



Algorithmic Trading with R

How to lose money without really trying.

Amis Consulting LLP

IT consultancy who reach the parts that other consultancies cannot reach.

- 1983-1997: Scientific computing and image processing.
- 1997-2003: Dotcom Boom (and bust) !!!
- 2003- Financial Systems.
- Currently involved in High Performance Computing and (*of course*) Big Data and well as all the other stuff.

Worked with a variety of technologies

- Languages (in anger):
Fortran / C / Ada / Perl / Python / Lisp / Java / PHP / Groovy ...
... our **GOTO** languages remain C and Perl but ???
- Back-ends
Unix (not just Linux) and Windows (so some .NET)
- Databases
Both relational and the NoSQL stuff
- Moving into the cloud
AWS: Map-reduce, (excited about) Redshift.

Then along came R ...

- At Kings in late-2000's
- Interest was in HPC (mainly **CUDA**) applied to financial systems.
- Started using Matlab but was looking for a similar *type* package for personal/company usage .
- Gnu/Octave and R both fitted the bill, R won.
- One new option (-- *more later* --)

R in Finance

(My) Taxonomy of R financial packages

CRAN has a Finance view: <http://cran.r-project.org/web/views/Finance.html>

- Econometrics
- Rmetrics Group
- Quantmod
- “TITs”

A Couple of TITs



Algorithmic Trading

You will need:

- Data Feed
Yahoo Financials, Pay for feeds, Platform API
- Analysis
Python, C/C++, C#, R + ... others
- Trade
Metatrader, NinjaTrader, TradeStation, ThinkOrSwim ...
- ***Cash !!!***

Real-time Trading (with IBrokers)

- ACL use Interactive Brokers (*not always in R*)
<https://www.interactivebrokers.co.uk/>
- A feed to do real-time trading.
- Java Application (TWS) and a Web-Trader Interface
- Good documentation and phone support.
- API which can be accessed via C, Java, .Net, Excel
- Several *other* languages exist, including at least one R package.

Interactive Brokers – Trader Workstation

IB Information System | Account | Help | Orders | Trades | DATA DU97143 | 13:13:36

Workspace: **Mosaic** | New Window | Event Calendars | News | Analyst Research

Watchlist - Market

| Contract | Last | Chng |
|------------|----------|---------------|
| INDU index | 12667.50 | -41.30 -0.32% |
| SPX index | 1313.01 | -2.99 -0.23% |
| NDX index | 2433.71 | -3.51 -0.14% |

SPX INDEX

1320.00
1313.01
1310.00
Jan 24
-2.99

Watchlist - Favorites

| Contract | Last | Chng |
|----------|--------|--------------|
| Auto | | |
| F | 12.74 | +0.08 0.63% |
| GM | 24.79 | -0.13 -0.52% |
| TM | 72.20 | +1.05 1.45% |
| Tech | | |
| MU | 7.95 | -0.01 -0.13% |
| DELL | 16.92 | +0.05 0.30% |
| GOOO | 579.68 | -5.84 -1.00% |

General News

13:13 *DJ S&P: Issuer Credit Rtg On Dexia Bank Four Notches Hight...
13:12 *DJ S&P: Risk Position Assessment For Dexia Bank 'Weak'
13:12 REUTERS Top Executives From Pipelines, Producers and Financi...
13:11 BRF Market Update: Slipping Along
13:11 *DJ S&P: Dexia Bank Creditwatch Update Follows Long-Term R...

Portfolio

DU97143

| Account P&L | Unreal P&L | Realized P&L | Account Margin | NetLiq | ExLiq | SMA |
|-------------|------------|--------------|----------------|---------|---------|--------|
| -461 | 5.1K | 0 | 614,935 | 614,935 | 576,330 | 44,605 |

| P&L | Positions | Mkt Val | Avg Price | Last | Change |
|--------|-----------|---------|-----------|---------|---------------|
| 480 | HQT | 1,200 | 65,292 | 50,4408 | +54.41 +0.40 |
| 141 | TM | 200 | 14,440 | 70,155 | +72.20 +1.05 |
| 15 | DELL | 300 | 5,076 | 16,635 | +16.92 +0.05 |
| 5 | JBLU | 100 | 547 | 5,23 | +5.47 +0.05 |
| -21 | GLD | 300 | 48,651 | 162,24 | +162.17 -0.99 |
| -1,081 | MSFT | 2,300 | 67,298 | 29,3476 | +29.26 -0.47 |
| | EUR CASH | | 576,428 | | |
| | USD CASH | | 336,903 | | |

Order Entry

DU97143

POSITION 0 N880 12.73 / 12.74 | PRESET | OPT CHAIN

Buy LMT 100 DAY

Orders

| Action | Type | Details | Qty | Fill Pk |
|--------|------|------------|-------|---------|
| BUY | LMT | LMT 12.42 | 0/100 | |
| GLD | BUY | LMT 162.25 | 100 | 162.20 |
| GLD | BUY | LMT 162.25 | 100 | 162.24 |
| GLD | BUY | LMT 162.26 | 100 | 162.25 |
| TM | BUY | LMT 71.83 | 100 | 71.83 |

