EUROPEAN CENTRAL BANK

EUROSYSTEM

Key insights
DG-M outreach on AI

20 November 2024
Foreign Exchange CG

ECB Directorate General Market Operations

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Summary and key take-aways

DG-M carried out an outreach initiative to gather information on counterparties' involvement in innovation activities related to AI...

Invitations and meeting overview

- **Fourteen invites** sent to members of **ECB Market Contact Groups**
- **Nine meetings** held with **BMCG**, **MMCG**, and **FXCG** members from **11 April and 10 May 2024**
- Participants from **sell-side, buy-side** (asset managers), and operators of **market data services**

Meeting preparation and structure

- Six high-level AI-related questions shared with participants **before meetings**
- Questions aimed to **assess AI use cases and maturity** of innovation initiatives in the industry

Participant engagement and meeting dynamics

- Roles of participants varied; **skilled AI experts at most meetings**
- Meetings conducted in an **informal, semi-structured format**

…where the following key take-aways were identified regarding the industry's adoption and practical applications of AI

- **Textual data** is used for ML analyses to extract information from large volumes of documents (e.g., Bloomberg chats, analyst reports)
- GenAI opens new avenues, but applications are still at an **exploratory stage**

- AI supports **systematic trading** of hedge funds and alpha generation
- Yet, **questions remain about the practical integration of AI** applications with canonical algorithmic strategies

- AI is used for **credit acceptance, pricing** and **personalisation**
- Anticipated to automate **Know Your Client applications** and **client communications**

- AI expected to enhance **productivity**
- Reducing the time to finalise **lending agreements** by automatically filling in relevant data in loan applications

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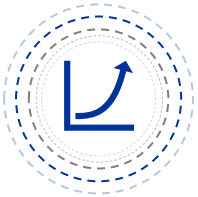
Key aspects of AI applications

Influence and perceptions of AI



Increased productivity

- AI is primarily seen as a **productivity enhancer**
- Participants focus on **efficiency gains** in their workstreams
- While predictive ML has been largely adopted, **applications of GenAI** are mostly **in exploratory phase**

Growing number of applications

- Process automation, **textual summaries** of various information sources
- **Chat bots** for customer-facing activities or help desk
- Automated trading in **ideation stage**

Little revenue generation (yet)

- Talk about significant **potential of GenAI as a groundbreaking technological advancement**
- **Concerns over unrealistic expectations** leading to a potential bubble
- **Risk of investment in AI projects** that may not yield immediate or tangible financial returns

Development and implementation

Sandbox preferred

- Participants are welcoming **safe sandbox environments** when deploying LLMs to keep data internal
- Some even work on their **own proprietary LLMs** to reduce their reliance on providers

Dependence on third parties

- Risk of **vendor lock-in**, with a few **big tech companies dominating the industry**
- Competing interests identified in relation to **cost effectiveness** on the customer side, while providers aim to boost **product usage and fees**

No common approach to governance and talent acquisition

- Participants are in **different stages** regarding their adoption and integration of AI into their frameworks
- There is **significant variation** in terms of HR and financial investments in AI across firms
- Most participants work with a **small central team** for governance and **decentralised** teams for implementation
- Some created **new organisational units, specifically recruiting AI talent**

Deployment and security concerns

Deployment Concerns	Security Concerns
Complexity of integration with existing systems	**Data protection** and privacy risks
High initial costs and resource allocation	Vulnerabilities to **cyber-attacks** and breaches
Gen AI not **interacting directly** in markets yet	**Human involvement** to control certain Gen AI systems
Trust issues and fear of **hallucinating generative AI**	Ensuring compliance with **regulatory requirements**

Background

Questionnaire to counterparties

1. What are the big pain points you have identified as being use cases that AI can resolve?
2. Could you describe any of your (non-confidential) flagship AI initiatives or important proof of concepts?
3. What are the main benefits, costs, and risks with your current AI endeavours?
4. What is your team structure and different roles and skills in your AI/innovation teams (e.g., Hub and Spoke)? Central or decentral or hybrid?
5. How do you measure the impact/success of your AI initiatives?
6. How do you collect business requirements and how do you ensure continuous alignment between IT and business over the full life cycle of an innovation project?

