks.com

