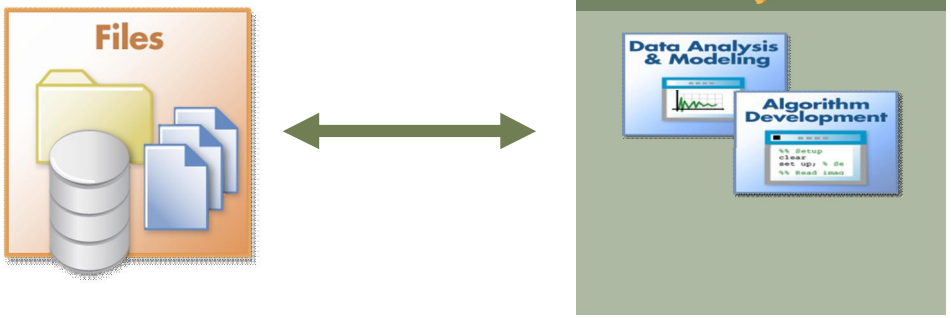
Production Deployment of MATLAB Algorithms

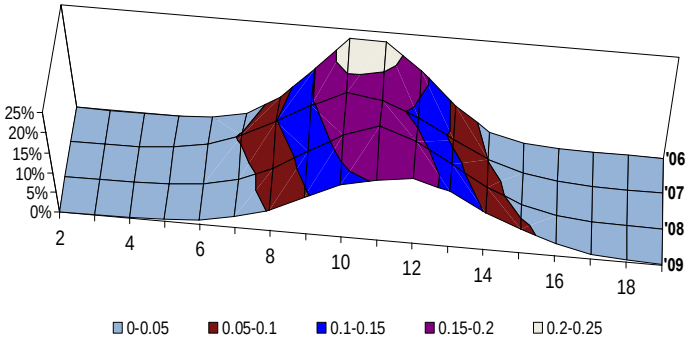
Eugene McGoldrick

MathWorks Evolution in Financial Services

1995



- Quick prototyping environment
  - Data pulled from flat files, Excel
    - Limited financial functionality
      - Ad-hoc research tool



MATLAB & Finance

Today

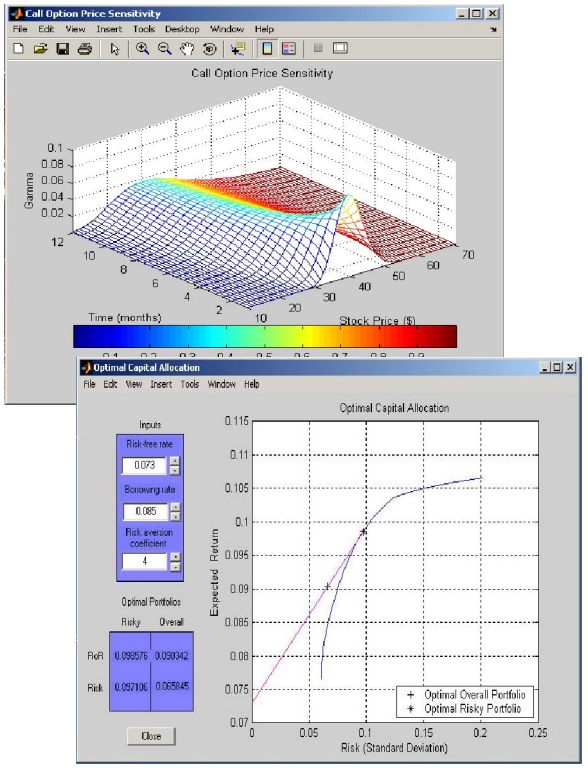
- Financial market is the 3rd largest Industry for the MathWorks

- Strong growth in all countries, and has become largest industry in many countries for the company

- Over 5000 financial companies worldwide use MathWorks software for financial modeling

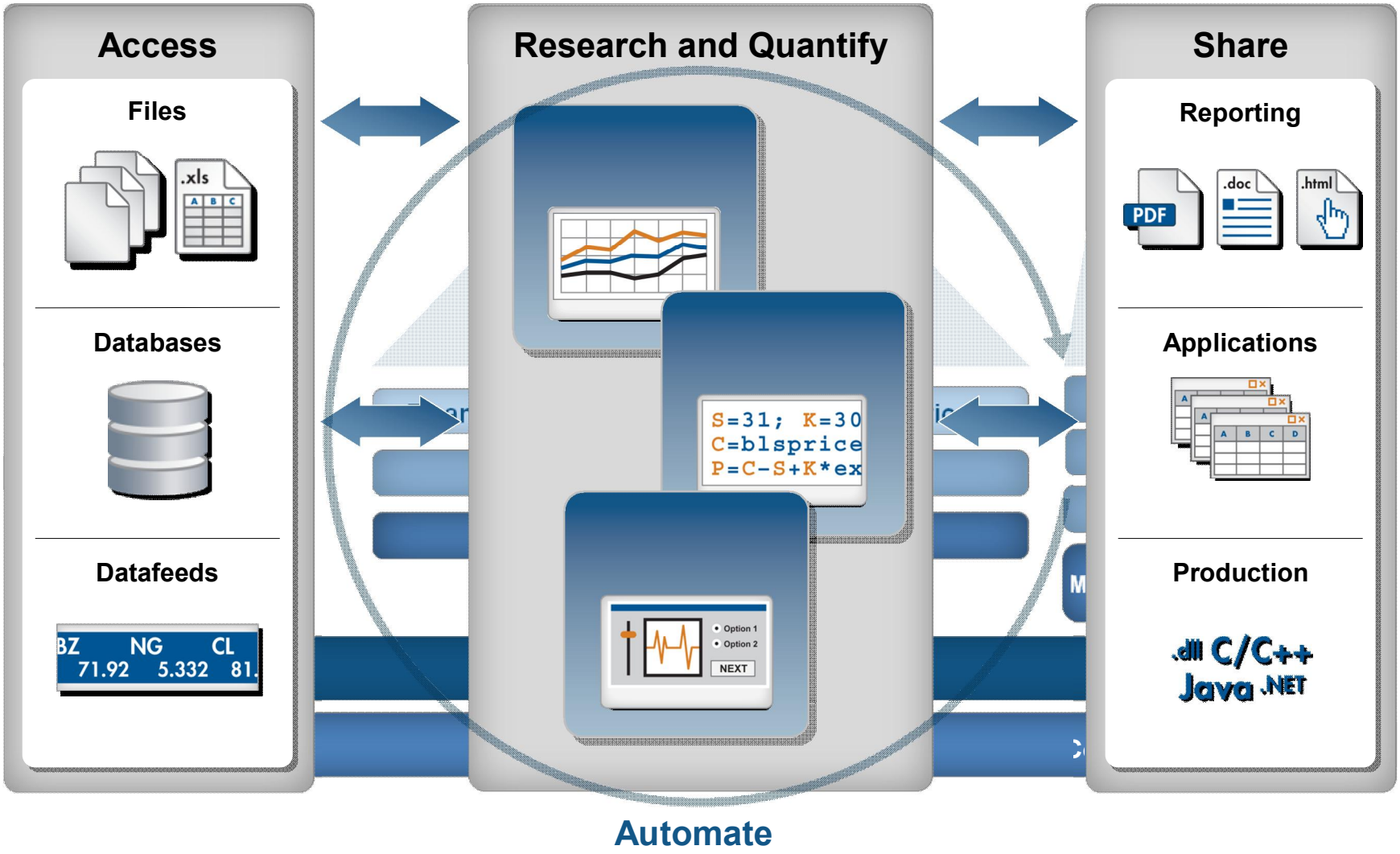
- MATLAB is now recognized as one of the leading financial development platforms.

