Front Office Fixed Income Application Integration - A Story

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RBC Capital Markets

Act I

The Story Begins

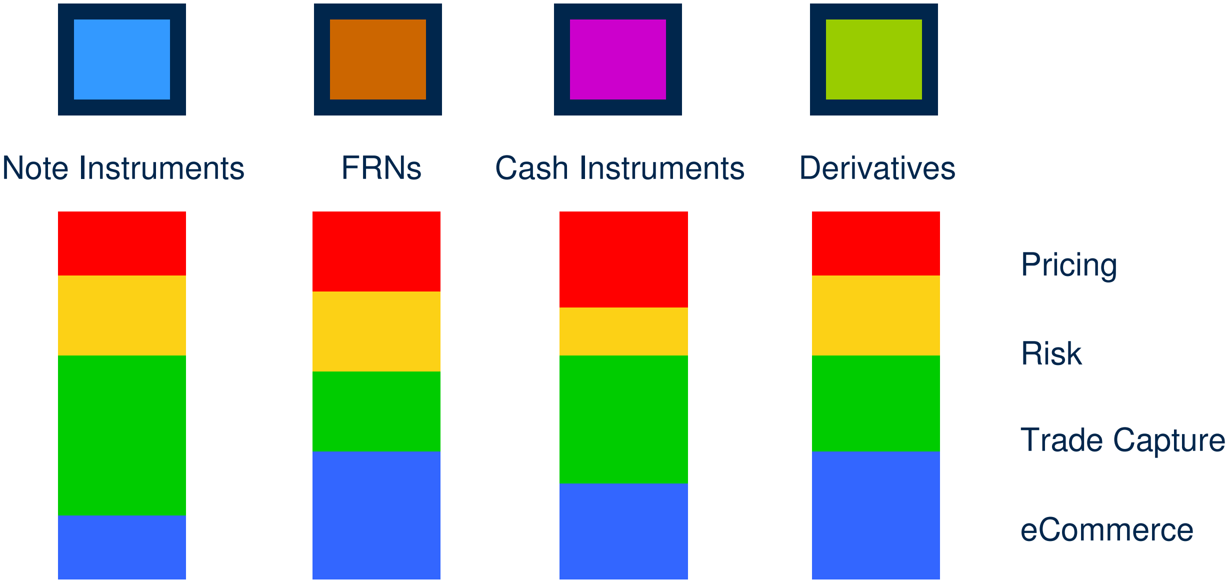
The Setting

- ➢ RBC Capital Markets
- ➢ Global Fixed Income Division

- ➢ Global development and user base
  - New York, London, Toronto
- ➢ Main focus on front office trading applications
  - Real-time display of fast-moving market data
- ➢ Numerous trading products
  - Note instruments
  - FRNs
  - Cash instruments (bonds, futures)
  - Derivatives

A Little History

- Application development historically <u>product-focused</u>
  - Trading localized to product types
  - Multiple product-specific application systems
  - Customized to needs of individual products
  - Varying levels of functionality across product application systems



