

Fox ML Infrastructure – System Architecture Diagram

This document provides a visual and textual representation of the Fox ML Infrastructure system architecture. This architecture diagram is essential for enterprise technical reviews and integration planning.

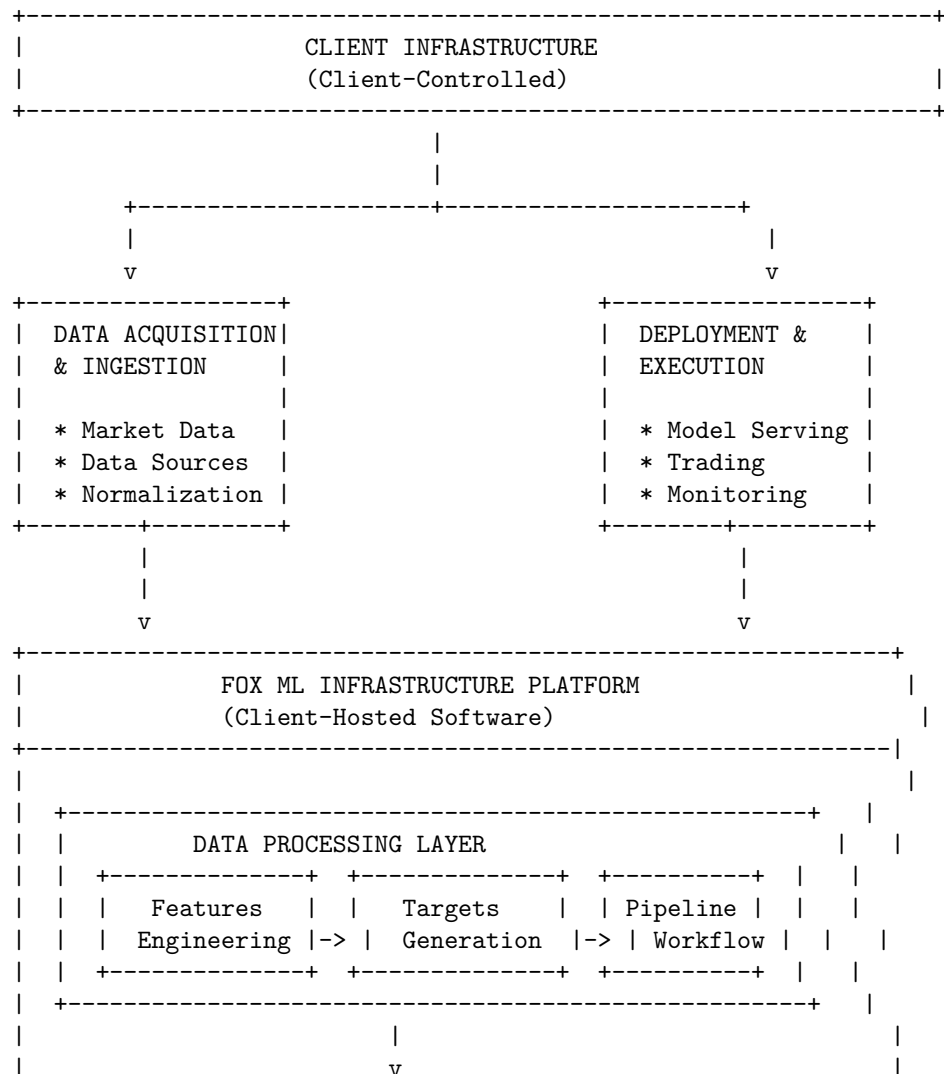
1. Executive Summary

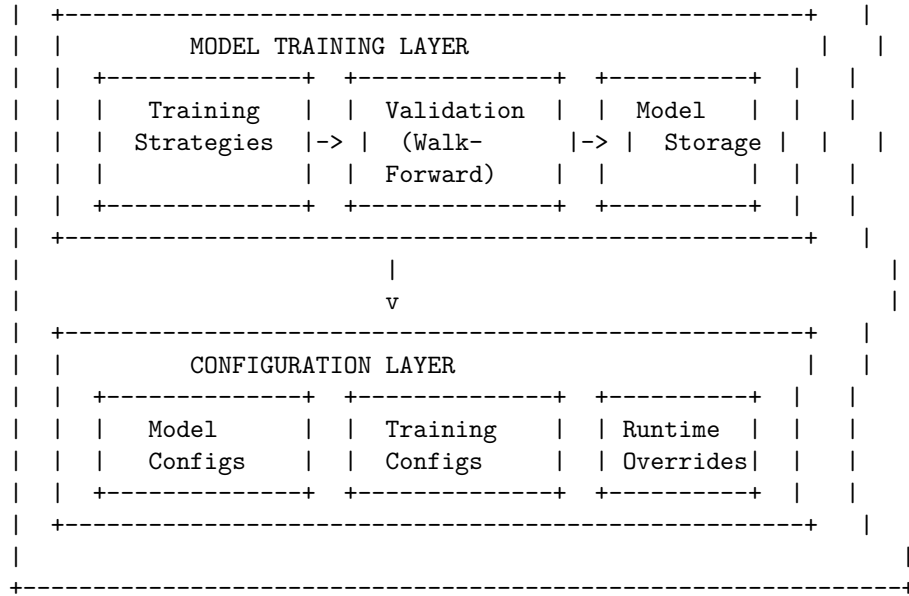
Fox ML Infrastructure is a client-hosted, modular ML research infrastructure platform.

Key architectural principles: - **Client-hosted** – Software runs entirely on client infrastructure - **Modular design** – Clear separation of concerns across modules - **Configuration-driven** – All runtime parameters from centralized configs - **Pipeline-based** – Data flows through well-defined pipeline stages - **Extensible** – Easy to add new models, features, and strategies

2. High-Level Architecture

2.1 System Overview





3. Component Architecture

3.1 Data Processing Layer

Purpose: Transform raw market data into ML-ready features and targets.

Components:

```
DATA_PROCESSING/
+-- features/
|   +-- SimpleFeatureComputer      # Basic technical indicators
|   +-- ComprehensiveFeatureBuilder # 200+ feature engineering
|   +-- StreamingFeatureBuilder    # Streaming/online features
+-- targets/
|   +-- BarrierTargetBuilder       # Barrier-based targets
|   +-- ExcessReturnsBuilder       # Excess return targets
|   +-- HFTForwardReturnsBuilder   # High-frequency targets
+-- pipeline/
|   +-- DataNormalization          # RTH alignment, grid correction
|   +-- FeaturePipeline            # End-to-end feature workflow
|   +-- TargetPipeline             # End-to-end target workflow
+-- utils/