BBVA

Creating Opportunities

Artificial Intelligence and Technological Innovation in FX Markets

Prepared for the ECB FX Contact Group

November 2024

/ Artificial Intelligence In a Nutshell

"The Science and Engineering of Making Intelligent Machines" (McCarthy, 1955)

Learning
Reasoning
Interpreting
Understanding
Adapting

First AI Winter

Second AI Winter

1950-60s | 1970s | 1980s | 1990s | 2000s | 2010s | 2020s | ??

Birth of AI

Expert Systems (rules based)

MYCIN

DENDRAL

Machine Learning

SVM

Random Forest

XgBoost

Deep Learning (neural networks)

Deep Reinforcement Learning

Alex Net

AlphaGo

Generative AI (LLMs)

ChatGPT

AGI

Knowledge Driven

Data Driven

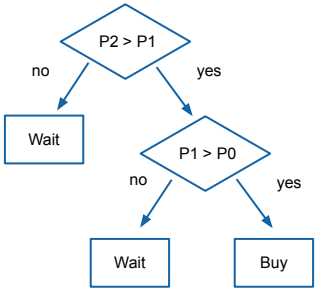
Agent Driven

/ Artificial Intelligence In a Nutshell

Expert Systems (1970s-80s)

Rules given by human experts

General purpose within domain



Machine Learning (1990s-2000s)

"Rules" are learnt from data examples

Good at solving very specific tasks

R(T-2), Imbalance (T-2), Order Flow (T-2) → Trend (T-1)
R(T-1), Imbalance (T-1), Order Flow (T-1) → Trend (T)

Decision Tree, Random Forest, SVM…

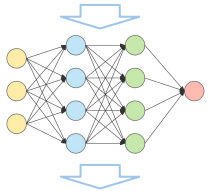
R(T), Imbalance (T), Order Flow (T) → ?

Deep Learning (2010s)

ML + Deep Neural Networks (DNN)

ML in steroids

R(T-2), Imbalance (T-2), Order Flow (T-2) → Trend (T-1)
R(T-1), Imbalance (T-1), Order Flow (T-1) → Trend (T)



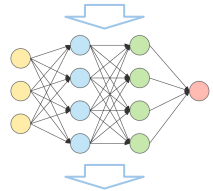
R(T), Imbalance (T), Order Flow (T) → ?

Deep Reinforcement Learning (2010s)

RL: learn to evaluate the best policy (action)

RL + DNN = DRL

R(T-2), Imbalance (T-2), Buy (T-2) → P&L
R(T-1), Imbalance (T-1), Wait(T-1) → P&L



Value[R(T), Imbalance (T), Buy]
Value[R(T), Imbalance (T), Wait]

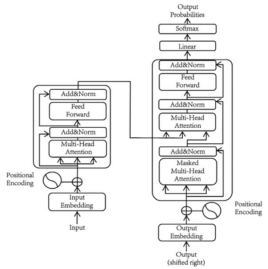
/ Blending Knowledge and Data Driven AI: Agent Driven Generative AI

Large Language Models (LLMs)

Self-supervised learning from text sequences

Models | Are | Useful | Tools

Transformer Architecture



RL fine-tuning (human in the loop)

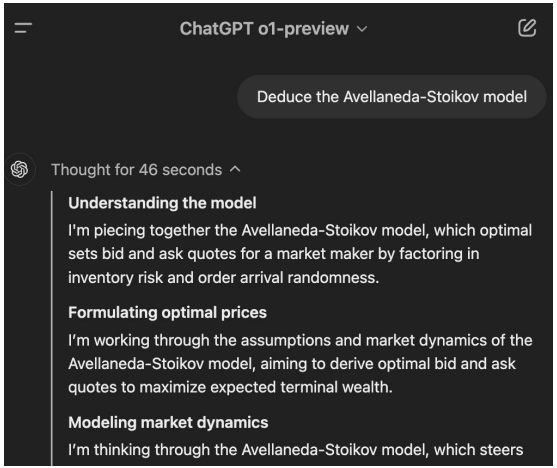
*Can be instructed for generic tasks via **prompts***