FORD MOTOR CO - Quote Details

12.74 N880 H/L 52 H/L EARN VAL

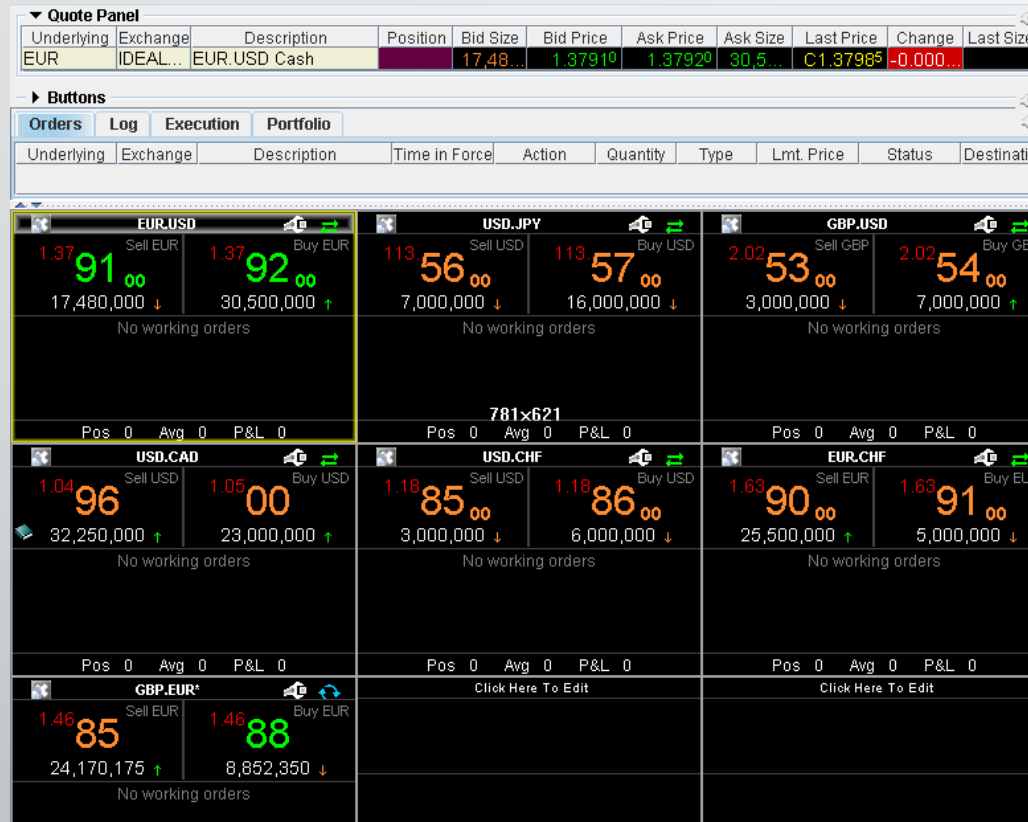
+0.08 12.73 x 1,924 12.78 18.88 EPS 1.66 MCap 48.1B

0.63% 12.74 x 727 12.46 9.05 P/E 7.6 P/Bk 8.08

Orders

01/23 17:00 REUTERS Michigan Gov prefers no Detroit emerg...
01/23 15:09 REUTERS BMW nears decision on south Brazil fac...
01/23 02:22 REUTERS UPDATE 1-Toyota cutting 350 jobs in A...
01/20 09:00 REUTERS Details of Ford Motor Company's Jan. ...
01/19 12:44 REUTERS All-New Ford Escape Gives Drivers Quie...