- 3rd party vendors constantly talk to us about integrating into the MATLAB platform.

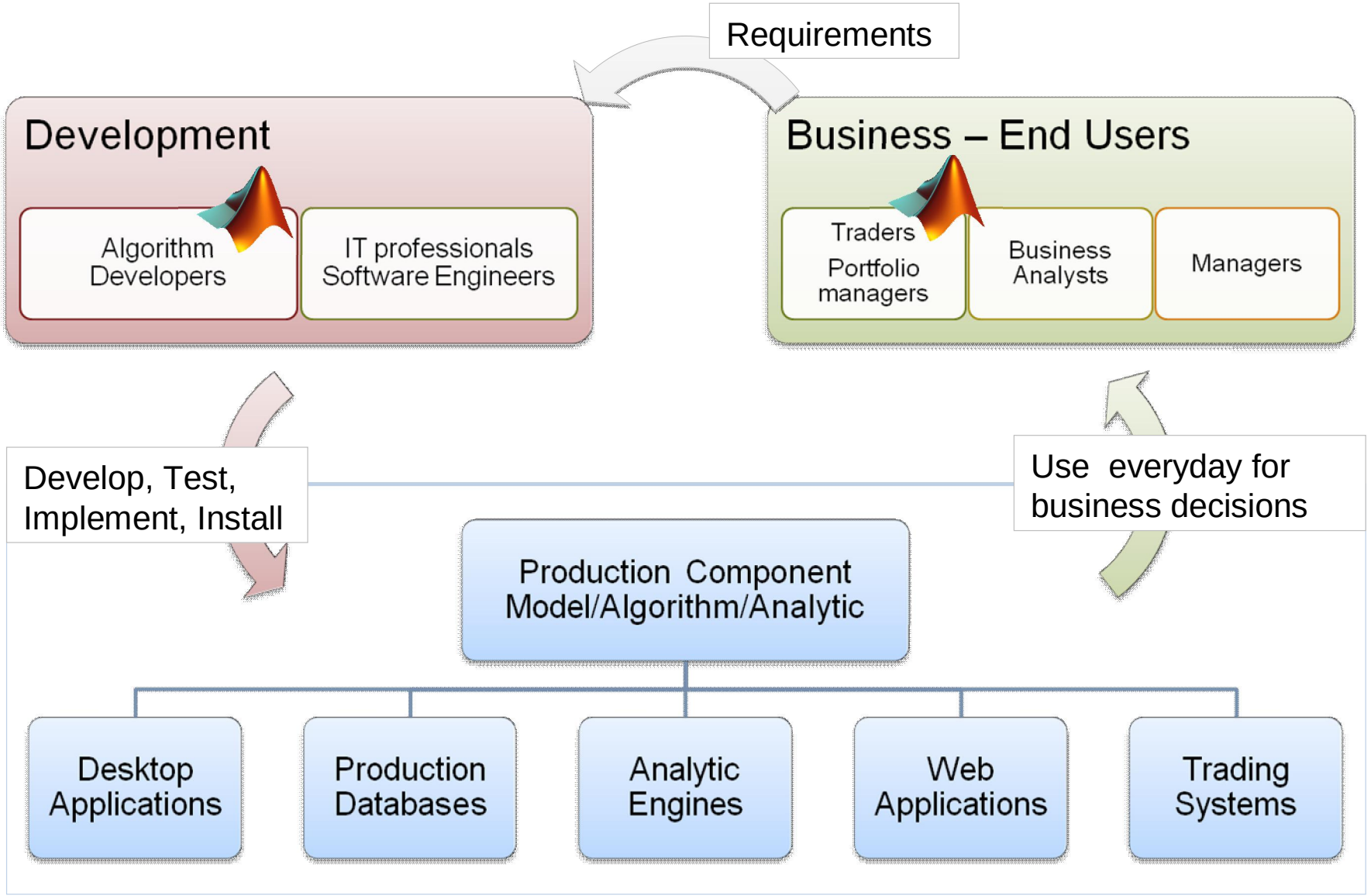


Capturing and Sharing Innovation

Customizing the foundation for your needs

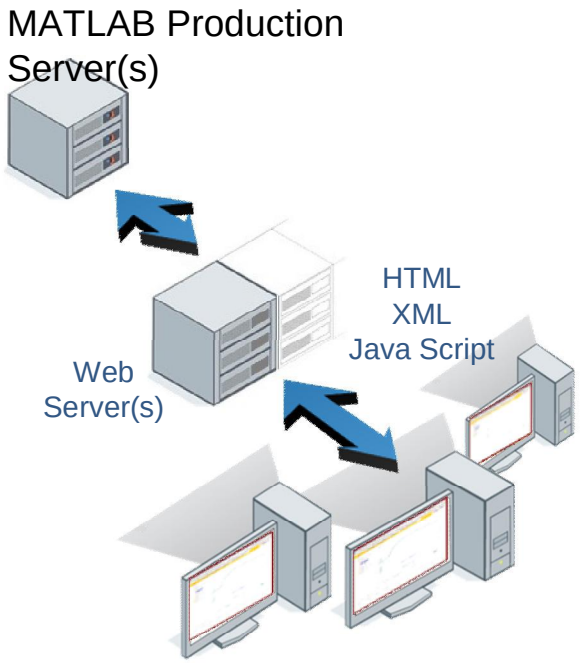


Integrating MATLAB into production systems



MATLAB Production Server

- Directly deploy MATLAB programs into production
  - Centrally manage multiple MATLAB programs & MCR versions
  - Automatically deploy updates without server restarts
- Scalable & reliable
  - Service large numbers of concurrent requests
  - Add capacity or redundancy with additional servers
- Use with web, database & application servers
  - Lightweight client library isolates MATLAB processing
  - Access MATLAB programs using native data types



Benefits of the MATLAB Production Server

- Enterprise class framework for running packaged MATLAB programs

- Server software
  - Manages packaged MATLAB programs & worker pool

- Manages MATLAB Runtime libraries for multiple releases
  - MATLAB Compiler Runtime (MCR) for various versions of MATLAB from R2012b onward live on the server.
  - Compiled MATLAB analytics from different versions of MATLAB from R2012b onward can co-exist on the server.

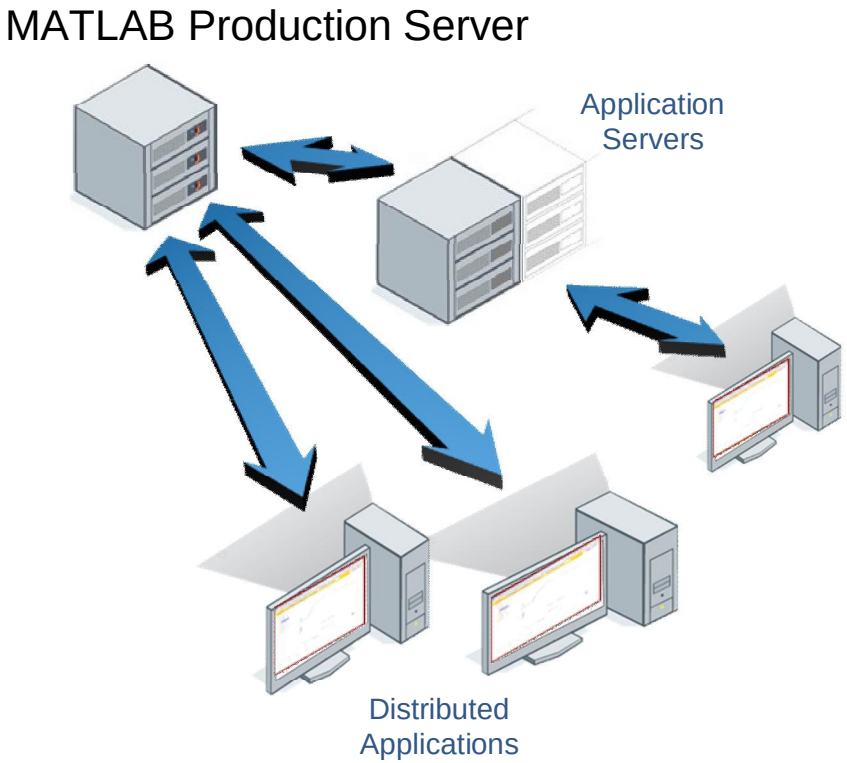
- Lightweight client library for both .NET and Java frameworks are supported.