Chain of Thought

Reason step by step

Generate alternatives for each step

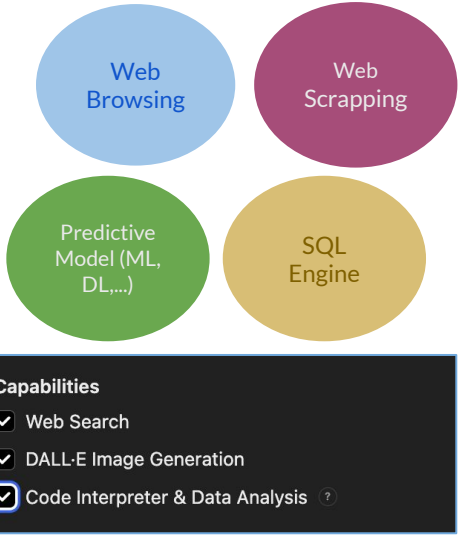
Evaluate quality using DRL



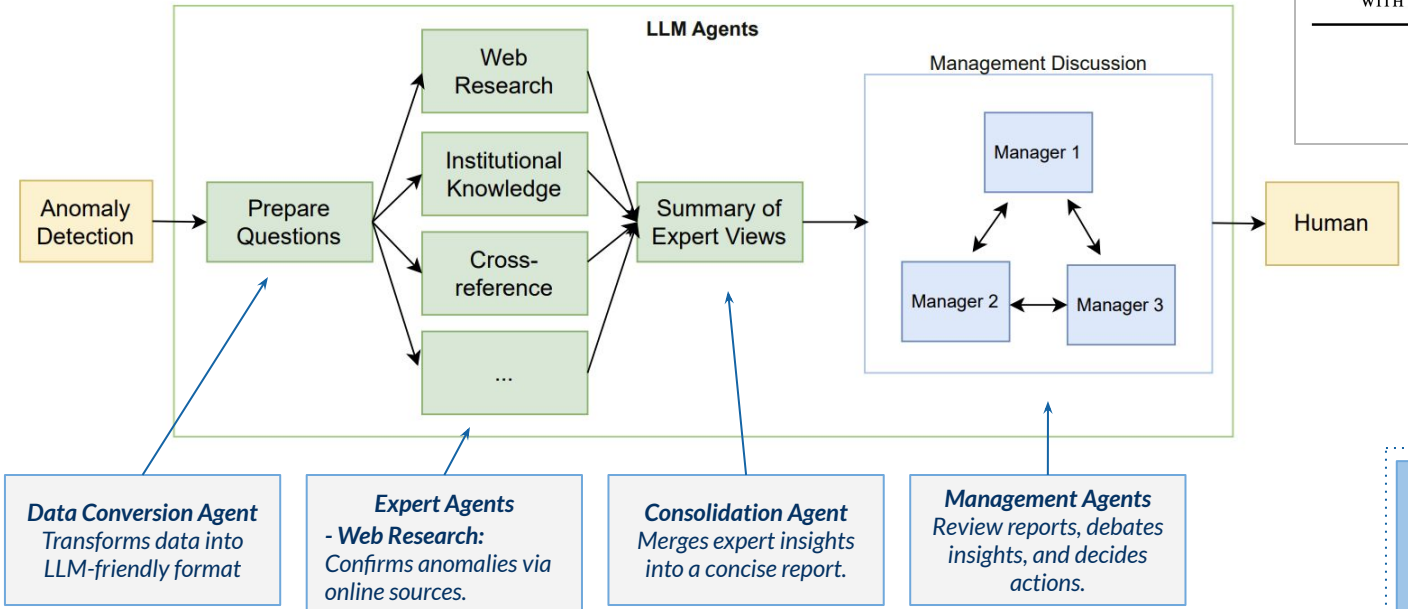
Agents (ReAct)

LMMs with access to tools

Tools expose APIs to the model



/ Example of Agent Driven AI in The Financial Markets: Anomaly Detection



Data Conversion Agent
Transforms data into LLM-friendly format

Expert Agents
- ***Web Research:*** *Confirms anomalies via online sources.*
- ***Institutional Knowledge:*** *Adds domain-specific context.*
- ***Cross-Checking:*** *Validates with related datasets.*

Consolidation Agent
Merges expert insights into a concise report.