TWS Mosaic Panels



Forex trading



AAPL stock movement

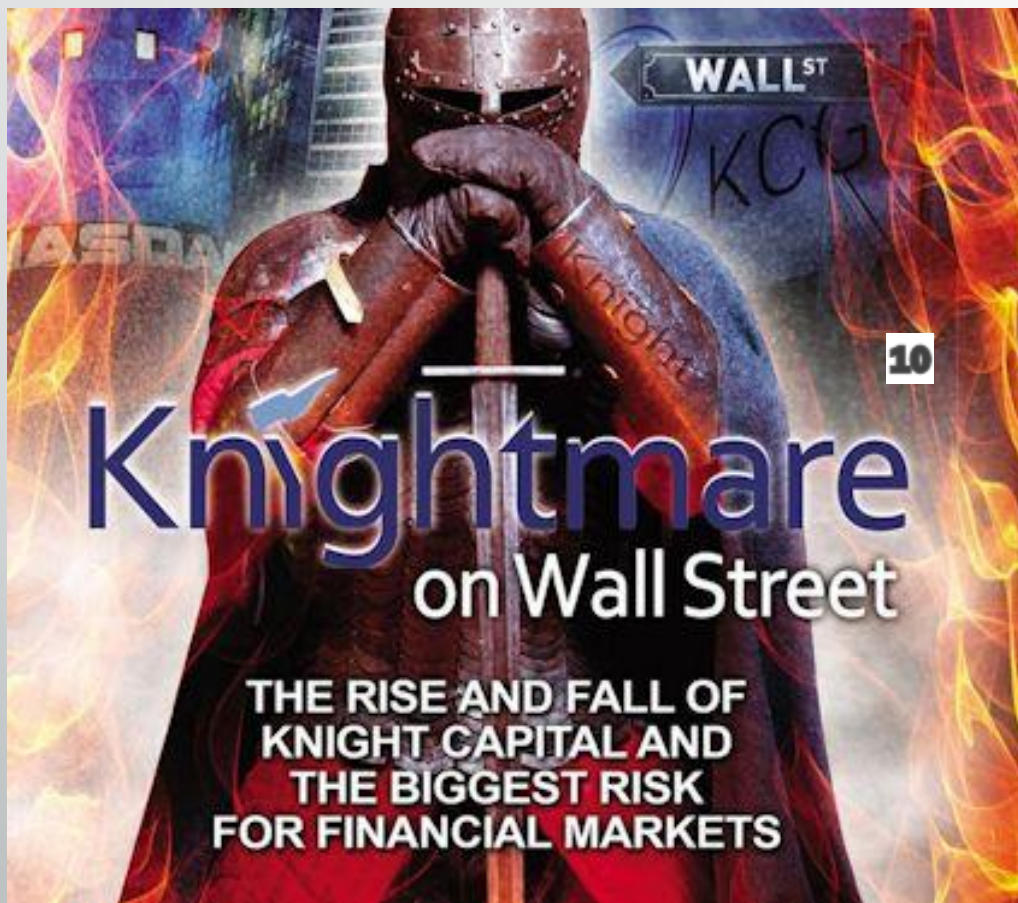
More on Algorithmic Trading

- Moving average
Closing prices, Yahoo/Google Financials
- Historical data
Back testing
- Real time
Forex, Stocks, Options, Futures
- High frequency trading
Black Arts, *not for us*

How do I start?

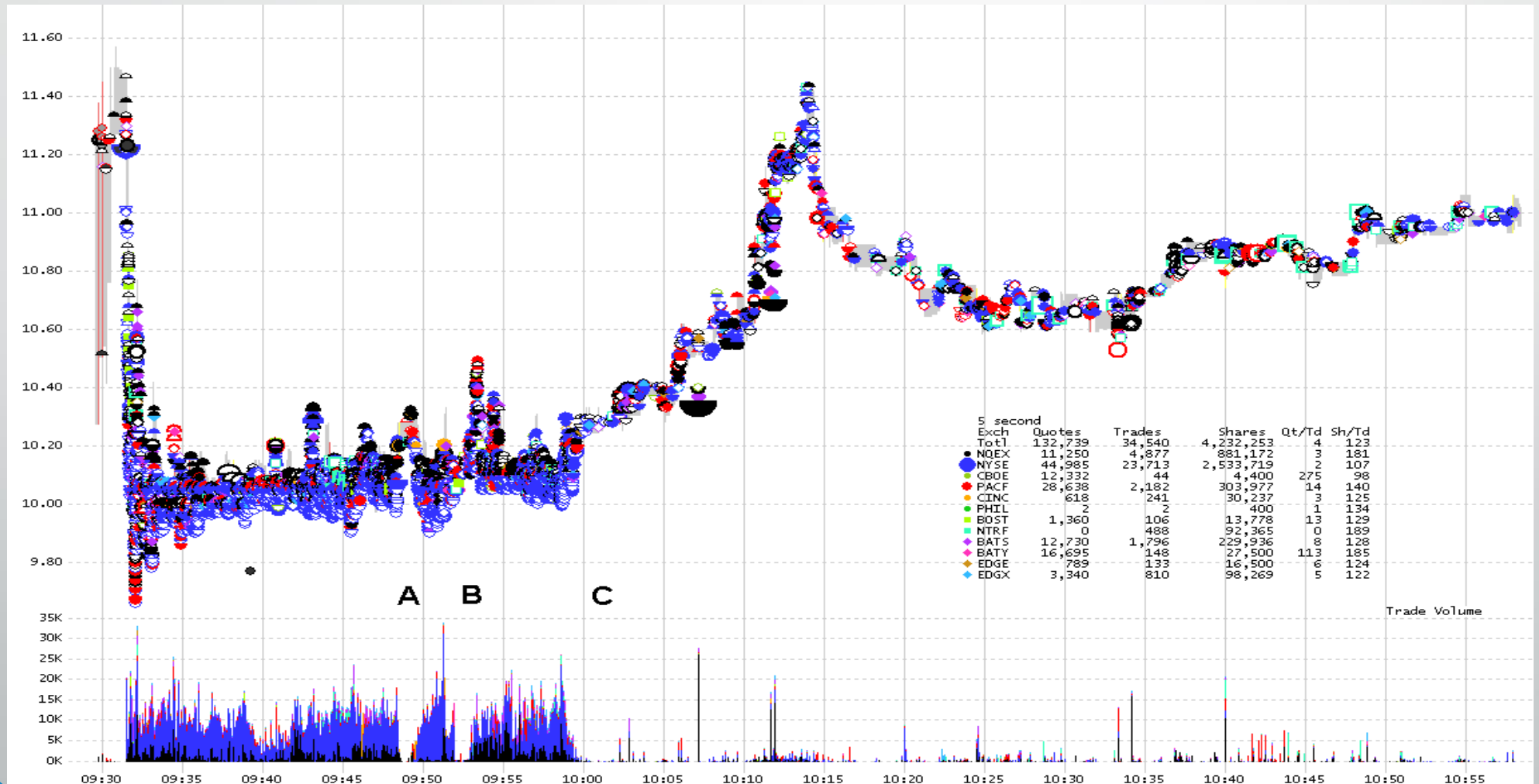
- Setup IB account.
Read the documentation and look at the videos / webinars.
- Use the “Paper” Account .
Forex, Stocks, Options ...
- Use the TWS and/or Web-trader with real money.
- Formulate your algorithmic strategy.
- Program it.
- Goto the PUB.