- Reduces the Total Cost Of Ownership for building and supporting in-house financial analytics development and deployment.

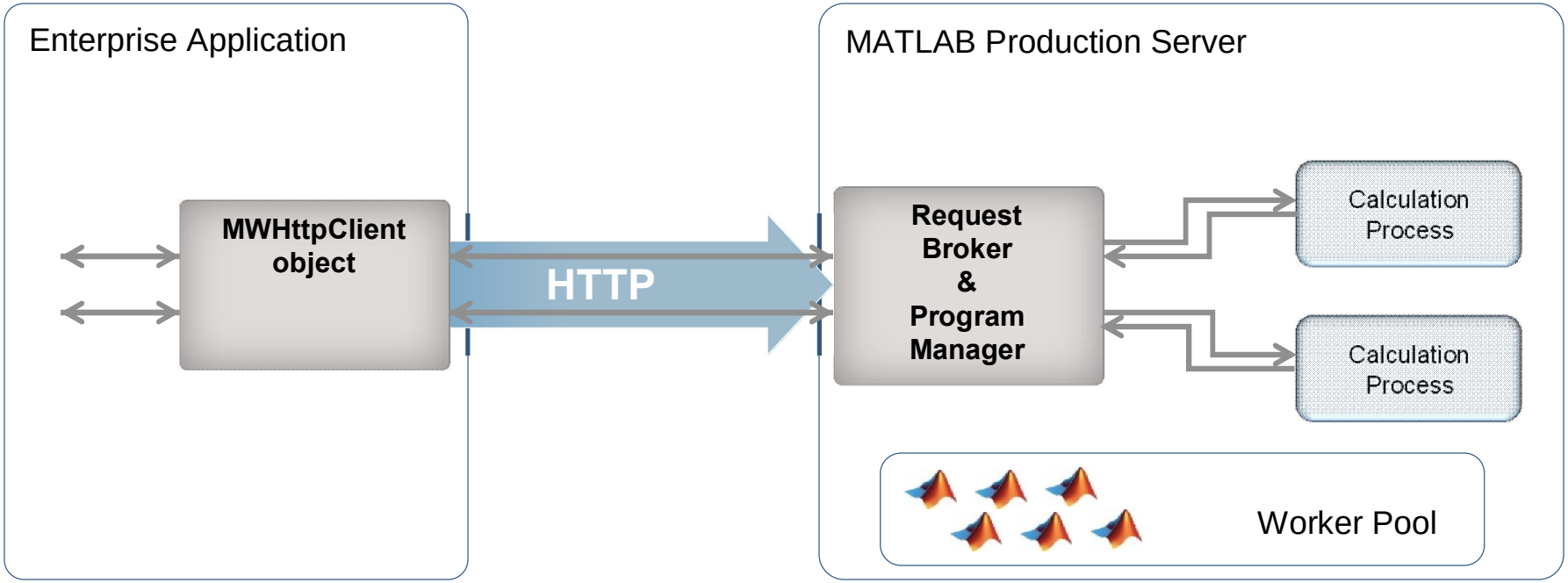
Central Management

Centrally run and manage numerical algorithms

- Simplifies applications
  - Analytics run within datacer
  - UI and business functionali
- Simplifies change management
  - Independent update of numerics



Calling Functions

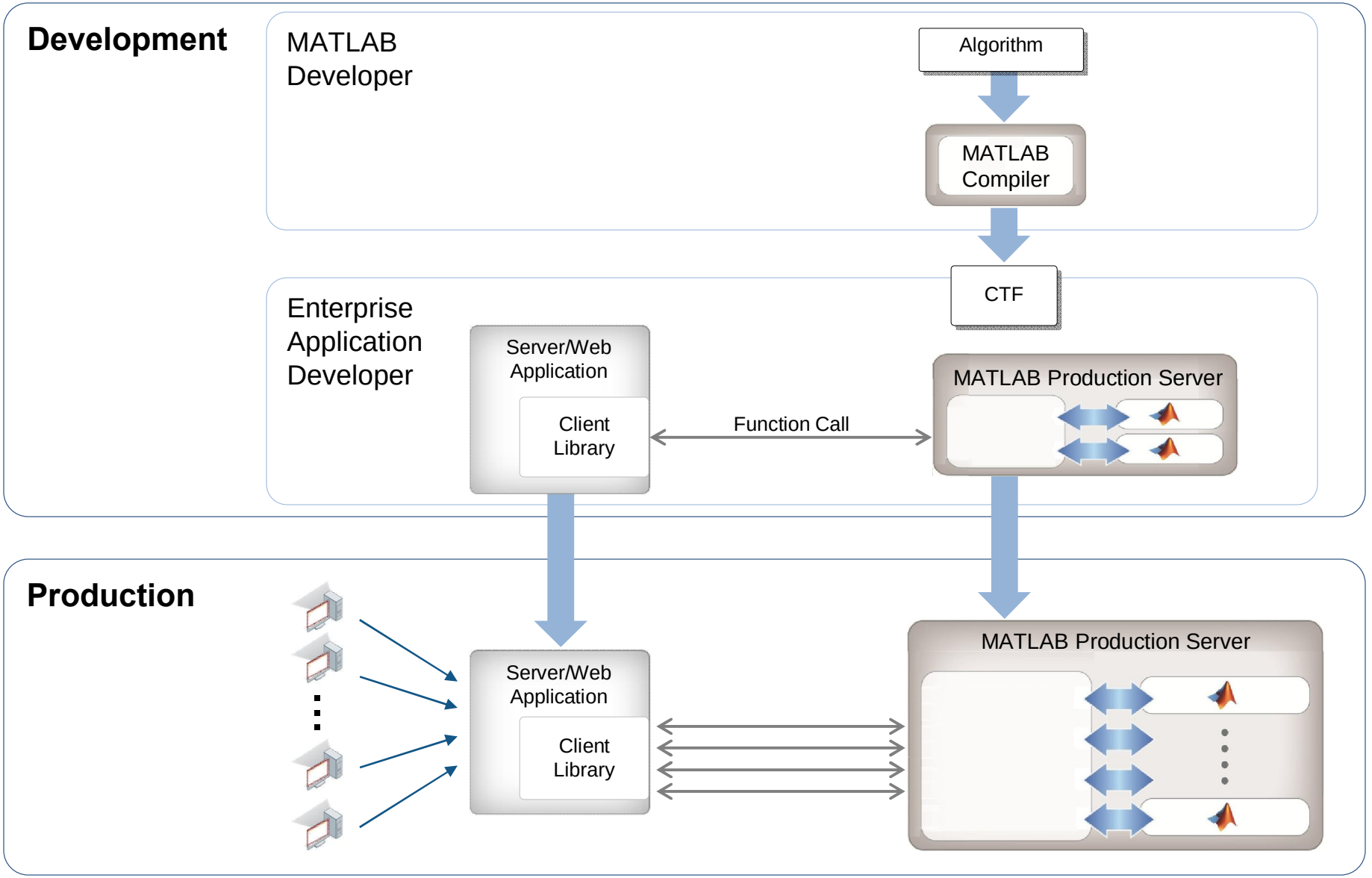


Reduce Cost of Building and Deploying In-House Analytics

- Single development environment for model development and testing.
- Quants/Analysts/Financial Modelers do not have to rewrite code in another language.
- IT can efficiently integrate models/analytics in to production system
- Time to deploy greatly reduced
  - Only need to supply function signature from Quant to IT for implementation into Enterprise system
  - Updates easily implemented and redeploy new model version