|   +-- MemoryManagement           # Efficient memory handling
|   +-- Logging                    # Structured logging
|   +-- Validation                 # Data sanity checks
```

Data Flow:

```
Raw Market Data
  v
Normalization (RTH alignment, grid correction)
  v
Feature Engineering (200+ technical features)
  v
Target Generation (barrier, excess returns, HFT)
```

v
Labeled Dataset (features + targets)

3.2 Model Training Layer

Purpose: Train and validate ML models using walk-forward validation.

Components:

```
TRAINING/  
+-- model_fun/  
|   +-- LightGBMTrainer      # Gradient boosting  
|   +-- XGBoostTrainer      # Gradient boosting  
|   +-- MLPTrainer          # Deep learning  
|   +-- TransformerTrainer   # Transformer models  
|   +-- EnsembleTrainer      # Model ensembles  
|   +-- MultiTaskTrainer     # Multi-task learning  
|   +-- [13+ additional trainers] # Probabilistic, advanced models  
+-- strategies/  
|   +-- SingleTaskStrategy   # One model per target  
|   +-- MultiTaskStrategy    # Shared model for targets  
|   +-- CascadeStrategy      # Sequential dependencies  
+-- walkforward/  
|   +-- WalkForwardValidator  # Time-series validation  
|   +-- PurgedTimeSeriesSplit # Leakage-safe splitting  
+-- memory/  
    +-- MemoryManager        # Memory optimization  
    +-- BatchProcessing       # Efficient batch handling
```

Training Flow:

```
Labeled Dataset  
  v  
Walk-Forward Validation (time-series split)  
  v  
Model Training (17+ model types)  
  v  
Model Validation (performance metrics)  
  v  
Trained Models (serialized)
```

3.3 Configuration Layer

Purpose: Centralized, version-controlled configuration management.