Management Agents
Review reports, debates insights, and decides actions.

ENHANCING ANOMALY DETECTION IN FINANCIAL MARKETS WITH AN LLM-BASED MULTI-AGENT FRAMEWORK

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Web Research Agent

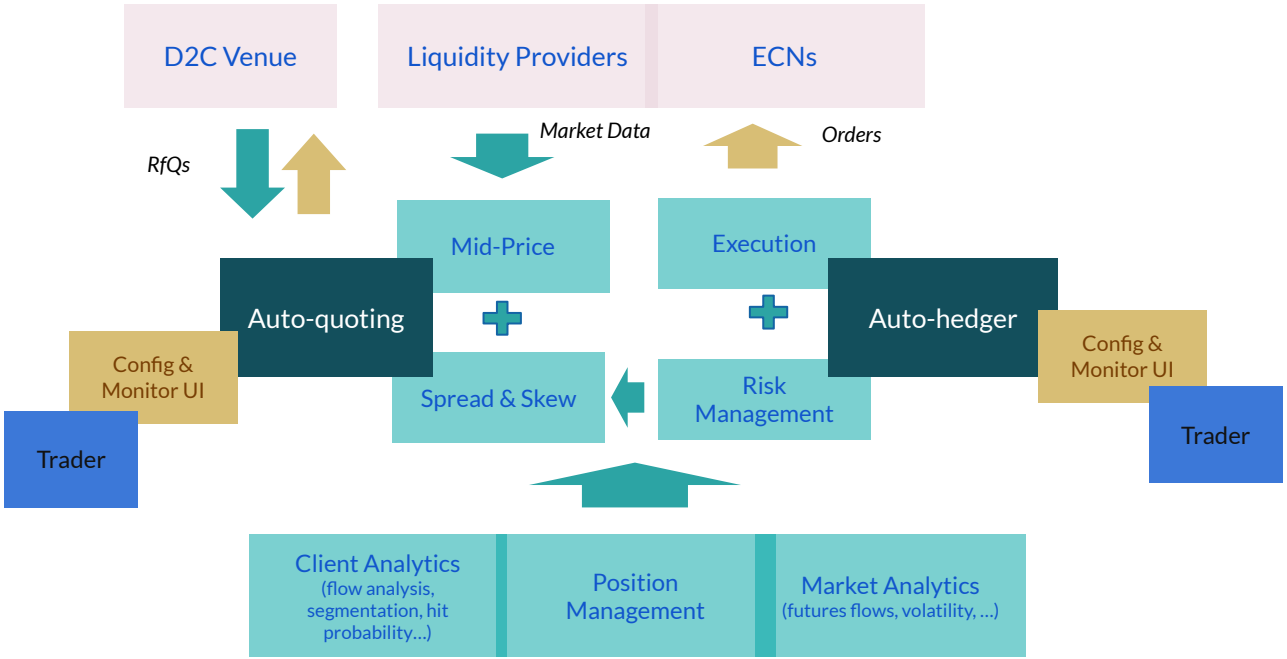
LMM
Generic LLM with specific expert knowledge via a prompt

Web Browsing Tool
API to access the Web and retrieve information

INSTRUCTION TO AGENT:
You are a web searching expert to verify some data-related questions. When I give you questions, can you search web and verify the information? As you need to verify all the bullets, please respond concisely. Your answer starts with Correct, Incorrect, or Uncertain. Then provide the reasoning in one sentence.