How to Test Your New Market Making Software and Lose a Pile of Money, Fast

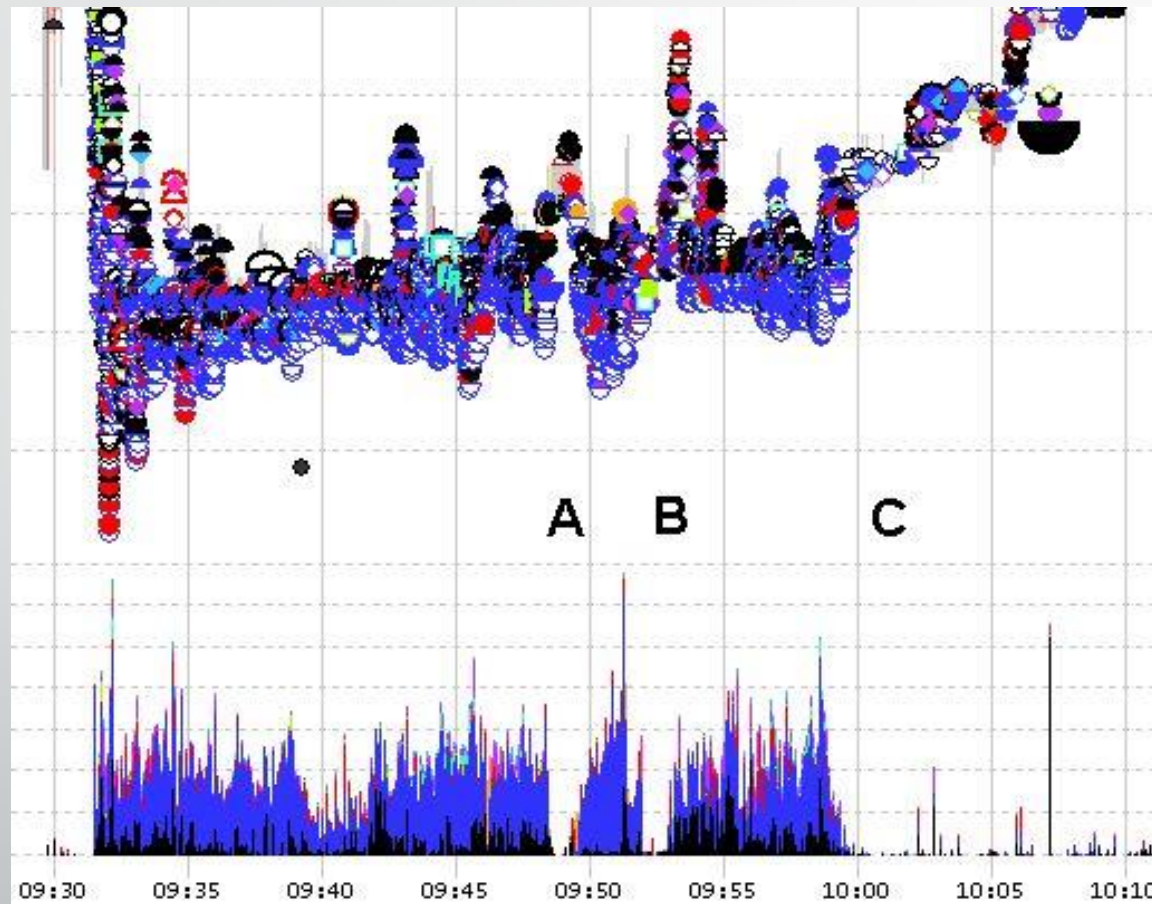


Wednesday, 1st August 2012

Nanex : 5 second interval chart showing all trades colour coded by exchange



Fatal First Forty minutes



| 5 second | | | | |
|----------|---------|--------|-----------|----|
| Exch | Quotes | Trades | Shares | Qt |
| Totl | 132,739 | 34,540 | 4,232,253 | |
| ● NQEX | 11,250 | 4,877 | 881,172 | |
| ● NYSE | 44,985 | 23,713 | 2,533,719 | |
| ● CBOE | 12,332 | 44 | 4,400 | |
| ● PACF | 28,638 | 2,182 | 303,977 | |