Note Instruments

FRNs

Cash Instruments

Derivatives

Pricing

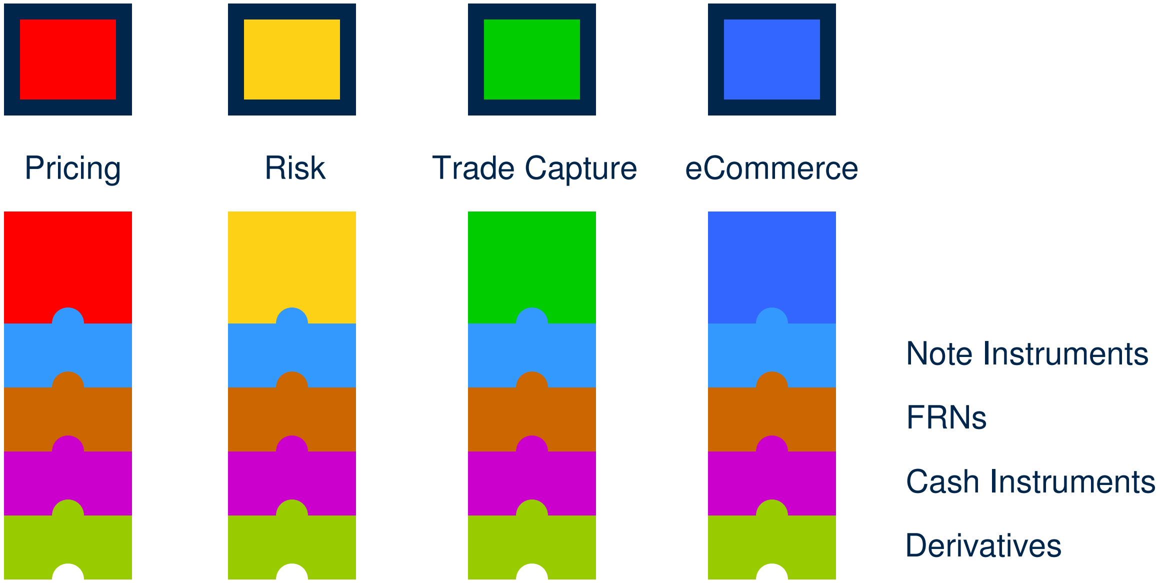
Risk

Trade Capture

eCommerce

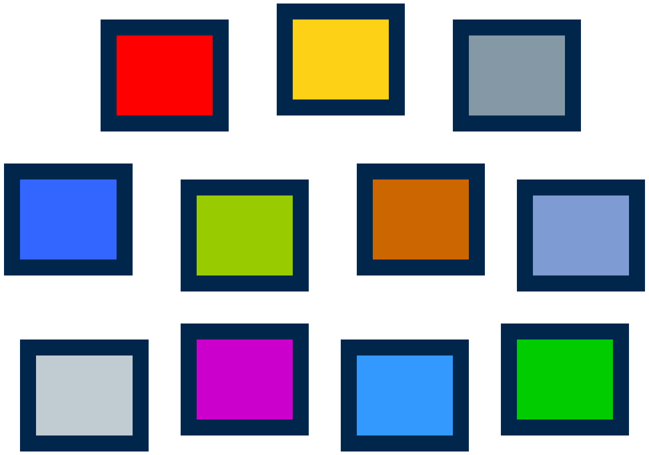
A Little History, continued

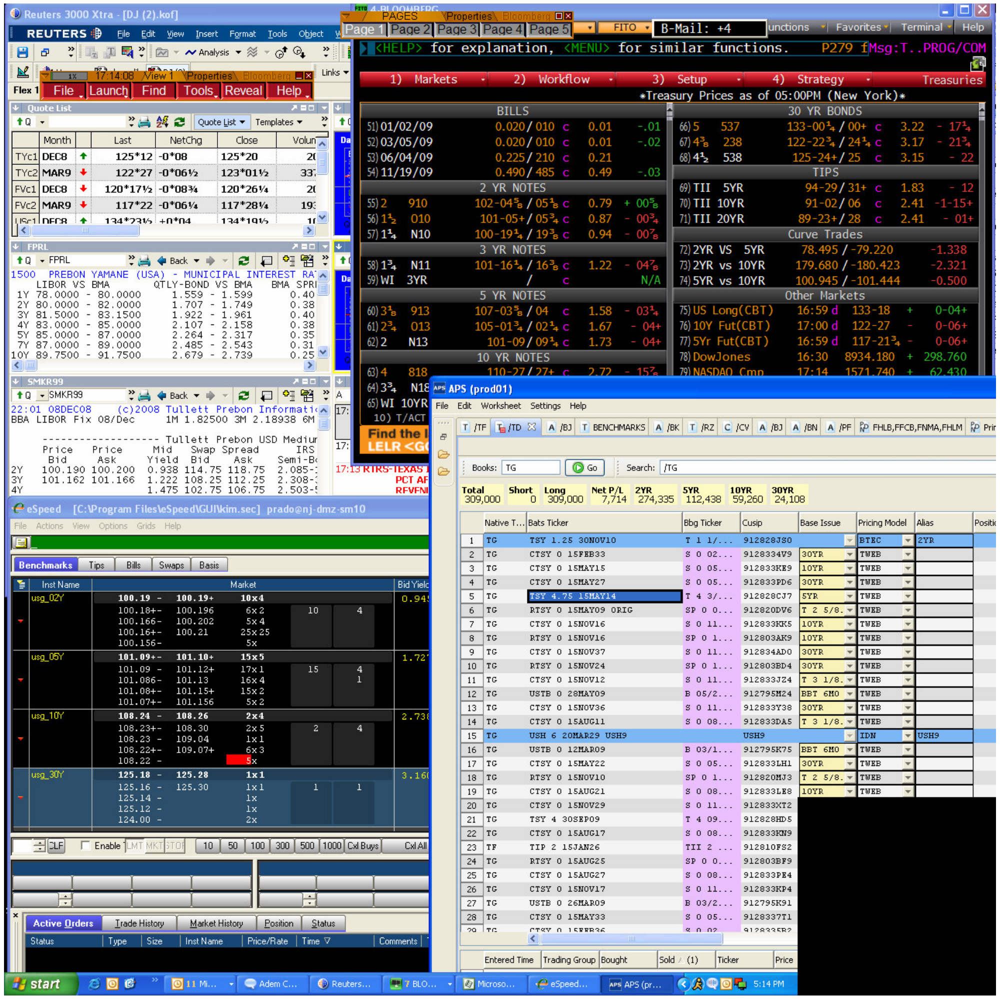
- Shift to <u>functional focus</u>
  - Cross-asset trading
  - Any product, any region, any currency
  - Increased need for functional integration
  - New development; Multiple function-specific applications



