# Generative AI Models for Time-Series Forecasting and What-If Analysis

This document provides a detailed list of deep learning-based generative AI models suitable for time-series forecasting, dynamic pattern understanding, and What-If analysis for infrastructure resource utilization across CFA, OCP, and Azure environments.

## 1. Generative AI Models for Time-Series Forecasting & What-If Analysis

### A. Generative Adversarial Networks (GANs)

#### TimeGAN (Time-Series GAN)

Best for learning temporal dependencies and generating synthetic time-series data. Can be fine-tuned for What-If scenarios by generating possible futures.

#### RCGAN (Recurrent Conditional GAN)

Best for autoregressive time-series forecasting. Uses LSTM-based generator and discriminator for sequential data.

### B. Transformer-Based Deep Learning Models

#### Temporal Fusion Transformer (TFT)

Best for multi-horizon time-series forecasting with attention mechanisms. Captures long-range dependencies in infrastructure utilization.

#### Informer

Handles large-scale time-series data efficiently with ProbSparse self-attention, reducing computational complexity.

#### DeepAR

Probabilistic forecasting model suitable for modeling server demand fluctuations.

### C. Diffusion Models for Uncertainty-Aware Forecasting

#### DiffTime (Diffusion Models for Time Series)

Best for capturing uncertainty and generating multiple possible futures. Handles uncertainty in predictions, crucial for What-If analysis.

### D. Hybrid Models

#### LSTM-VAE (Variational Autoencoder + LSTM)

Models resource usage trends and enables counterfactual analysis.

#### Neural Prophet

An enhanced Facebook Prophet model, useful for decomposing trends and seasonality in time-series data.

## 2. Handling Business Drivers for What-If Analysis

#### TimeGAN + External Drivers

Learns infrastructure patterns while factoring in external business constraints such as user load and transactional data.

#### Temporal Fusion Transformer + Business Constraints

Captures long-term interactions between business metrics and infrastructure load.

#### Informer with Exogenous Variables

Handles external factors like peak hours, system failures, and workload migration.

#### DiffTime + Business Variables

Generates plausible What-If scenarios considering multiple business conditions.

#### Graph Neural Networks (GNN) + Temporal Embeddings

Captures interdependencies across 250,000 servers to predict failures and bottlenecks.

## 3. Implementation Strategy

1. \*\*Data Collection & Engineering\*\* - Aggregate infrastructure and business metrics, normalize, and prepare time-series datasets.

2. \*\*Model Selection & Training\*\* - Choose appropriate deep learning models based on real-time and long-term forecasting needs.

3. \*\*Scenario-Based What-If Analysis\*\* - Run multiple simulations under different infrastructure and business conditions.

4. \*\*Deployment & Monitoring\*\* - Deploy models in a scalable pipeline integrated with Prometheus, Grafana Mimir, and cloud services.