| ● CINC | 618 | 241 | 30,237 | |
| ● PHIL | 2 | 2 | 400 | |
| ● BOST | 1,360 | 106 | 13,778 | |
| ● NTRF | 0 | 488 | 92,365 | |
| ● BATS | 12,730 | 1,796 | 229,936 | |
| ● BATY | 16,695 | 148 | 27,500 | |
| ● EDGE | 789 | 133 | 16,500 | |
| ● EDGX | 3,340 | 810 | 98,269 | |

<http://www.nanex.net/aqck2/3522.html>

Why Use R as a trading platform

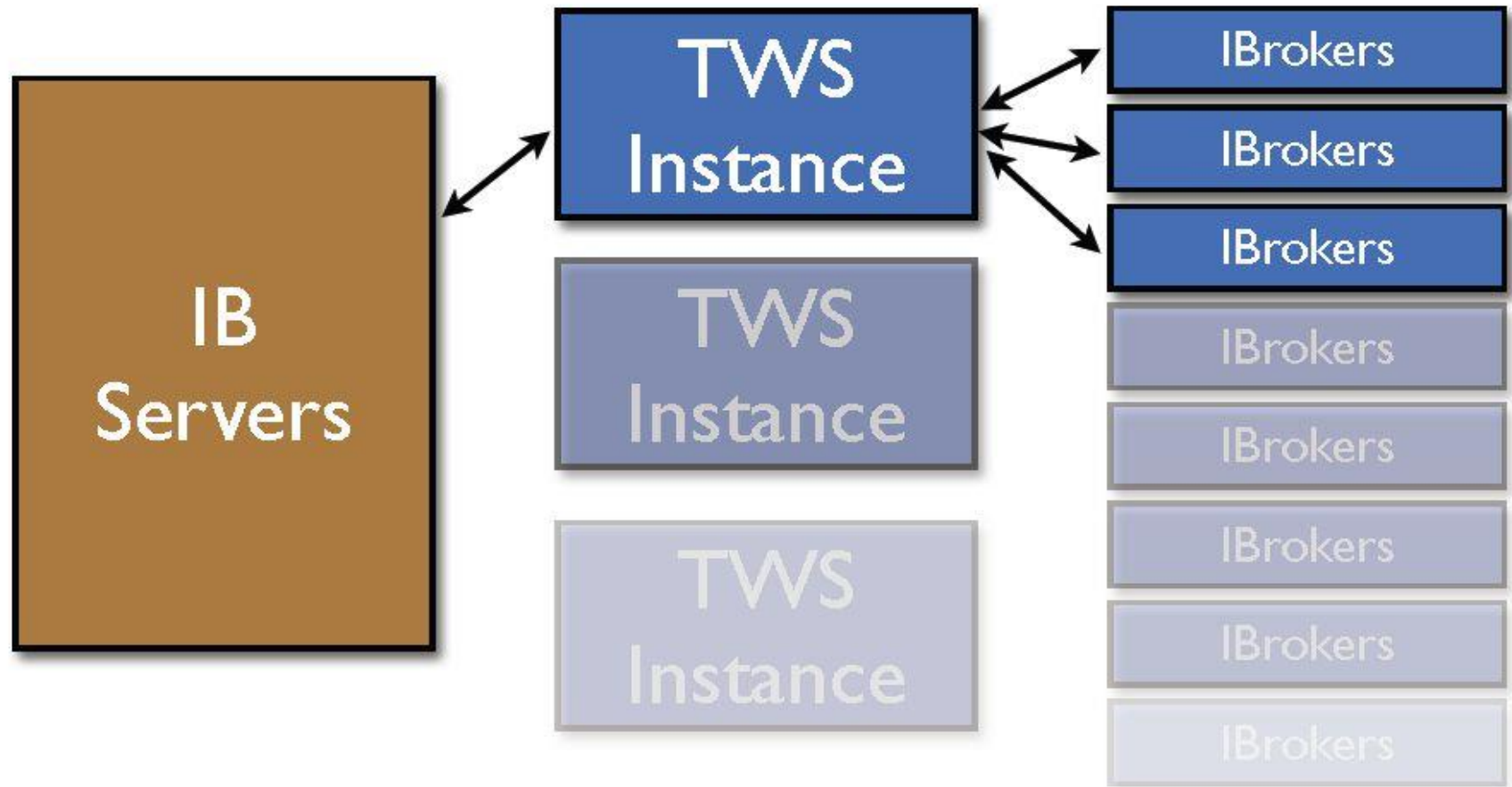
- Advantages
 - Flexible, powerful language
 - Best of class tool chain
 - Community, open source, cross-platform
- Disadvantages
 - Single threaded
 - Not as quick as C/C++