MATLAB Development to Production Workflow

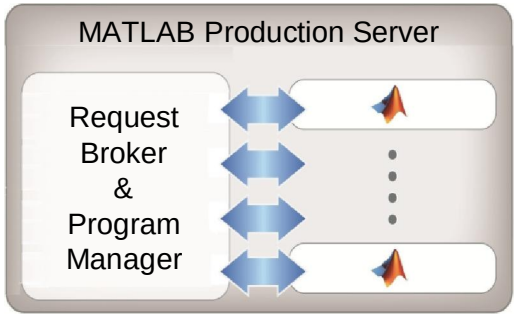
Production Deployment Workflow



MATLAB Production Server for development and testing analytics can be a small 4 worker thread system

MATLAB Developer
MATLAB & Toolboxes, Access to Compiler

MATLAB Developer:
Builds, tests models in MATLAB, Compiles them with the compiler into a MPS ctf file and deploys it to the server



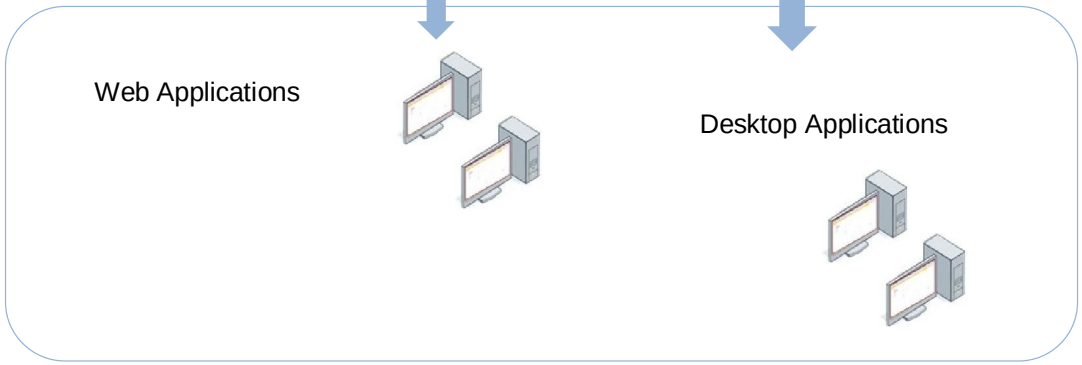
MATLAB Developer:
Describes function signature to the Systems developer so that they can integrate MPS models into variety of front end/Server Applications

Systems Developer
Visual Studio Tools, Web Development Tools

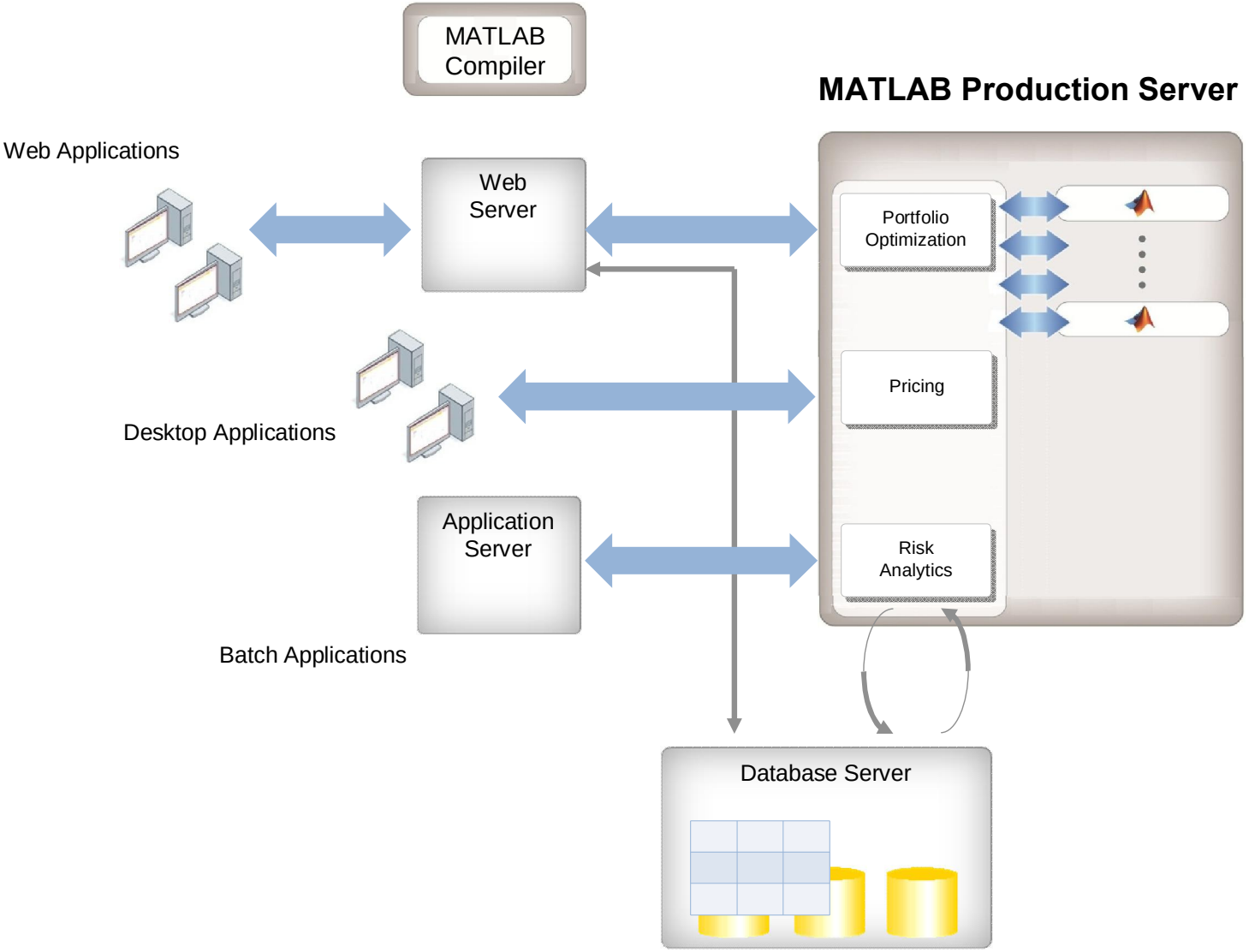
Web Server

Models reside on the server and can be updated regularly by the development team without bringing the server down

Integrates MPS functions into C#/.Net or JAVA Framework so that they can be called from a variety of different client applications



Sharing algorithms across the organization



Easy integration into existing Enterprise Systems

Integration Example … Java

- Reference client library
- Define function signatures
- Define connection (server & CTF)

MATLAB Function

```
function B = BlackScholes(CP,S,X,T,r,v)

d2=d1-v*sqrt(T);
if CP=='c'
B = (S*normcdf(d1)-X*exp(-r*T)*normcdf(d2))-noise;
```