/ FX Trading & Sales Applications: Algorithmic Trading

Sketch of an Algorithmic Market Making System for FX D2C Venues



Rules Based Systems
Based on trading heuristics or mathematical optimization (e.g. Avellaneda-Stoikov framework)

Machine Learning Systems
Complement rules based systems with ML driven indicators: probability of hit, flow prediction, volatility prediction…

Deep Reinforcement Learning Systems
Rules Systems are replaced by a trading strategy learnt from trading simulations driven by P&L and Risk "rewards"

Agent Driven AI Systems
Blend expert knowledge via prompts with LMM reasoning and repurposed previous systems as tools: rules-based, ML based, DRL based

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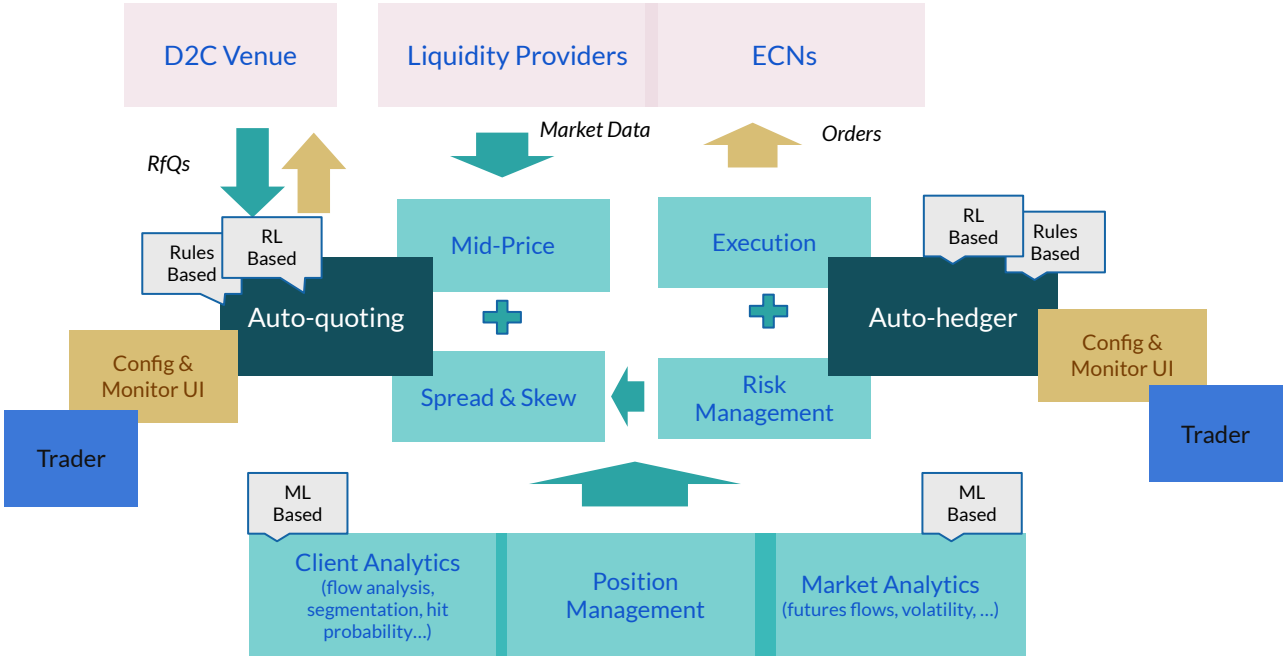