IBrokers: R package (1)

- Connections
R has a native socket interface providing relatively high performance.
- Threads
Single-threaded R makes true "*threading*" impossible.
- Data Persistence and Sharing
Closures allow for single process data persistence among calls.
- Thorough-put
Event REPL bounded by costly R loops
Message structure dependent

IBrokers: R package (2)

- Authored by Jeff Ryan
Member of the “Quant Mods”, his first cut 2008, revised 2012
- Works via the Trader Workstation API
Uses this for authentication and for the data feed
- Establishes a socket to socket local connection
- Written in almost native R, not a wrapper
- Revised version almost complete implementation of IB API



Up to **8** API connection per TWS

IBrokers : R Implementation

- **Historical Data** : `reqHistoricalData`
Direct access to IB historic data
- **Real Time Data** : `reqMktData`, `reqRealTimeBars`
Live market data – stocks, options, futures, FX
- **Live Execution** : `placeOrder`, `cancelOrder`, `reqAccountUpdates`
Place and cancel orders
View account information

Using IBrokers from R

A quick example of capturing data to disk:

```
library(IBrokers)
twc <- twsConnect()
aapl.csv <- file("AAPL.csv", open="w")
reqMktData (twc,
            twsSTK("AAPL"),
            eventWrapper = eWrapper.MktData.CSV(1),
            file = aapl.csv)

close(aapl.csv)
close(twc)
```

Be familiar with the IB API documentation on a call as well as the R implementation (viz.)

<https://www.interactivebrokers.com/en/software/api/apiguide/c/reqmktdata.htm>

Real Time Data Model (1a)

```
> reqMktData(tws, twsFUT("NQ","GLOBEX","201309"))  
<20130629 11:17:13.117602> id=1 symbol=NQ Volume: 0  
<20130629 11:17:15.323245> id=1 symbol=NQ bidPrice: 1480.75 bidSize: 8  
<20130629 11:17:15.324615> id=1 symbol=NQ askPrice: 1481.25 askSize: 19  
<20130629 11:17:15.325706> id=1 symbol=NQ bidSize: 8  
<20130629 11:17:15.326655> id=1 symbol=NQ askSize: 19  
<20130629 11:17:15.327537> id=1 symbol=NQ lastPrice: 1480.75  
<20130629 11:17:15.328335> id=1 symbol=NQ lastSize: 1  
<20130629 11:17:15.329518> id=1 symbol=NQ lastTimestamp: 1246313805
```