Enterprise Application

```
import com.mathworks.mps.client.MWClient;
import com.mathworks.mps.client.MWHttpClient;
import com.mathworks.mps.client.MATLABException;;

   public interface BlkSchInterface
    {        double BlackScholes(string C, double S, double X, double T, double r, double v); }

   MWClient client = new MWHttpClient();
   BlkSchInterface blksch_1 = client.CreateProxy(new URL("http://192.168.240.220:9910/BlkSch1"), BlkSchInterface);
   double optionprice = blksch_1.BlackScholes("c", BasePrice.Value, 1, 1, 1, Volatility.Value));
```

Integration Example … .NET

- Reference client library
- Define function signatures
- Define connection (server & CTF)

MATLAB Function

```
function B = BlackScholes(CP,S,X,T,r,v)

d2=d1-v*sqrt(T);
if CP=='c'
B = (S*normcdf(d1)-X*exp(-r*T)*normcdf(d2))-noise;
```

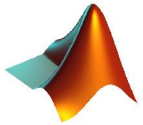
Enterprise Application

```
using Mathworks.MATLAB.ProductionServer.Client;

   public interface BlkSchInterface
    {        double BlackScholes(string C, double S, double X, double T, double r, double v); }

   MWClient client = new MWHttpClient();
   BlkSchInterface blksch_1 = client.CreateProxy<BlkSchInterface>(new Uri("http://192.168.240.220:9910/BlkSch1"));
   double optionprice = blksch_1.BlackScholes("c", BasePrice.Value, 1, 1, 1, Volatility.Value));
```

Workflow for Embedding MATLAB Components in Production Systems

The development to production process is a two step process

- Step 1: Bring Data to MATLAB
  - Multiple data sources
  - Build algorithms/models
  - Test
  - Compile to target platform component



- Step 2: Bring algorithm to the Data
  - Install MATLAB component into the enterprise production applications.
  - Same functionality/single source

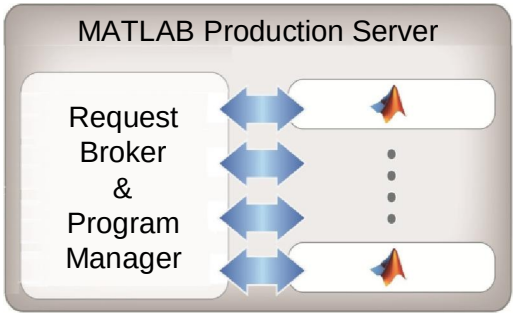
Easy to configure to existing hardware

Flexible System to Manage

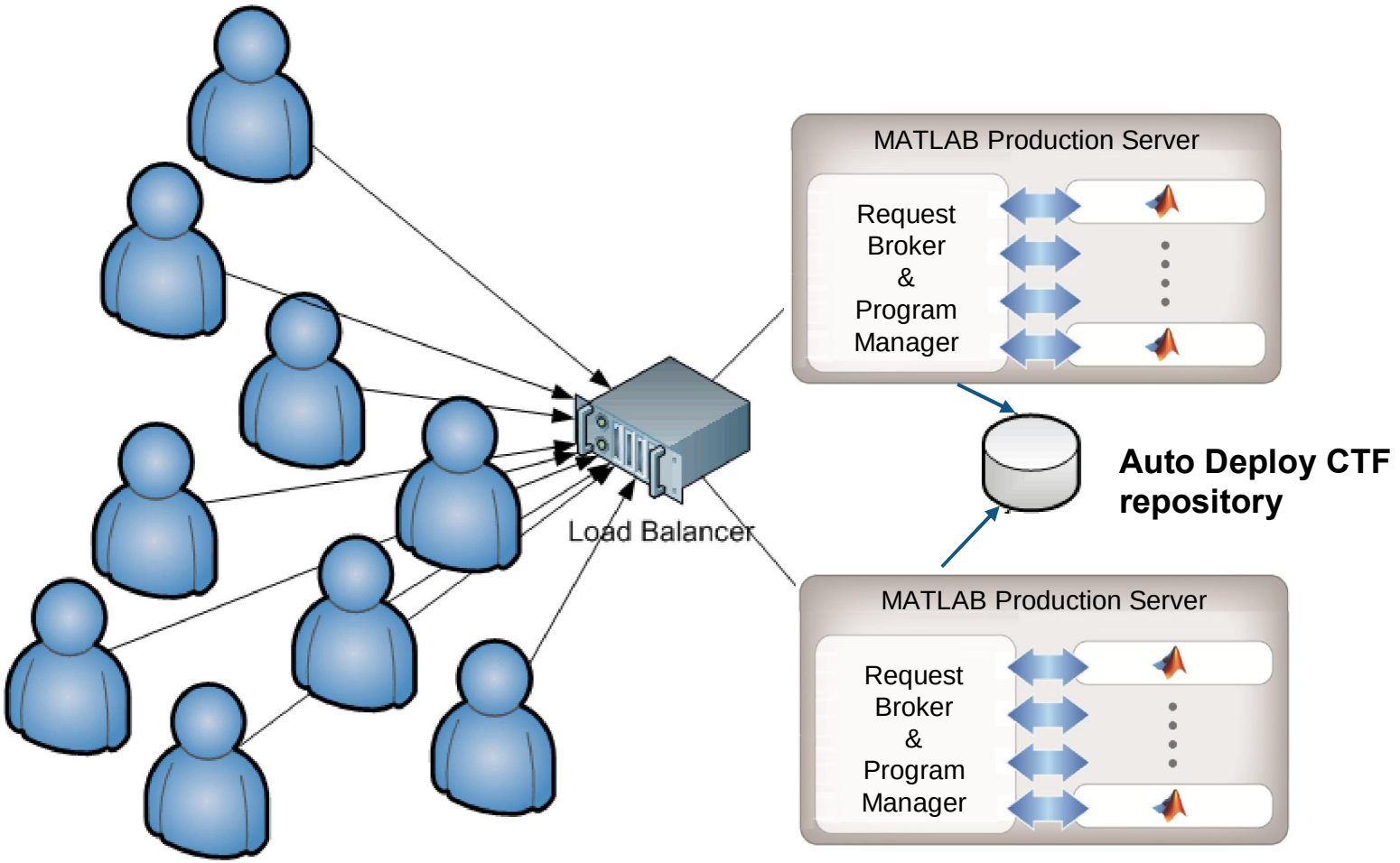
- Licensed on workers/worker threads not on Broker process
- Infinitely configurable to take advantage of existing in-house hardware
- Hosted Analytics platform that can be installed enabling rapid updating and deployment of analytics/models
- Accessed by any front end application by means of thin client communications library.

MATLAB Production Server … Customer Configurations (1)

- Request Broker and 24 worker processes
- Can have multiple instances of the MATLAB Production Server
  - 2 request brokers and twelve worker servers
  - 3 request brokers and eight worker servers
  - 4 request brokers and six worker servers
  - 6 request brokers and four worker servers
- Increase capacity by increasing number of servers and combining them
  - One request broker and 48 worker processes



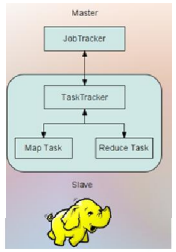
MATLAB Production Server … Customer Configurations (2)