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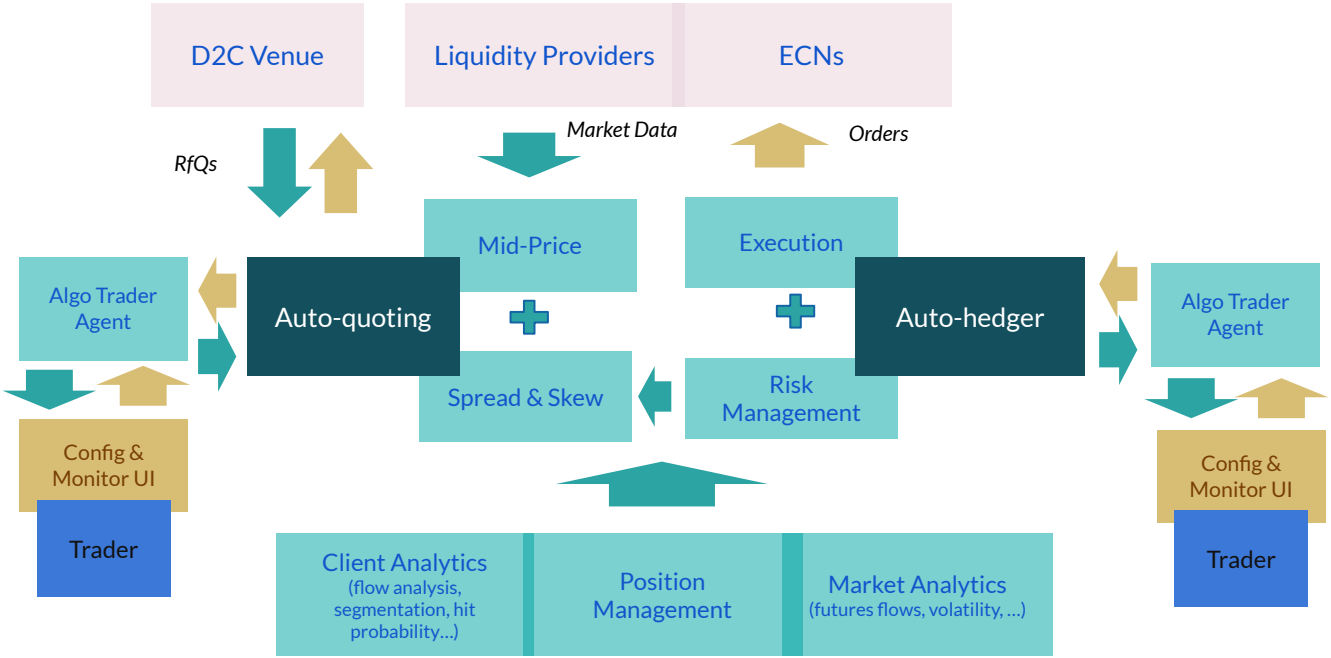

Algo Trader Agent

Metrics Interpreter
LLM that interprets analytics for trading and suggest actions

Trading Copilot
LLM that converts trading goals to parameters of the system

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Based on trading heuristics or mathematical optimization (e.g. Avellaneda-Stoikov framework)

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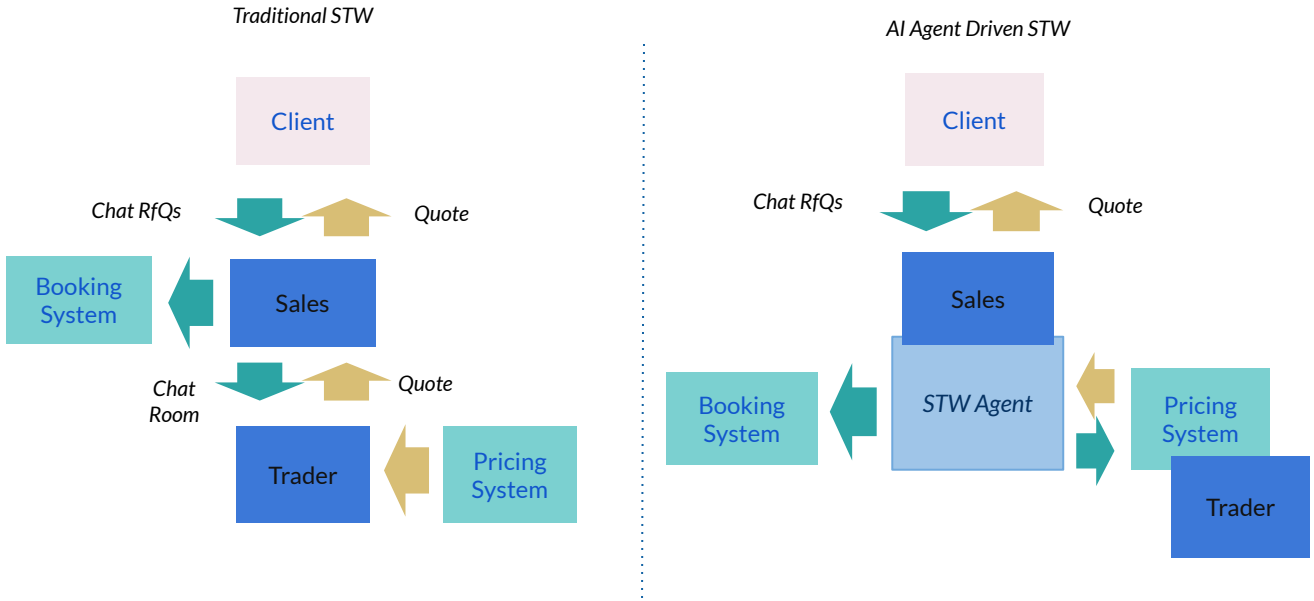
/ FX Trading & Sales Applications: Sales Trader Workflow (STW)