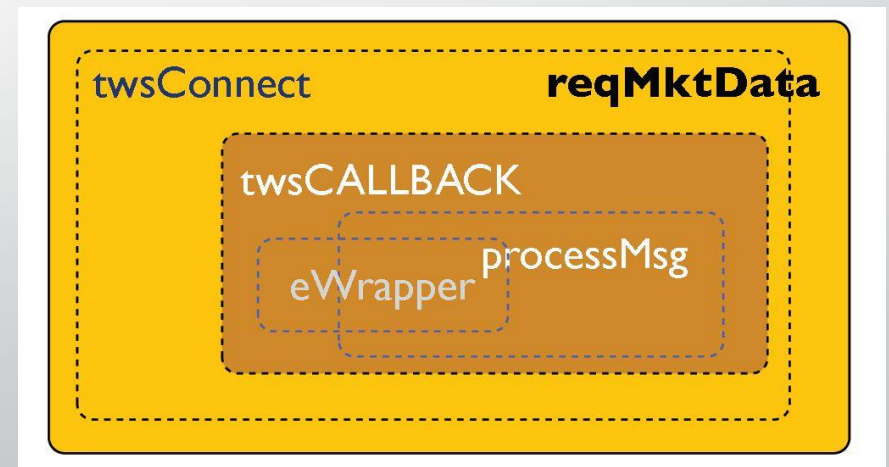
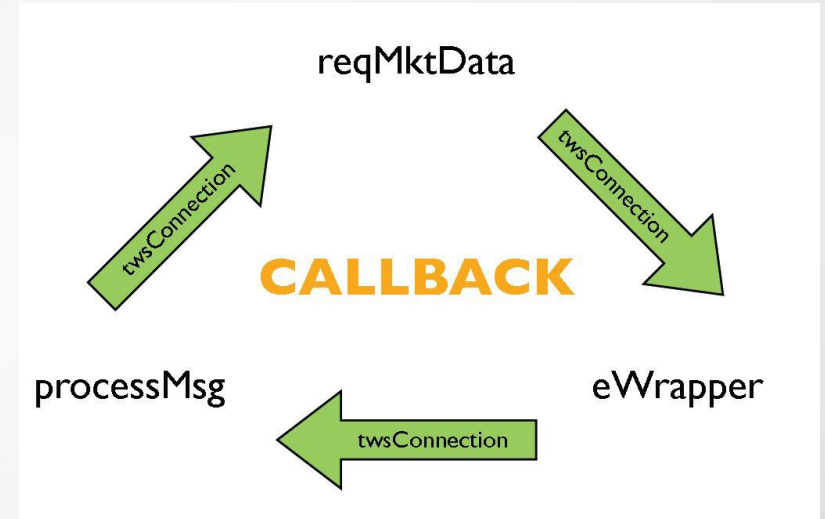
Real Time Data Model (1b)

```
> reqMktData(tws, list(twsSTK("MSFT"),twsSTK("AAPL")))
<20131029 13:34:55.649897> id=1 symbol=MSFT Volume: 622549
<20131029 13:34:55.652436> id=1 symbol=MSFT highPrice: 24.03
<20131029 13:34:55.653531> id=1 symbol=MSFT lowPrice: 23.55
<20131029 13:34:55.656226> id=1 symbol=MSFT shortable: 3.0
<20131029 13:34:55.657129> id=1 symbol=MSFT bidPrice: 23.89 bidSize: 2
<20131029 13:34:55.658781> id=1 symbol=MSFT bidSize: 2
<20131029 13:34:55.659603> id=1 symbol=MSFT askPrice: 23.9 askSize: 30
<20131029 13:34:55.660695> id=1 symbol=MSFT askSize: 30
<20131029 13:34:55.850867> id=2 symbol=AAPL bidPrice: 141.82 bidSize: 1
<20131029 13:34:55.852082> id=2 symbol=AAPL askPrice: 141.9 askSize: 6
<20131029 13:34:55.853202> id=2 symbol=AAPL lastPrice: 141.95
<20131029 13:34:55.854040> id=2 symbol=AAPL bidSize: 1
<20131029 13:34:55.854956> id=2 symbol=AAPL askSize: 6
```

Real Time Data Model (2)

```
reqMktData ( tws,  
             Contract = twsSTK("QQQQ"),  
             eventWrapper = eWrapper(TRUE),  
             timeStamp=NULL)
```

```
1 5 1 6 36.75 0 0  
1 5 1 7 36.12 0 0  
45 5 1 49 0.0  
45 5 1 46 3.0  
1 5 1 1 36.48 3 1  
2 5 1 0 3  
2 5 1 2 36.49 80 1  
2 5 1 3 80  
2 5 1 8 978607
```



Callback routine

```
> twsCALLBACK
function (twsCon, eWrapper, timestamp, file, playback = 1, ...)
{
  if (missing(eWrapper))
    eWrapper <- eWrapper() con <- twsCon[[1]]
    if (inherits(twsCon, "twsPlayback")) {

    }
  }
  else {
    while (TRUE) {
      socketSelect(list(con), FALSE, NULL)
      curMsg <- readBin(con, character(), 1)
      if ( !is.null(timestamp) ) {
        processMsg(curMsg, con, eWrapper, format(Sys.time(), timestamp), file, ...)
      }
    }
  }
}
```

Process Message

```
> processMsg
function (curMsg, con, eWrapper, timestamp, file, ...)
{
  if (curMsg == .twsiIncomingMSG$TICK_PRICE) {
    msg <- readBin(con, character(), 6)
    eWrapper$tickPrice(curMsg, msg, timestamp, file, ...)
  }
  else if (curMsg == .twsiIncomingMSG$TICK_SIZE) {
    msg <- readBin(con, character(), 4)
    eWrapper$tickSize(curMsg, msg, timestamp, file, ...)
  }
}

... # Dispatch to custom eWrapper method
```