Components:

```
CONFIG/  
+-- model_config/  
|   +-- lightgbm.yaml        # LightGBM configs (3 variants)  
|   +-- xgboost.yaml         # XGBoost configs (3 variants)  
|   +-- mlp.yaml             # MLP configs (3 variants)  
|   +-- [14+ additional configs] # All model types  
+-- training_config/  
|   +-- walkforward.yaml     # Walk-forward parameters
```

```
|   +-- feature_selection.yaml      # Feature selection configs
|   +-- first_batch_specs.yaml     # Training specifications
+-- config_loader.py
    +-- load_model_config()        # Load model configs
    +-- list_available_configs()   # List available configs
    +-- apply_overrides()          # Runtime overrides
```

```
Base Config (YAML)
  v
Variant Selection (conservative/balanced/aggressive)
  v
Runtime Overrides (environment variables, CLI args)
  v
Final Configuration (validated, applied)
```

Purpose: Generation and storage of trained models, predictions, and performance metrics.

```

outputs/           # Model artifacts and outputs
+-- models/        # Serialized trained models
|   +-- lightgbm/   # LightGBM model artifacts
|   +-- xgboost/    # XGBoost model artifacts
|   +-- [other model families] # Additional model types
+-- predictions/    # Model predictions
|   +-- validation/ # Validation set predictions
|   +-- test/       # Test set predictions
+-- reports/        # Performance reports
    +-- metrics/    # Performance metrics
    +-- diagnostics/ # Model diagnostics

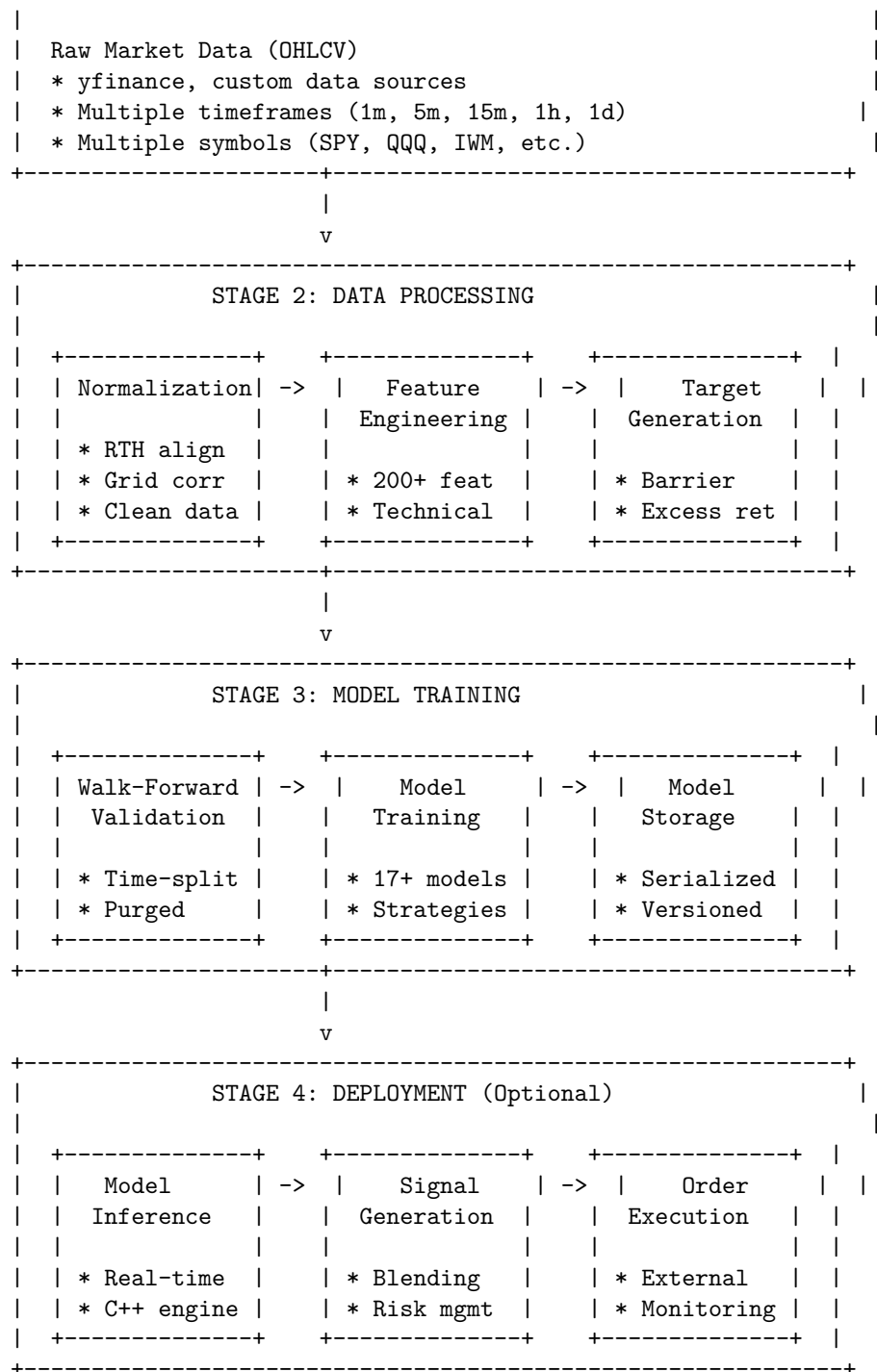
```

```

Trained Models
  v
Model Serialization (standard formats)
  v
Signal Generation (trading signals)
  v
Risk Management (safety guards, position sizing)
  v
Order Execution (broker integration)
  v
Performance Tracking (PnL, metrics)