User Experience – What We Have

- ➢ n Product-specific applications
- ➢ m Function-specific applications
- ➢ Lots of user context switching across application UIs
- ➢ Reduced efficiency, increased cost
- ➢ Big problem

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Active Orders Trade History Market History Position Status
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	Month		Last	NetChg	Close	Volun
TYc1	DEC8	↑	125*12	-0*08	125*20	2(
TYc2	MAR9	↓	122*27	-0*06½	123*01½	33:
FVc1	DEC8	↓	120*17½	-0*08¾	120*26¼	2(
FVc2	MAR9	↓	117*22	-0*06¼	117*28¼	19:
USc1	DEC8	↑	134*23½	+0*04	134*19½	1(

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1500  PREBON YAMANE (USA) - MUNICIPAL INTEREST RA
    LIBOR VS BMA         QTLY-BOND VS BMA    BMA SPRI
 1Y 78.0000 - 80.0000     1.559 - 1.599       0.40
 2Y 80.0000 - 82.0000     1.707 - 1.749       0.38
 3Y 81.5000 - 83.1500     1.922 - 1.961       0.40
 4Y 83.0000 - 85.0000     2.107 - 2.158       0.38
 5Y 85.0000 - 87.0000     2.264 - 2.317       0.35
 7Y 87.0000 - 89.0000     2.485 - 2.543       0.31
10Y 89.7500 - 91.7500     2.679 - 2.739       0.25
```

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22:01 08DEC08     (c)2008 Tullett Prebon Informati
BBA LIBOR Fix 08/Dec       1M 1.82500 3M 2.18938 6M

    ------------------- Tullett Prebon USD Mediu
    Price    Price      Mid   Swap Spread     IRS
     Bid      Ask      Yield  Bid     Ask    Semi-B
2Y  100.190 100.200  0.938 114.75 118.75  2.085-
3Y  101.162 101.166  1.222 108.25 112.25  2.308-
4Y                   1.475 102.75 106.75  2.503-
```

```
<HELP> for explanation, <MENU> for similar functions.     P279 fMsg:T..PROG/COM
 1) Markets      2) Workflow      3) Setup      4) Strategy         Treasuries
                         *Treasury Prices as of 05:00PM (New York)*
                    BILLS                                    30 YR BONDS
51) 01/02/09       0.020 / 010  c  0.01  -.01   66) 5    537    133-00¼ / 00+  c  3.22  - 17¼
52) 03/05/09       0.020 / 010  c  0.01  -.02   67) 4⅜   238    122-22¾ / 24¼  c  3.17  - 21¾
53) 06/04/09       0.225 / 210  c  0.21         68) 4½   538    125-24+ / 25   c  3.15  - 22
54) 11/19/09       0.490 / 485  c  0.49  -.03                      TIPS
                 2 YR NOTES                     69) TII  5YR     94-29 / 31+   c  1.83  - 12
55) 2    910   102-04⅝ / 05⅛  c  0.79  + 00⅝    70) TII 10YR     91-02 / 06    c  2.41  -1-15+
56) 1½   010   101-05+ / 05¾  c  0.87  - 00¾    71) TII 20YR     89-23+ / 28   c  2.41  - 01+
57) 1¼   N10   100-19¼ / 19⅜  c  0.94  - 00⅞                   Curve Trades
                 3 YR NOTES                     72) 2YR VS  5YR    78.495 / -79.220    -1.338
58) 1¾   N11   101-16¼ / 16⅜  c  1.22  - 04⅞    73) 2YR vs 10YR   179.680 / -180.423   -2.321
59) WI   3YR           /      c         N/A     74) 5YR vs 10YR   100.945 / -101.444   -0.500
                 5 YR NOTES                                    Other Markets
60) 3⅛   913   107-03⅝ / 04   c  1.58  - 03¼    75) US Long(CBT)  16:59 d  133-18   +  0-04+
61) 2¾   013   105-01¾ / 02¼  c  1.67  - 04+    76) 10Y Fut(CBT)  17:00 d  122-27   -  0-06+
62) 2    N13   101-09 / 09¼   c  1.73  - 04+    77) 5Yr Fut(CBT)  16:59 d  117-21¾  -  0-06+
                 10 YR NOTES                    78) DowJones      16:30    8934.180 + 298.760
63) 4    818   110-27 / 27+   c  2.72  - 15⅞    79) NASDAQ Cmp    17:14    1571.740 +  62.430
64) 3¾   N18
65) WI   10YR
 10) T/ACT
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LELR <G
```

```
17:13 RTRS-TEXAS
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Inst Name   Market                                        Bid Yield
usg_02Y     100.19  -   100.19+   10x4                    0.945
            100.18+-    100.196    6x2      10     4
            100.166-    100.202    5x4
            100.16+-    100.21    25x25
            100.156-               5x
usg_05Y     101.09+-    101.10+   15x5                    1.727
            101.09  -   101.12+   17x1      15     4
            101.086-    101.13    16x4             1
            101.08+-    101.15+   15x2
            101.07+-    101.156    5x2
usg_10Y     108.24  -   108.26     2x4                    2.738
            108.23+-    108.30     2x5       2     4
            108.23  -   109.04     1x1
            108.22+-    109.07+    6x3
            108.22  -              5x
usg_30Y     125.18  -   125.28     1x1                    3.160
            125.16  -   125.30     1x1       1     1
            125.14  -              1x
            125.12  -              1x
            124.00  -              2x
```