eWrapper

Define custom message handling functions quickly and easily

```
> str(eWrapper())
List of 37
$ .Data :<environment: 0x307cbfo>
$ get.Data :function (x)
$ assign.Data :function (x, value)
$ remove.Data :function (x)
$ tickPrice :function (curMsg, msg, timestamp, file, ...)
$ tickSize :function (curMsg, msg, timestamp, file, ...)
$ tickOptionComputation :function (curMsg, msg, timestamp, file, ...)
$ tickGeneric :function (curMsg, msg, timestamp, file, ...)
$ tickString :function (curMsg, msg, timestamp, file, ...)
$ tickEFP :function (curMsg, msg, timestamp, file, ...)
$ orderStatus :function (curMsg, msg, timestamp, file, ...)
$ errorMessage :function (curMsg, msg, timestamp, file, ...)
$ openOrder :function (curMsg, msg, timestamp, file, ...)
$ openOrderEnd :function (curMsg, msg, timestamp, file, ...)
$ updateAccountValue :function (curMsg, msg, timestamp, file, ...)
$ updatePortfolio :function (curMsg, msg, timestamp, file, ...)
$ updateAccountTime :function (curMsg, msg, timestamp, file, ...)
$ accountDownloadEnd :function (curMsg, msg, timestamp, file, ...)
$ nextValidId :function (curMsg, msg, timestamp, file, ...)
$ contractDetails :function (curMsg, msg, timestamp, file, ...)
$ bondContractDetails :function (curMsg, msg, timestamp, file, ...)
$ contractDetailsEnd :function (curMsg, msg, timestamp, file, ...)
```

```
$ execDetails :function (curMsg, msg, timestamp, file, ...)
$ updateMktDepth :function (curMsg, msg, timestamp, file, ...)
$ updateMktDepthL2 :function (curMsg, msg, timestamp, file, ...)
$ updateNewsBulletin :function (curMsg, msg, timestamp, file, ...)
$ managedAccounts :function (curMsg, msg, timestamp, file, ...)
$ receiveFA :function (curMsg, msg, timestamp, file, ...)
$ historicalData :function (curMsg, msg, timestamp, file, ...)
$ scannerParameters :function (curMsg, msg, timestamp, file, ...)
$ scannerData :function (curMsg, msg, timestamp, file, ...)
$ scannerDataEnd :function (curMsg, msg, timestamp, file, ...)
$ realtimeBars :function (curMsg, msg, timestamp, file, ...)
$ currentTime :function (curMsg, msg, timestamp, file, ...)
$ fundamentalData :function (curMsg, msg, timestamp, file, ...)
$ deltaNeutralValidation :function (curMsg, msg, timestamp, file, ...)
$ tickSnapshotEnd :function (curMsg, msg, timestamp, file, ...)
```

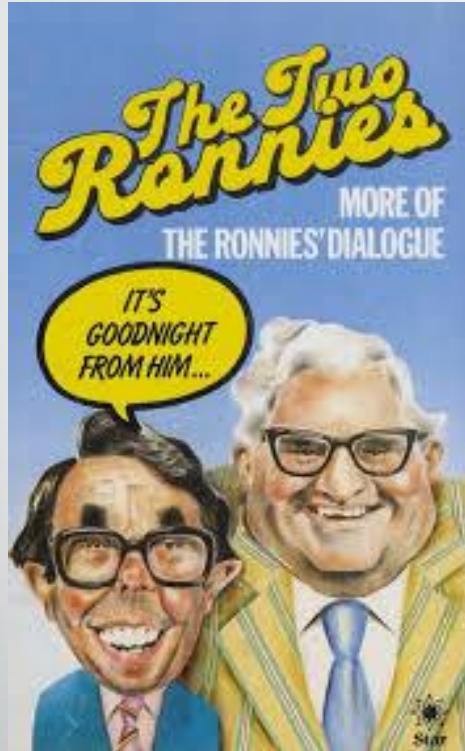
Real Time Data Model (3)

```
twsOC <- twsConnect(2) # Our order connection
ocWrapper <- eWrapper(TRUE)
traded <- FALSE
while (TRUE) {
  cons <- socketSelect(list(con, twsOC[[1]]), FALSE, 0.01)
  if(cons[1]) { ## Data ##
    curMsg <- readBin(con, character(), 1)
    if (!is.null(timestamp)) {
      processMsg(curMsg, con, eWrapper, format(Sys.time(), timestamp), file, ...)
    }
    else {
      processMsg(curMsg, con, eWrapper, timestamp, file, ...)
    }
  }
  else if(cons[2]) { ## Order messages ##
    curMsg <- readBin(twsOC[[1]], character(), 1)
    if (!is.null(timestamp)) {
      processMsg(curMsg, twsOC[[1]], ocWrapper, format(Sys.time(), timestamp), file, ...)
    }
    else {
      processMsg(curMsg, twsOC[[1]], ocWrapper, timestamp, file, ...)
    }
  }
  curBid <- as.numeric(eWrapper$.Data$data[[1]][3]) ## Trade Logic ##
  if( !traded && !is.na(curBid) && curBid > 140.00) {
    IBrokers:::placeOrder(twsOC, twsSTK("AAPL"), twsOrder(1053, "BUY", "10", "MKT"))
    traded <- TRUE
  }
}
```

Conclusions

- R can be used from real-time trading.
- Do some online trading first.
- If you still have any cash left -- try programming your strategy.
- The IBrokers package is a good example of what can be achieved natively in R.
- There is a new kid(-ess) on the block: ***Julia***

And it's goodnight from him



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