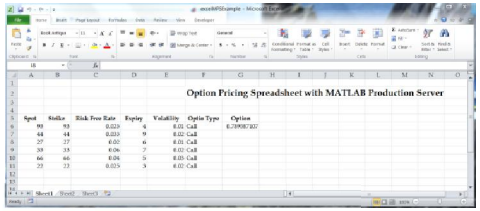


Customer use cases

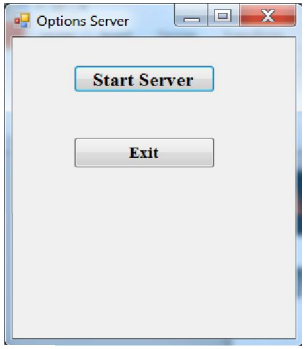
MATLAB Production Server Use Cases

Big Data …
HADOOP

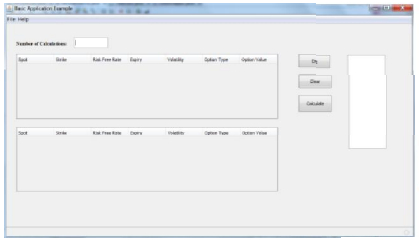




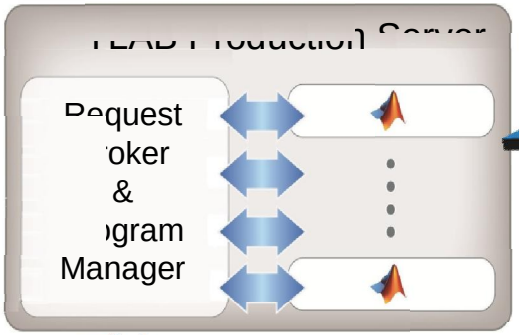
Spreadsheet Applications

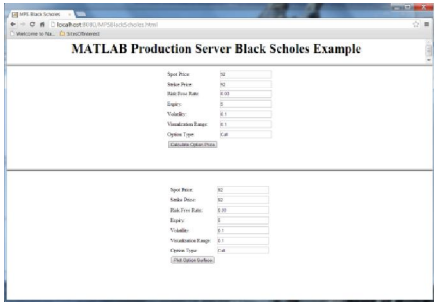


Application Servers



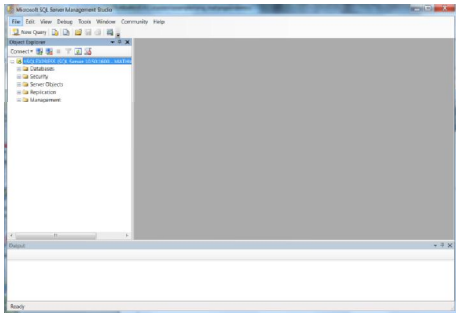
Client Front End
Applications





Web Applications

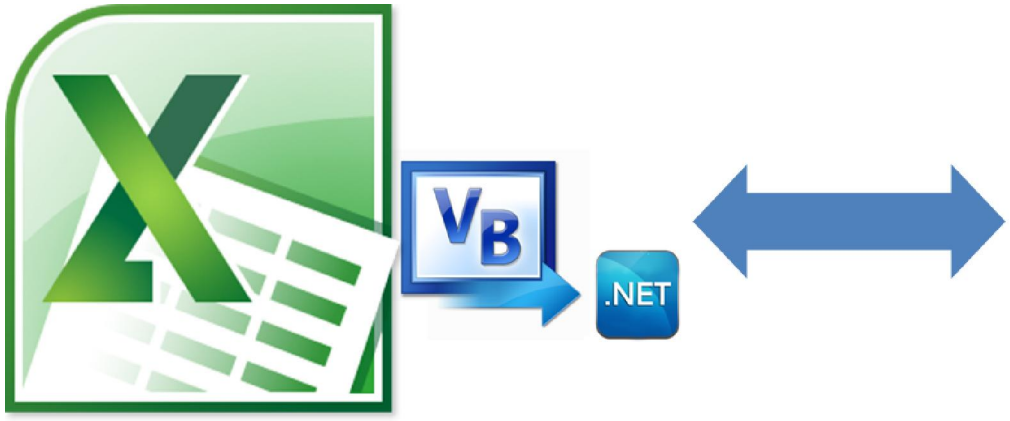
MSMQ, JMS, IBM MQ

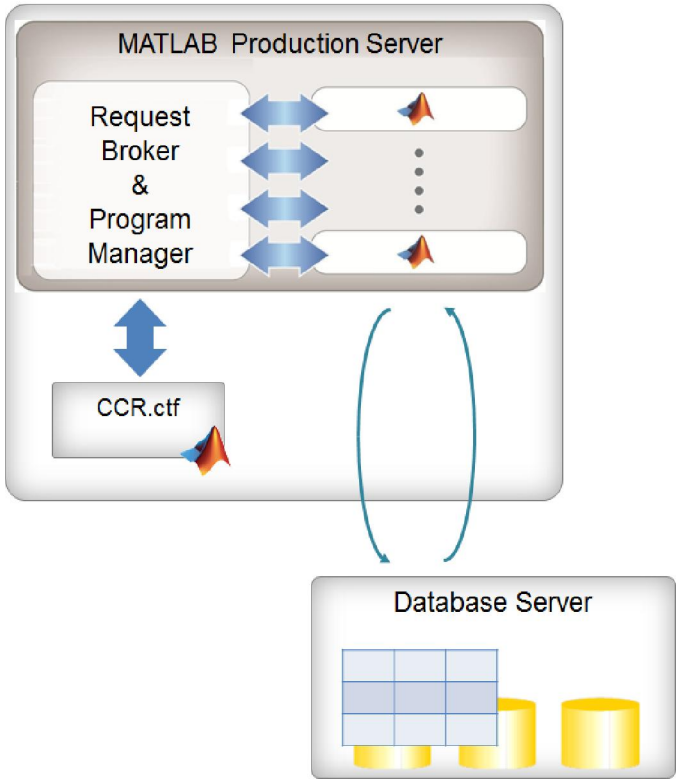


Database Servers

Enterprise Service/Messaging Buses

Trader: Architecture

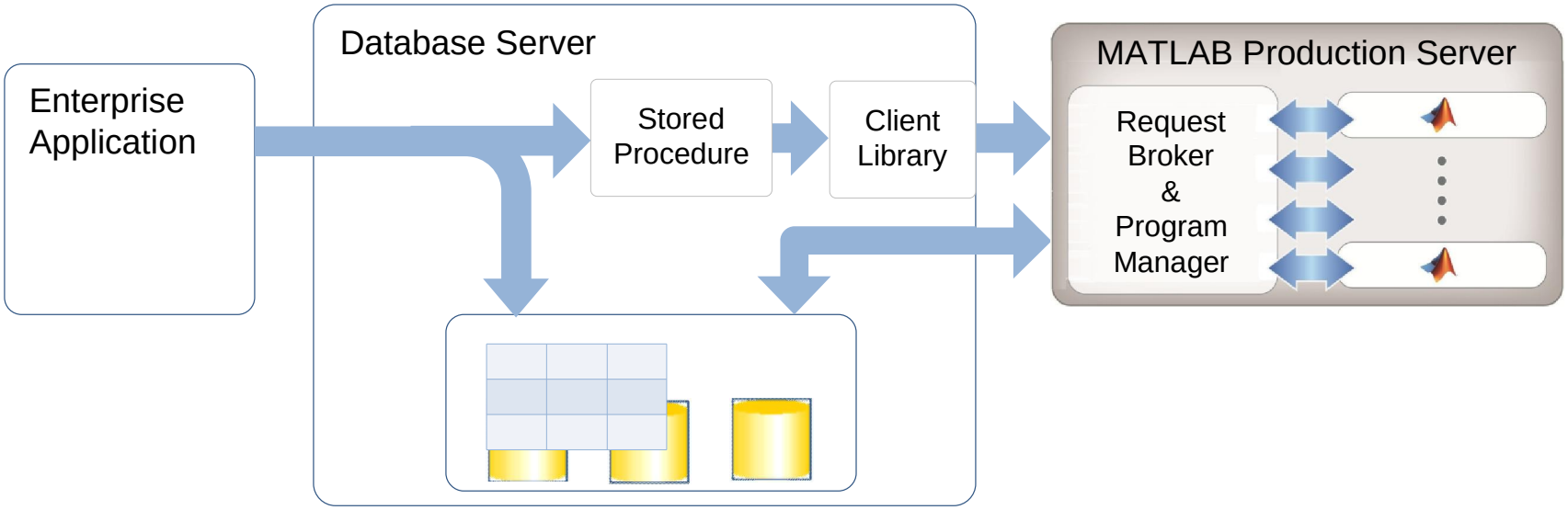




- VB to the .NET client library
- Adds trade to portfolio
- New exposures & CVA
- Small data transfer