Books: TG Search: /TG

Total	Short	Long	Net P/L	2YR	5YR	10YR	30YR
309,000	0	309,000	7,714	274,335	112,438	59,260	24,108

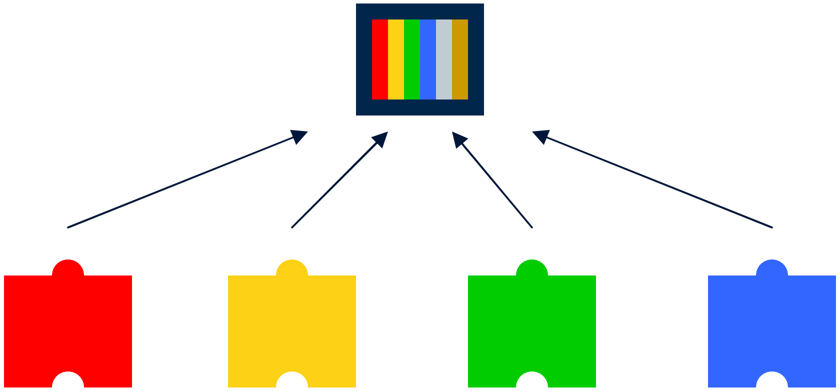
	Native T...	Bats Ticker	Bbg Ticker	Cusip	Base Issue	Pricing Model	Alias	Positi
1	TG	TSY 1.25 30NOV10	T 1 1/...	912828JS0		BTEC	2YR	
2	TG	CTSY 0 15FEB33	S 0 02...	9128334V9	30YR	TWEB		
3	TG	CTSY 0 15MAY15	S 0 05...	912833KE9	10YR	TWEB		
4	TG	CTSY 0 15MAY27	S 0 05...	912833PD6	30YR	TWEB		
5	TG	TSY 4.75 15MAY14	T 4 3/...	912828CJ7	5YR	TWEB		
6	TG	RTSY 0 15MAY09 ORIG	SP 0 0...	912820DV6	T 2 5/8.	TWEB		
7	TG	CTSY 0 15NOV16	S 0 11...	912833KK5	10YR	TWEB		
8	TG	RTSY 0 15NOV16	SP 0 1...	912803AK9	10YR	TWEB		
9	TG	CTSY 0 15NOV37	S 0 11...	912834AD0	30YR	TWEB		
10	TG	RTSY 0 15NOV24	SP 0 1...	912803BD4	30YR	TWEB		
11	TG	CTSY 0 15NOV12	S 0 11...	912833JZ4	T 3 1/8.	TWEB		
12	TG	USTB 0 28MAY09	B 05/2...	912795M24	BBT 6MO	TWEB		
13	TG	CTSY 0 15NOV36	S 0 11...	912833Y38	30YR	TWEB		
14	TG	CTSY 0 15AUG11	S 0 08...	912833DA5	T 3 1/8.	TWEB		
15	TG	USH 6 20MAR29 USH9		USH9		IDN	USH9	
16	TG	USTB 0 12MAR09	B 03/1...	912795K75	BBT 6MO	TWEB		
17	TG	CTSY 0 15MAY22	S 0 05...	912833LH1	30YR	TWEB		
18	TG	RTSY 0 15NOV10	SP 0 1...	912820MJ3	T 2 5/8.	TWEB		
19	TG	CTSY 0 15AUG21	S 0 08...	912833LE8	10YR	TWEB		
20	TG	CTSY 0 15NOV29	S 0 11...	912833XT2				
21	TG	TSY 4 30SEP09	T 4 09...	912828HD5				
22	TG	CTSY 0 15AUG17	S 0 08...	912833KN9				
23	TF	TIP 2 15JAN26	TII 2 ...	912810FS2				
24	TG	RTSY 0 15AUG25	SP 0 0...	912803BF9				
25	TG	CTSY 0 15AUG27	S 0 08...	912833PE4				
26	TG	CTSY 0 15NOV17	S 0 11...	912833KP4				
27	TG	USTB 0 26MAR09	B 03/2...	912795K91				
28	TG	CTSY 0 15MAY33	S 0 05...	9128337T1				

