Patterns for scalability and availability in (trading) systems

Michel André – CTO – Saxo Bank
Saxo Bank – introduction

- Global online investment bank – facilitator/broker setup - offices in 25 countries clients in 180 countries
- Specialises in online trading and investment, servicing retail clients, corporations and financial institutions
- A leading presence in online trading due to client service, competitive pricing and industry-leading trading platforms.
- Enables private investors and institutional clients to trade FX, CFDs, ETFs, Stocks, Futures, Options and other derivatives via multi-award winning online trading platform.
- 3rd generation technical platform and evolving – Microsoft based, mostly custom developed in house
- 10 of thousands of concurrent users, 100 of thousands of price updates/sec, very high transaction peaks around numbers and market state changes.
Core Business Model

Cloud based – Platform as service – White label
## Truly multi-asset / single account

<table>
<thead>
<tr>
<th>OTC</th>
<th>Exchange Traded</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forex</strong></td>
<td><strong>FX Options</strong></td>
</tr>
<tr>
<td>![Fx] 160+ crosses</td>
<td>![Fx] 40+ crosses</td>
</tr>
<tr>
<td>![Fx] Tradable quotes</td>
<td>![Fx] Tradable quotes</td>
</tr>
<tr>
<td>![Fx] Request for quotes</td>
<td>![Fx] Broad coverage 1d-1y</td>
</tr>
<tr>
<td>![Fx] Margin</td>
<td>![Fx] Vanilla, binary touch</td>
</tr>
<tr>
<td><strong>CFD</strong></td>
<td><strong>Bonds</strong></td>
</tr>
<tr>
<td>![CFD] 8700+ stocks, 22 index trackers, 20 commodities</td>
<td>![Bo] Wide range sovereign, government, corporate bonds</td>
</tr>
<tr>
<td>![CFD] Tradable quotes, extensive liquidity</td>
<td>![Bo] Offline traded</td>
</tr>
<tr>
<td>![CFD] Algorithmic orders/Smart order routing/DMA</td>
<td>![Bo] Collateral</td>
</tr>
<tr>
<td><strong>Stocks</strong></td>
<td><strong>ETFs &amp; ETCs</strong></td>
</tr>
<tr>
<td>![Eq] 18400+ equities</td>
<td>![Eq] 2270+ exchange traded funds (ETF), commodities (ETC)</td>
</tr>
<tr>
<td>![Eq] 33 exchanges</td>
<td>![Eq] Listed, traded and settled as stocks</td>
</tr>
<tr>
<td>![Eq] Algorithmic orders/Smart order routing/DMA</td>
<td><strong>Futures</strong></td>
</tr>
<tr>
<td><strong>Contract options</strong></td>
<td><strong>Futures</strong></td>
</tr>
<tr>
<td>![Fu] 230+ base contracts</td>
<td>![Fu] 230+ base contracts (stock indices, commodities, interest rates, forex)</td>
</tr>
<tr>
<td>![Fu] 22 exchanges</td>
<td>![Fu] 17 exchanges</td>
</tr>
<tr>
<td>![Fu] Margin</td>
<td>![Fu] Margin (SPAN/Portfolio)</td>
</tr>
</tbody>
</table>
Workflow/service requirements

Trading & execution
- Tradable quotes
- Request for Quotes
- DMA Access

Order handling
- Order management
- Order routing
- Order execution

Risk
- Pre trade/pre order risk checks
- Margining Credits
- Account summary

Price/instruments
- Price formation
- Price distribution
- Reference data

Content
- Charts
- News
- Analysis/research

Authentication (SSO)
Authorization Claims
Subscriptions
Settings Profiles Configuration
The numbers...

- Over **13,000** concurrent online clients - operational and open 5.5 days * 24 hours
- In excess of **400,000** price feed updates per second
- Intraday execution of up to **900** trades per second
- Over **500,000** trades booked and processed daily
- **160,000** unique users monthly to our trading portal
- While maintain latencies in the single digit millisecond range throughout
Business challenges

Unified and compelling client experience
- Across devices/platforms
- Across products
- Across segments
- Across geographies

Cost-efficiency
- Technology sharing
- Reuse
- Avoid duplication and proliferation

Faster time to market and flexibility
- New products
- Features/sophistication
- New geographies

Compliance and regulation
- Regulated in many geographies direct/indirect
Critical business flows – where milliseconds matter

Liquidity

Price formation

Feed Handler Connectivity → Price Aggregation → Price Distribution

Price IN

Price OUT

Hedge

Flow handling

Exposure calculation

Trade capture

Trade processing

Clients

Margin check
Challenge - Business growth – with corresponding data growth
Trading systems are “Reactive systems” - at heart ...