Integration with Databases

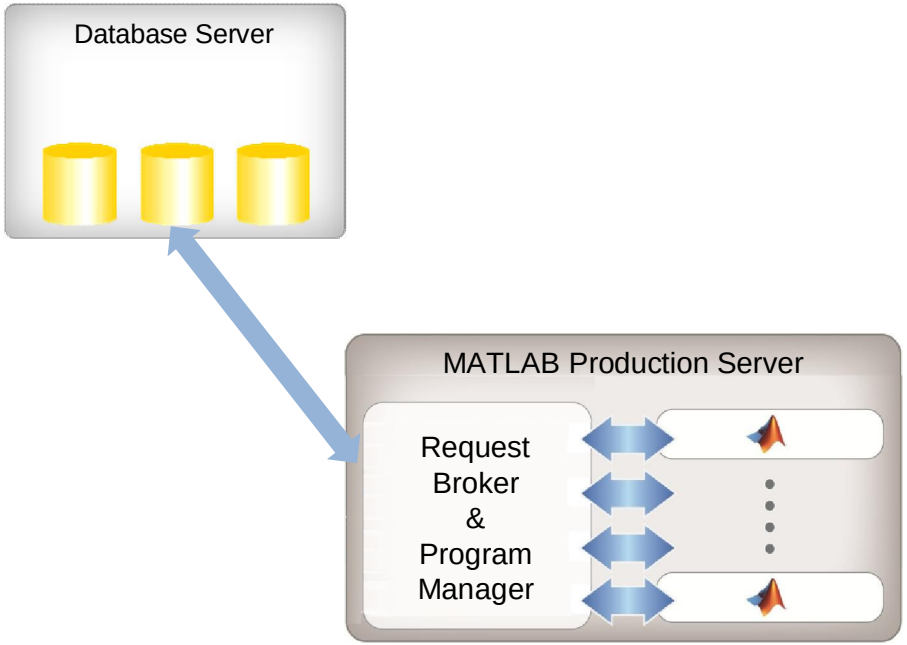
- Optimize numerical processing within databases
  - Request MATLAB analytics directly from database servers
  - Trigger requests based upon database transactions
- Minimize data handling using Database Toolbox



MATLAB Components in Production Databases

MATLAB Production Server can provide predictive analytics in the database

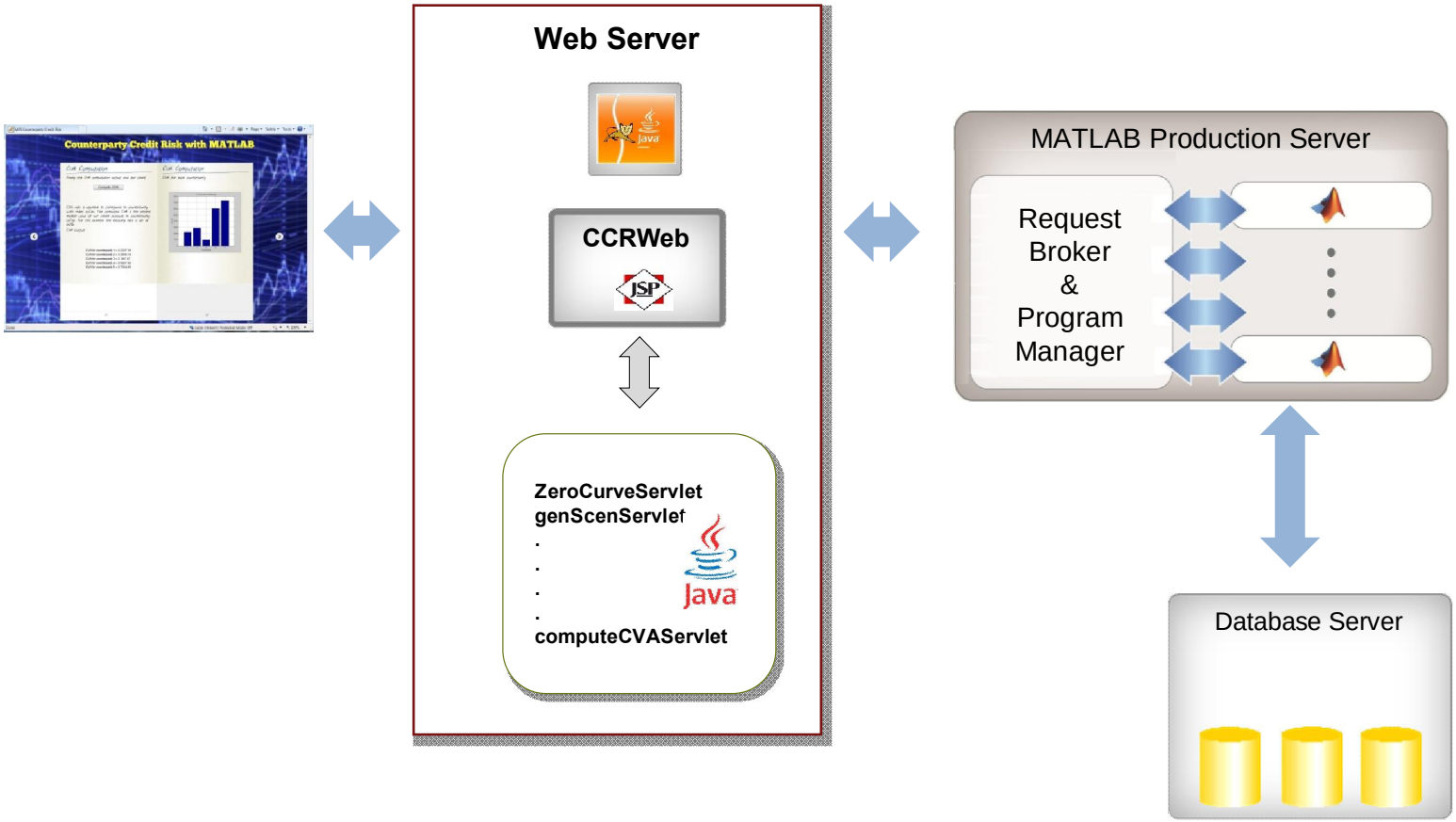
- Oracle (Java, .NET)
- Microsoft SQL Server (.NET)
- Microsoft Access (.NET)
- Netezza (JAVA)
- SAS (JAVA)
- Teradata (JAVA)