Entered Time	Trading Group	Bought	Sold (1)	Ticker	Price

Status	Type	Size	Inst Name	Price/Rate	Time	Comments

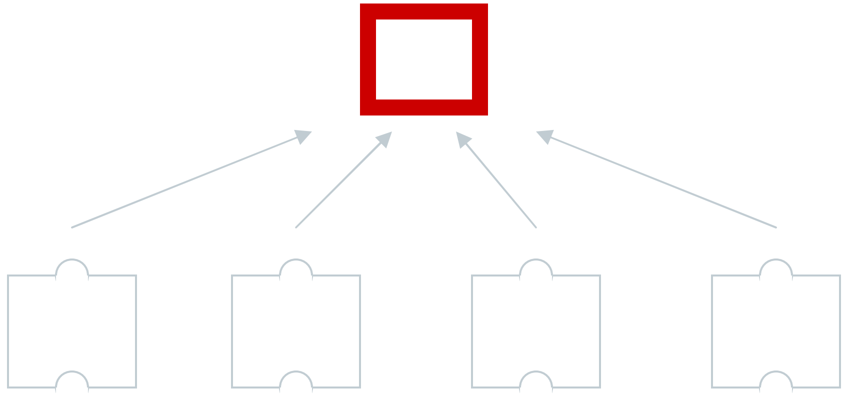
User Experience – What We Want

- One integrated UI where users can access relevant product and functional application components
- Extremely high value to users
- It can be done!
  - Eclipse demonstrates this
  - Eclipse solves many of the hard problems



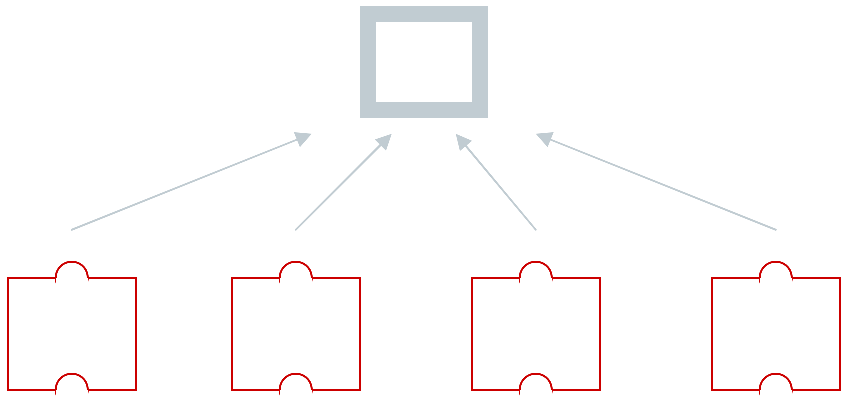
Things That Are In Common

- Bootstrap installer
- Unified user authentication (SSO)
- Automatic application component provisioning
- Inter-component communication mechanisms
- Master application UI window
- UI extension points
- Common look and feel for components
- User preference management
- Component model



Things That Are Different

- Many different application components
- Multiple independent application development teams
- Different development, testing and release schedules
- Different users (e.g. traders, salespeople, support staff) will need different sets of application components



Act II

Helios

Helios

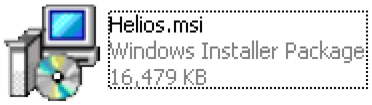
- Eclipse RCP-based UI container
- Hosts multiple application plugins
- Provides common services, mainly through plugins
  - Eclipse, Spring, etc
- Insulates component developers from some degree of complexity
  - Pre-built, pre-configured RCP application
  - Encapsulates common environment configuration, e.g. connection to RBC Active Directory LDAP