```

4.1 End-to-End Pipeline



5. Module Dependencies

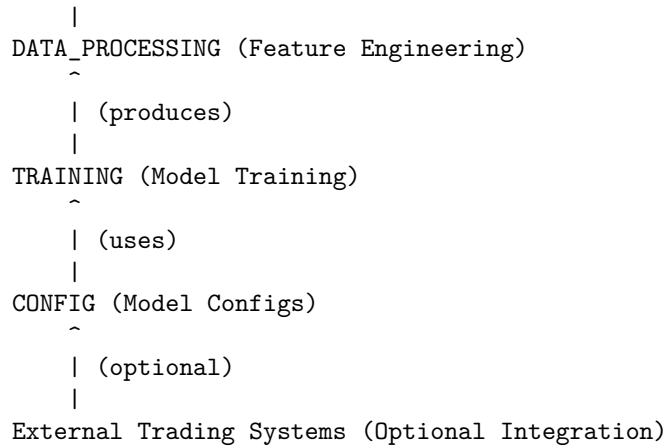
5.1 Dependency Graph

CONFIG (Configuration Management)

```

^
| (used by)

```



5.2 External Dependencies

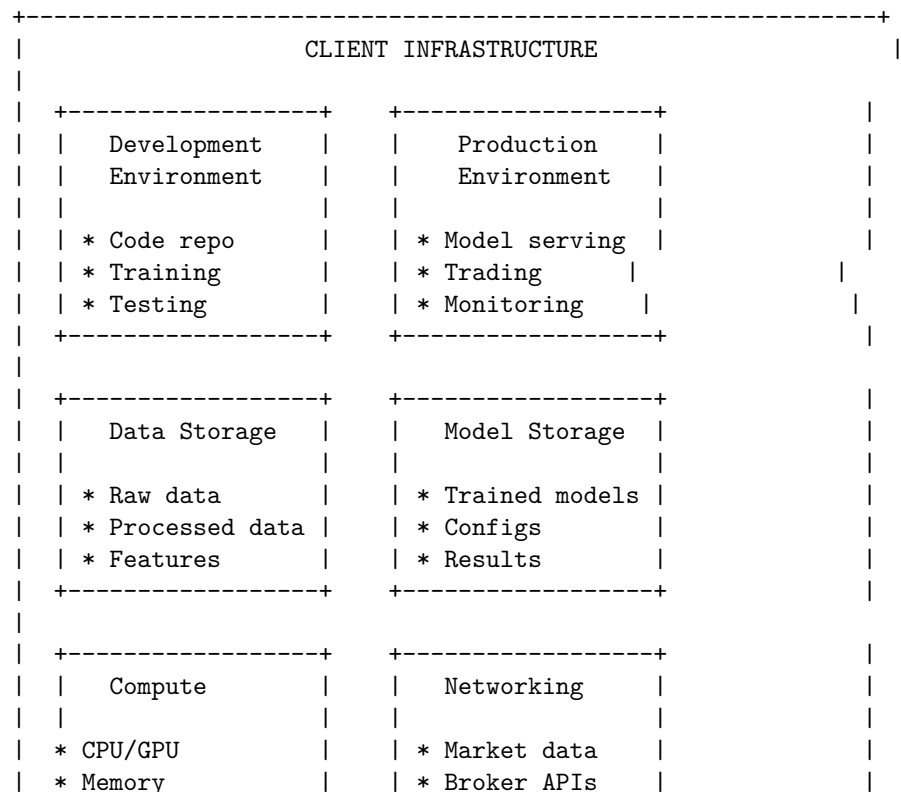
Core Dependencies: - **Python 3.9+** – Core runtime - **NumPy, Pandas** – Data processing - **Scikit-learn** – ML utilities - **LightGBM, XGBoost** – Gradient boosting models - **PyTorch** – Deep learning models (optional)

Trading Dependencies: - **ib_insync** – Interactive Brokers API - **alpaca-trade-api** – Alpaca API