LMM STW Agent

Parsing Agent
*LLM with instructions to extract RfQ information + **tool** to convert to XML, JSON..*

Parsing Correction Agent
LLM that evaluates the quality of the extraction and pass feedback to the Parsing Agent

Pricing Agent
*LLM that calls the Pricing System as a **tool**. It has instructions to handle errors and evaluate if prices make sense*

Booking Agent
*LLM that upon the client accepting the RfQ, sends the structure to booking as a **tool***

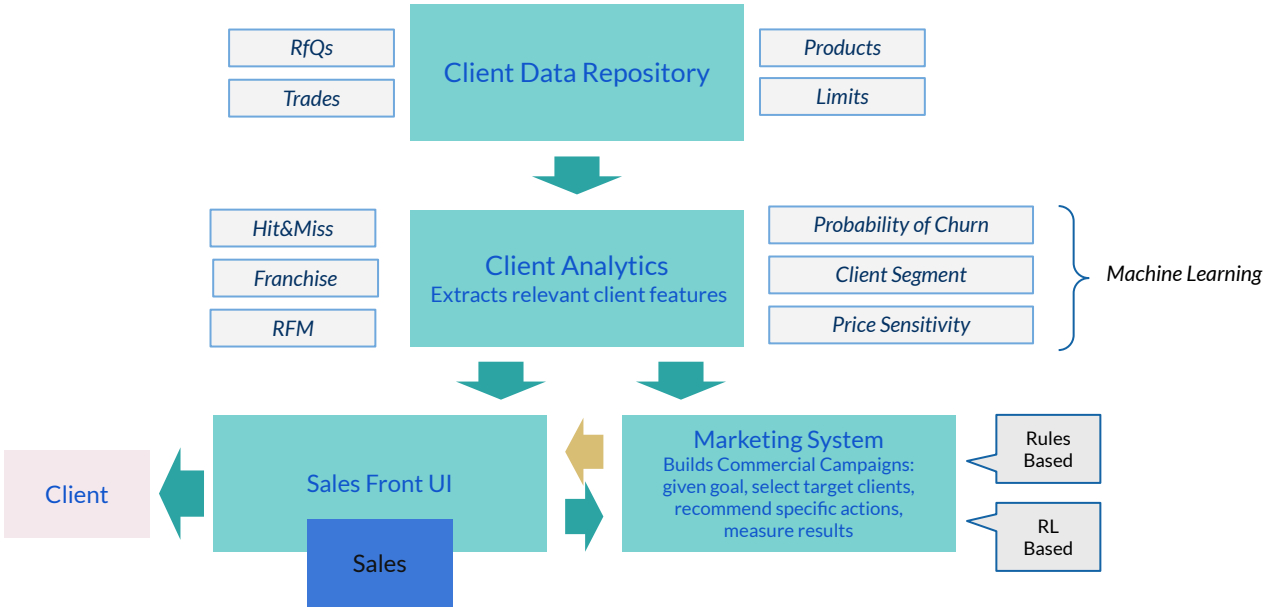
Rules Based Systems
Parsing rules to extract information from chats

Machine Learning Systems
Natural Language Processing (NLP)
Machine Learning models

Generative AI
GPT like models with expert prompt to extract relevant information, human supervised

Agent Driven AI Systems
Full autonomous system with a self criticism layer and response to errors

/ FX Trading & Sales Applications: Algorithmic Marketing



Rules Based Systems
Heuristic rules to alert of client activity
Heuristic rules to segment clients

Machine Learning Systems
Churn prediction, client clustering, product recommendation

Deep Reinforcement Learning Systems
Generate next best commercial action based on context

Agent Driven AI Systems
End-to-end commercial campaigns, handling (written) communications