Development Notes

- A little less than a year old, 1 developer for most of that time
- Lots of functionality comes for free with Eclipse, Spring plugins
- Had to build some things; had to configure and integrate a lot of things

Installation and Provisioning

- **Installer**
  - **One installer for everyone**
  - **Simple, standard installation for all workstations**

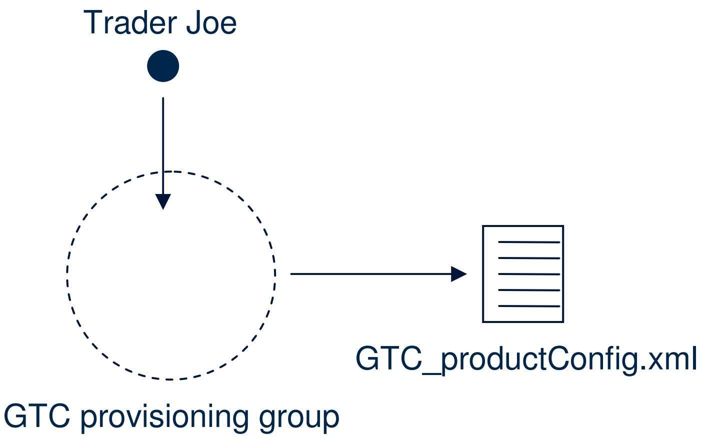


Helios.msi
Windows Installer Package
16,479 KB

- **Executable**
  - **One executable for everyone**
  - **Application components are automatically downloaded and installed when the user logs in**

helios.exe

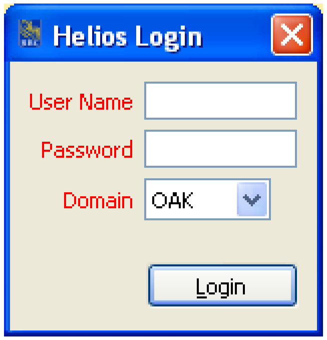
- **Provisioning**
  - **Users are associated with provisioning groups**
  - **Provisioning groups have associated product configurations which specify what components to install for members of the group**
  - **P2-based automatic provisioning**



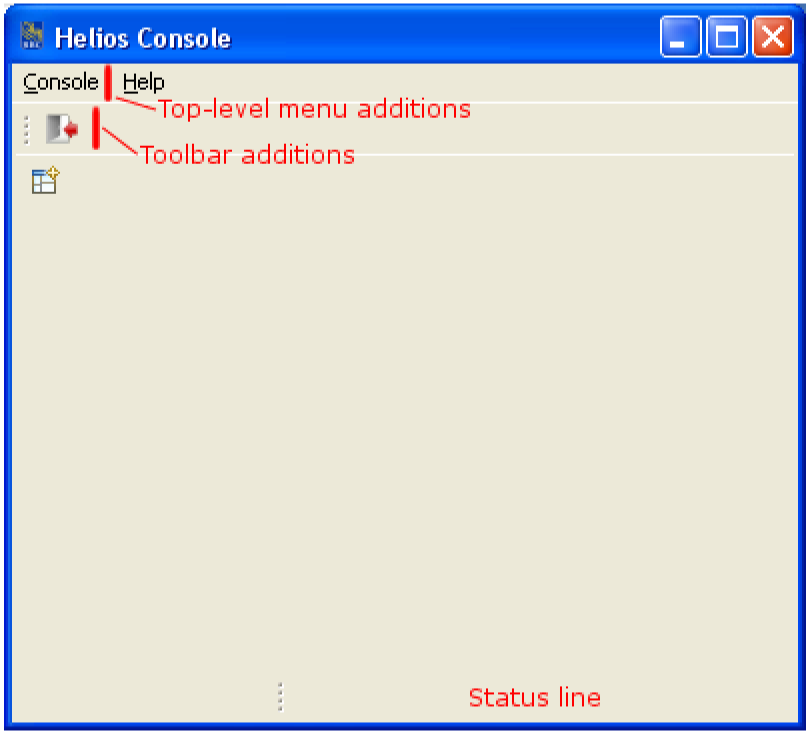
Authentication and Authorization

- Login dialog is the first thing the user sees
- Uses Spring Security
- Authenticates against RBC Active Directory LDAP
- Users can be associated with one or more security roles
- User security role info is installed in the SecurityContext on successful login
- The SecurityContext can then be queried for role membership to drive authorization behavior, e.g.:

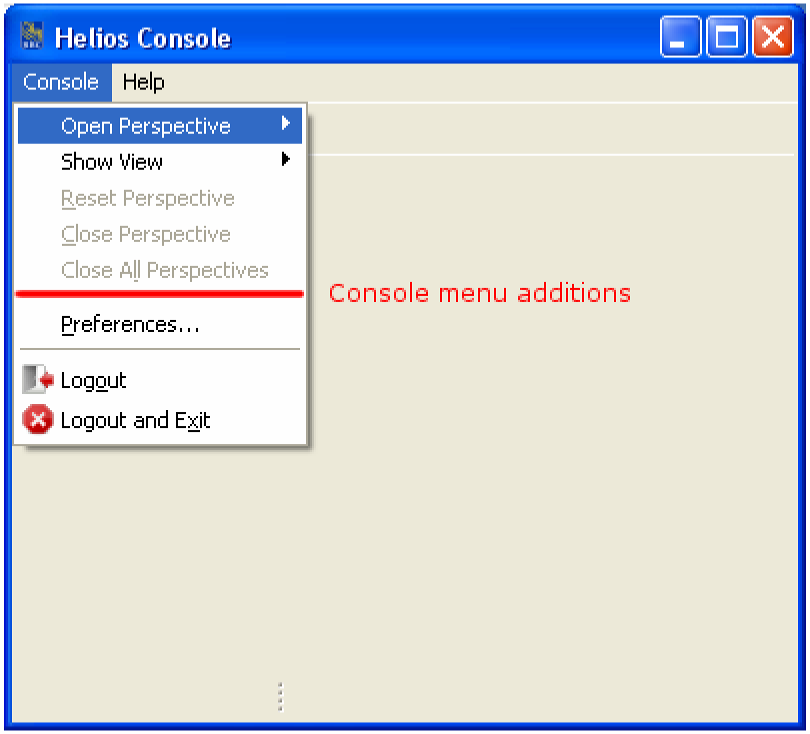
  -
    ```
    if (AuthUtil.hasAuthority("ROLE_ADMINISTRATOR")) {
      // do something
    }
    ```
- The SecurityContext is available to any component hosted in Helios for authentication/authorization



Master Application Window

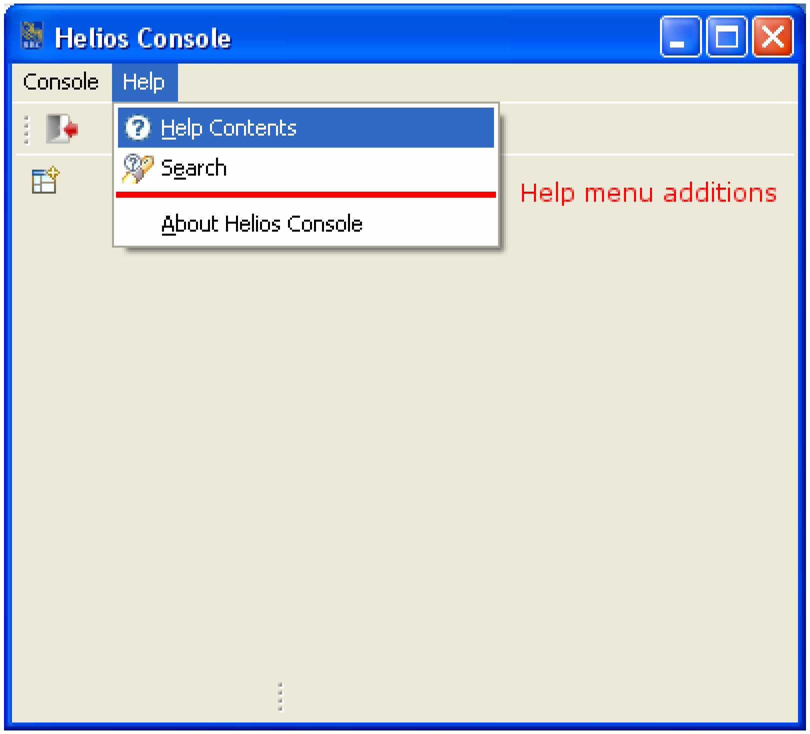


Master Application Window



Console menu additions

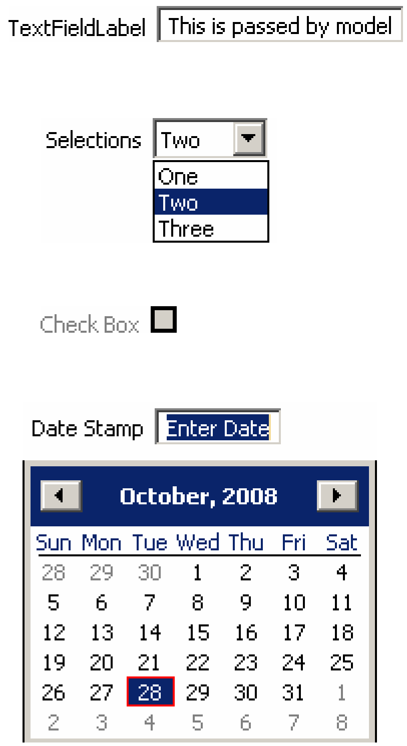
Master Application Window



Help menu additions

Common Look And Feel

- Standard set of UI controls
  - Mostly stock SWT controls
  - A few custom controls (date picker, data grid)
- Eclipse Forms Framework
- Built UI framework on top of above to encapsulate higher-order behavior and associations
  - Labels associated with form fields
  - Required field rendering
  - Etc
- Looking to also provide declarative UI specification
  - Eclipse modeling tools



TextFieldLabel: This is passed by model

Selections: Two

One
Two
Three

Check Box □

Date Stamp: Enter Date

October, 2008

Sun	Mon	Tue	Wed	Thu	Fri	Sat
28	29	30	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1
2	3	4	5	6	7	8

Inter-Component Communication

- **OSGi services**
  - **Can easily expose classes as OSGi services or get references to OSGi services via Spring DM**
  - <osgi:service ref="application" interface="org.eclipse.equinox.app.IApplication"/>
  - <osgi:reference id="ldapAuthoritiesPopulator" interface="org.acegisecurity.providers.ldap.LdapAuthoritiesPopulator"/>

- **Eclipse extension points**

- **Spring Remoting**

User Preferences Management

- Eclipse automatically saves user preferences on application shutdown and restores UI state when the application is restarted
- Eclipse normally stores user preferences in the workspace folder
- We want to move preferences to the server side
  - Allow preferences to be shared between users
  - Allow support to retrieve and locally apply a user’s preferences for troubleshooting purposes

Act III

The Wider World

Think Different

RBC Capital Markets

- ➢ Major shift from monolithic to component-oriented development
  - Developing parts rather than entire applications
- ➢ Much more reliant on common/shared stuff
  - Technology stack, component model, development infrastructure
- ➢ Requires coordination across development teams
  - Shared vision of macro application functionality
  - Need to make sure parts can work together