Infrastructure: - **Git** – Version control - **GitHub** – Repository hosting - **YAML** – Configuration format

6. Deployment Architecture

6.1 Client-Hosted Deployment



* Storage		* Internal	
+-----+		+-----+	
+-----+			

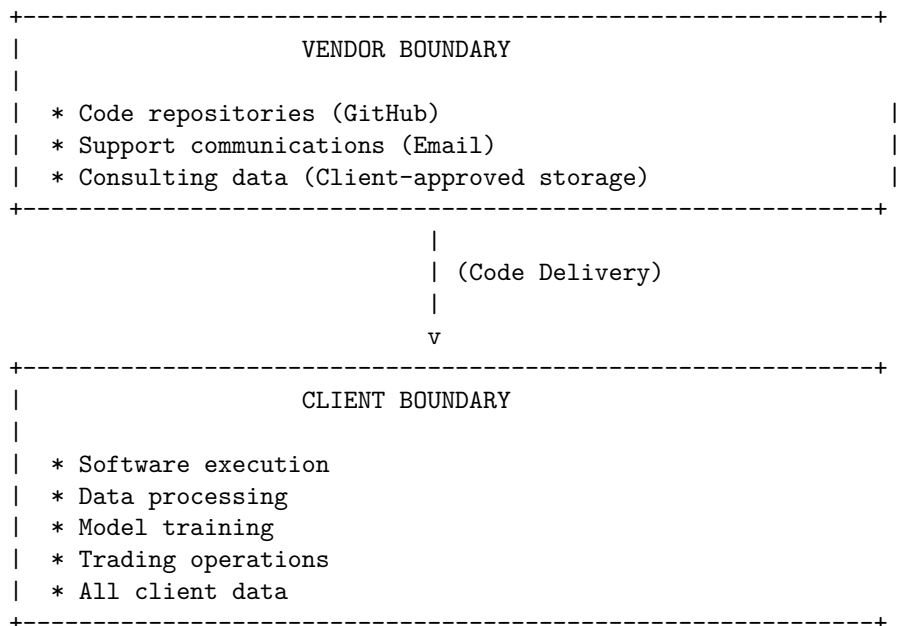
6.2 No Vendor Infrastructure

Important: Fox ML Infrastructure does not operate: - [X] Vendor-hosted servers - [X] Vendor-hosted databases - [X] Vendor cloud services - [X] Vendor network infrastructure

All infrastructure is client-controlled and client-managed.