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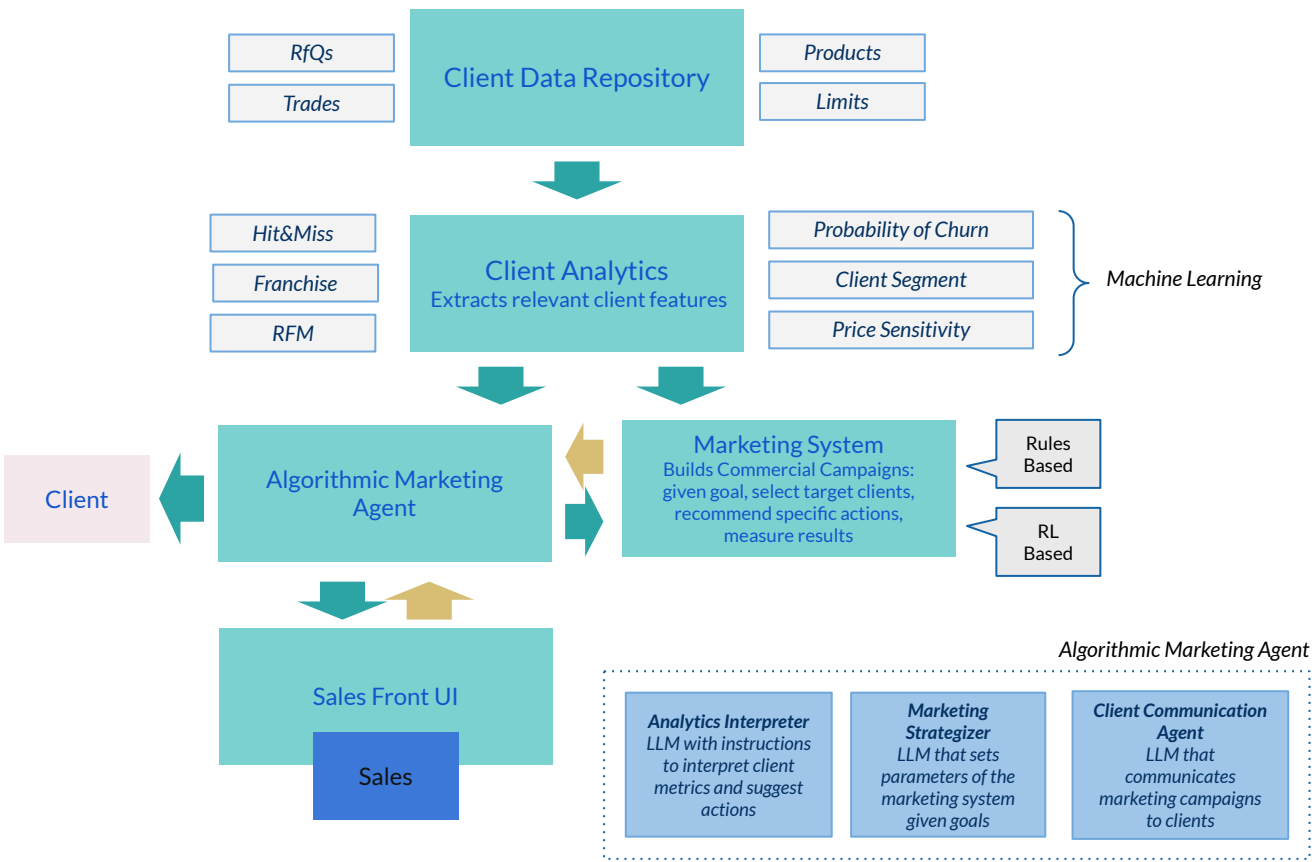

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/ Regulatory Challenges

Black-box

- The lack of understanding of AI operations can lead to unpredictable and potentially detrimental outcomes. This opacity could jeopardise accountability.
- Nonbanks may be better placed to use them due lo a lighter supervisory regime.

Third parties dependencies and concentration

- AI services currently concentrated in a handful of providers. This creates strong interdependencies potentially as critical as some financial market infrastructures (FMIs)
- Potential to exacerbate market procyclicality and volatility

Cyber

- AI might increase the financial markets' vulnerability due to cyber threats.