- ➢ The most crucial issue in making component-oriented development work is not really a technical one – it is figuring out how to work together as part of a larger development community

- ➢ Not just interested in Eclipse technologies, but also Eclipse development model

Fusion

- ➢ Moniker for shared development at RBC
- ➢ Emulating Open Source development model

- ➢ Core
  - Core Technology team
  - Coordinate and are 100% allocated to Fusion projects
- ➢ Contributors
  - Individuals from other teams that develop for Fusion
  - Allocated part time
  - Represent application requirements in Fusion development and communicate Fusion knowledge back to application team
- ➢ Community
  - People and teams that use Fusion products

Development Process Infrastructure

- Version control – source code repository, release tags, maintenance branches
- Automated build – build from source, continuous integration
  - Custom maven plugin wrapper for PDE Build
    - Encapsulates build conventions (directory locations, etc)
    - Reduces number of required configuration parameters
- Artifact repository – well-known location to find released artifacts
- Issue tracking system – plan and track releases
- Wiki – knowledge repository, reference information
- Forum – public discussions, support

- Favor lots of transparency, accessibility
- Always looking to improve our process and tooling

Rules Of Thumb

- Make sure you’re building something people need, with the quality that they want
- Make others part of the solution and then you won’t have to worry so much about adoption
- Get support from the top (management) to make resource and schedule accommodations for shared technology projects

Act IV

Epilogue

So Here We Are

- Helios currently used by 2 FI applications in standalone mode
- Those and several other applications will be starting to migrate onto Helios in shared mode in early 2009

- Strategic application integration platform for RBC Fixed Income applications
- Impacting how applications are being developed and composed

Parting Shots

- ➢ Combination of Eclipse and Spring is extremely powerful
- ➢ Technology alone is not sufficient for success
- ➢ Need to pay a lot of attention to how the technology will be used and who will be using it

- ➢ Eclipse allowed us to address the really high value problem first
- ➢ This is just the beginning, there's a long way to go from here
  - Adding additional shared functionality to Helios
  - Other middle and backend integration infrastructure