7. Security Architecture

7.1 Security Boundaries



7.2 Security Controls

Vendor-side: - Repository access controls (2FA, SSH keys) - Code integrity (version control, signed commits)
- Supply chain integrity (no telemetry, explicit dependencies)

Client-side: - Infrastructure security (client-managed) - Data security (client-managed) - Network security (client-managed) - Access control (client-managed)

8. Scalability Architecture

8.1 Horizontal Scalability

Scalable components: - **Data processing** – Parallel processing of multiple symbols/timeframes - **Model training** – Distributed training (if configured) - **Feature engineering** – Batch processing for large datasets
- **Inference** – Parallel inference for multiple models

8.2 Vertical Scalability

Resource requirements: - **CPU** – Multi-core processors (8+ cores recommended) - **RAM** – 16GB+ (32GB+ for large datasets) - **GPU** – Optional but recommended for deep learning - **Storage** – Sufficient for datasets and models

9. Integration Points

9.1 Data Integration

Data sources: - **yfinance** – Equity market data (default) - **Custom adapters** – Client-specific data sources
- **File-based** – CSV, Parquet, HDF5 files

9.2 Model Integration

Model deployment: - **Serialized models** – Pickle, joblib, PyTorch formats - **REST API** – Model serving via REST API (if configured)

9.3 Model Integration

Integration points: - Models can be integrated with external trading systems - Standard formats for model serialization - Performance tracking and monitoring interfaces

10. Configuration Architecture

10.1 Configuration Hierarchy

```
Base Config (YAML)
  v
Variant Selection (conservative/balanced/aggressive)
  v
Environment Overrides (environment variables)
  v
Runtime Overrides (CLI arguments)
  v
Final Configuration (validated, applied)
```

10.2 Configuration Sources

Configuration sources: - **YAML files** – CONFIG/model_config/*.yaml - **Environment variables** – Runtime overrides - **CLI arguments** – Command-line overrides - **Code defaults** – Fallback defaults

11. Monitoring and Observability

11.1 Logging

Logging components: - **Structured logging** – JSON-structured logs - **Log levels** – DEBUG, INFO, WARNING, ERROR - **Contextual information** – Run IDs, symbols, fold numbers - **Client-managed** – Logs stored and managed by client

11.2 Metrics

Metrics tracked: - **Performance metrics** – Training time, inference latency - **Model metrics** – Accuracy, loss, validation scores - **Pipeline metrics** – Data processing throughput - **Client-managed** – Metrics collected and stored by client

12. Contact

For architecture questions or integration planning:

Jennifer Lewis

Fox ML Infrastructure LLC

Email: jenn.lewis5789@gmail.com

Subject: *Architecture Inquiry – Fox ML Infrastructure*

13. Related Documents

- docs/00_executive/ARCHITECTURE_OVERVIEW.md – Detailed architecture overview
 - docs/03_technical/design/ARCHITECTURE_DEEP_DIVE.md – Deep technical dive
 - LEGAL/ENTERPRISE_DELIVERY.md – Repository structure and delivery model
 - LEGAL/CLIENT_ONBOARDING.md – Client onboarding and integration guide
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14. Summary

Key Architectural Principles:

1. **Client-hosted** – Software runs entirely on client infrastructure
2. **Modular** – Clear separation of concerns across modules
3. **Configuration-driven** – All runtime parameters from configs
4. **Pipeline-based** – Data flows through well-defined stages
5. **Extensible** – Easy to add new models, features, strategies
6. **Scalable** – Horizontal and vertical scalability
7. **Secure** – Security boundaries and controls clearly defined

This architecture provides a comprehensive foundation for ML research and quantitative workflows.