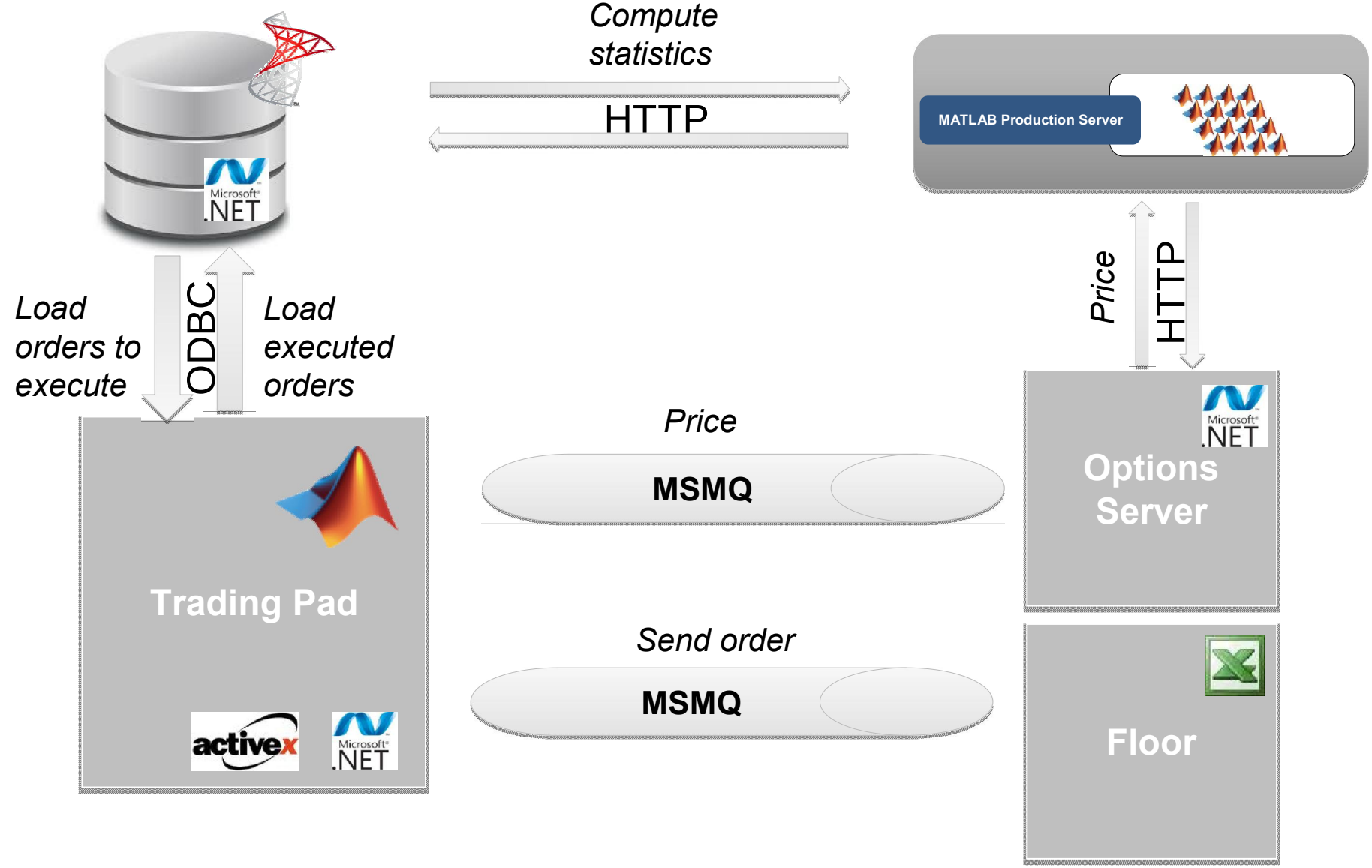
- Thin client with MPS
  - Java and .NET supported
- Central repository for models … Simplifies change management

Risk Manager: Architecture

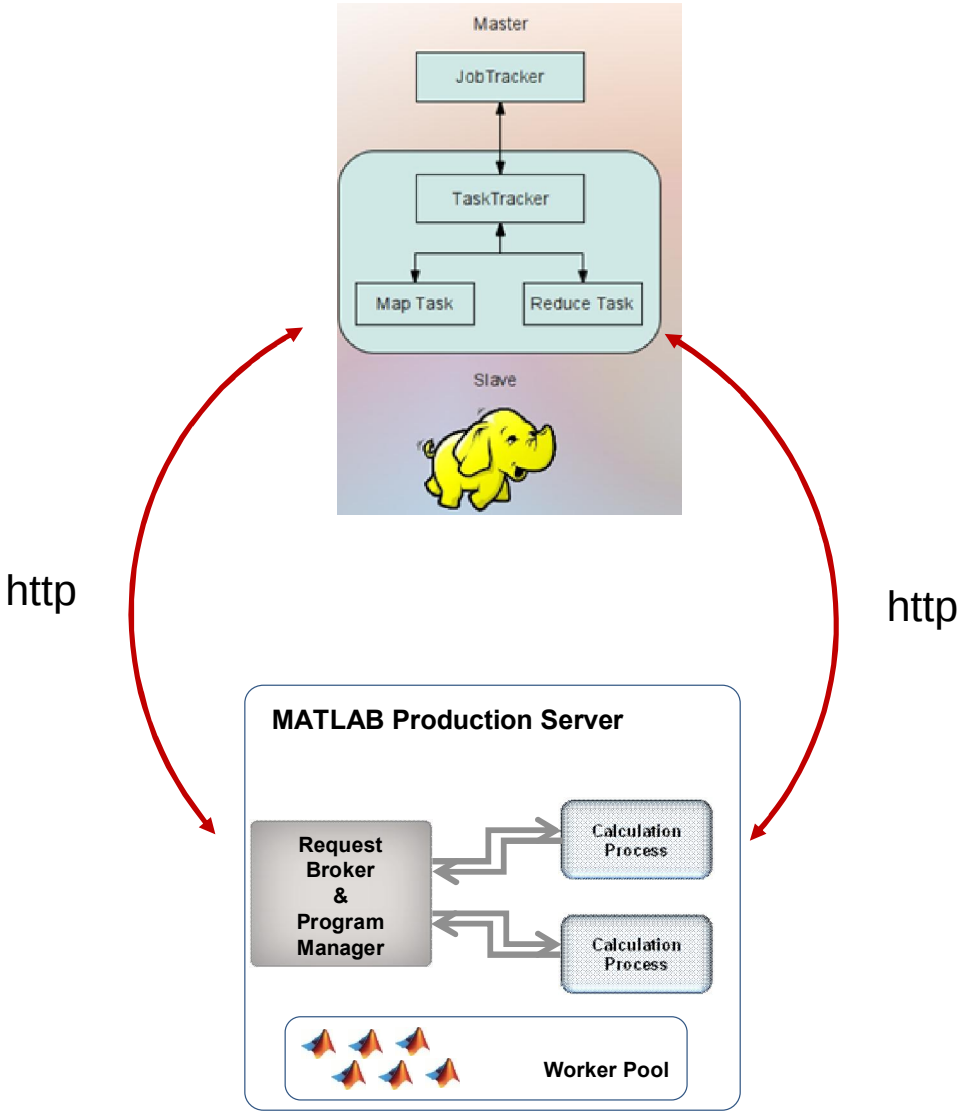
- Architecture



MPS in a multi-tiered financial system



HADOOP calling MATLAB Analytic/Model



Workflow

- Build algorithm in MATLAB
- Execute Hadoop in pseudo mode enabling interactive debugging of MATLAB code
- Compile code into MATLAB Production Server component
- Integrate MATLAB Production Server into HADOOP cluster
- Execute HADOOP job and MATLAB Production Server component.

MATLAB Calling HADOOP

- MATLAB and JAVA are tightly integrated
  - Users can instantiate JAVA classes in MATLAB
  - Can invoke JAVA Methods from the command prompt
  - HADOOP can be invoked directly from the MATLAB prompt
    - Set HADOOP configuration files to local file system(for testing) or HDFS for production

Development of MATLAB Production Server continues at a significant pace

- Https supported in R2013b
- MATLAB Builder Ex supports server based xla's R2014a
  - Thin client on desktop, compiled MATLAB analytic on the server
  - Install package for both client and server
- Support for other programming frameworks/languages in development