...core design principles mapped to tenets of reactive

<table>
<thead>
<tr>
<th>Responsive</th>
<th>Elastic</th>
<th>Resilient</th>
<th>Message Driven</th>
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</thead>
<tbody>
<tr>
<td>Casual/eventual</td>
<td>Scale out on commodity hardware</td>
<td>Redundancy (active/active)</td>
<td>Event driven / Message based</td>
</tr>
<tr>
<td>consistency</td>
<td>Horizontal scaling/partitioning</td>
<td>No single points of failure</td>
<td>Losely coupled through topic</td>
</tr>
<tr>
<td>guarantee</td>
<td>of work sets</td>
<td>Automated seamless failover</td>
<td>based pub/sub (location independent)</td>
</tr>
<tr>
<td>Horizontal</td>
<td>Swift capacity growth by</td>
<td>Survive with reduced service a</td>
<td></td>
</tr>
<tr>
<td>scaling/partitioning</td>
<td>horizontal scaling</td>
<td>datacenter failure/ outage</td>
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<tr>
<td>of work sets</td>
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<td>State replication</td>
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<td>Asynchronouse/fire</td>
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<td>interaction where</td>
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<td>it can be supported</td>
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<td>Very high</td>
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<td>throughput and</td>
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<td>tight latency</td>
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<tr>
<td>requirements</td>
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</table>

http://www.reactivemanifesto.org/
Technical Environment

Microsoft through and through

- Windows 2008/2012 servers
- SQL Server 2012

Middleware/Messaging

- 29West / Informatica (Multicast messaging and persistence)
- WCF
- MS Biztalk (Integration backoffice/enterprise)
- Plain old sockets

Standard Windows Services (.NET C#, C++, IIS 7.5)

Shared in process components for business logic and caching

Monitoring, instrumentation & tracing

- Velocimetrics
- SCOM
- Standard Windows performance counters
- Eventlog and Logfiles

Cisco infrastructure

- ISP Grade
- MPLS
Target architecture – front office

Presentation layer for different clients and front ends. Scales horizontally. Sticky sessions. Front loading of business logic.

High performance messaging middleware with horizontally scalable persistence (Prices, Trades, Orders)

Back end, infrastructure services, horizontally partitioned and fault tolerant (redundant)

Data store running mirroring/HA. Single instance.

Active/active MESH segmenting/partitioning of workloads along some axis

Large grained shared components encapsulating in-process bus logic and in memory data

REST based Open API with streaming over websockets for services
Interesting patterns

Asynchronous transaction logging backed by messaging system

Meshes of partitioned servers executing real-time automated business processes and actions

Witness server to achieve seamless failover (active/active)

Scalable session management shared streaming channel among service groups, pluggable service groups

Monitoring/Tracking
• Long latency
• Database bottleneck
• Capped throughput (by DB)
Asynchronous Transaction Registrations – Target state (3 gen)

- Long latency
- Database bottleneck
- Capped throughput (by DB)

Transaction fully verified and accepted

Transaction message persisted in memory in 2 machines of 3 (Quorom) for resilience, replay

- Scalable
- Resilient
- High throughput
- Low latency
- Event driven

Transaction asynchronously written to DB

Transaction picked up and processed, aggregate sent out

Blotters and aggregate views updated immediately
Asynchrounous Transaction Registrations – Final Twist (fully active)

- Transaction published as a persistent message
- Transaction received by logger 1
- Transaction booked by logger 1
- Transaction received by logger 2
- Transaction fails gracefully by logger 2

- Simple
- Robust
- Failure code path always executed
- No failover logic
It's not all architecture and technology.

<table>
<thead>
<tr>
<th>People</th>
<th>Process</th>
<th>Business</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Hire the best</td>
<td>• Change/Release</td>
<td>• Close cooperation</td>
</tr>
<tr>
<td>• Performance culture</td>
<td>• Test/quality</td>
<td>• Agile methodology</td>
</tr>
<tr>
<td>• Cultivate engineering mindset and agility</td>
<td>• Incident management</td>
<td>• Change management</td>
</tr>
<tr>
<td>• Supporting management</td>
<td>• Monitoring</td>
<td>• Hamper complexity</td>
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</tbody>
</table>
Learning points - liabilities

 Architecture needs resilience, scalability, monitoring, supportability built in and taken care from the start due to complexity and number of nodes/ci

 Synchronize projects and implementation with infrastructure (machine rooms, firewalls, network segmentation - is also part of the solution)

 Do gradual rollout and provide rollback and backwards compatibility to decrease operational risk of large architectural impacting changes.
    This comes at a cost both in development and phasing out of old style clients

 Test and verify thoroughly

 Your architects might get skinny and lose some hair