FOG VS CLOUD COMPUTING: REAL-TIME BUSINESS APPLICATIONS

Presented By:
RISHABH SINGH -054

FOG VS CLOUD IN REAL-TIME BUSINESS

CLOUD COMPUTING	Works on a centralized model with large, remote data centers. Best suited for tasks requiring huge storage and processing power (e.g., big data analytics, enterprise systems). Challenge: Latency – data travels long distances, slowing down time-critical tasks.
FOG COMPUTING	Extends the cloud closer to IoT devices through local nodes, routers, and gateways. Enables faster responses by processing data near the source. Reduces bandwidth usage as only filtered/processed data is sent to the cloud.
WHY BUSINESSES NEED BOTH?	Real-time industries (healthcare, logistics, autonomous driving, smart cities) cannot rely on cloud alone due to delay. Hybrid approach ensures Fog = immediate response and Cloud = long-term analytics & scalability.

OPERATIONAL DIFFERENCES IN BUSINESS CONTEXT

Latency

- Cloud: Data travels to distant servers → higher delay.
- Fog: Local gateways process instantly → low delay, suitable for emergencies.

Processing Location

- Cloud: Centralized data centers handle everything.
- Fog: Local devices/nodes handle nearby workloads, reducing dependency on the internet.

Data Flow & Bandwidth

- Cloud: Continuous raw data transfer → higher bandwidth costs.
- Fog: Filters/aggregates data locally → saves cost, prevents congestion.

Scalability

- Cloud: Virtually unlimited resources → best for global operations.
- Fog: Limited by node capacity → effective for localized workloads.

Security & Cost

- Cloud: Centralized control → easier enforcement, but higher transfer costs.
- Fog: Distributed, more vulnerable at the edges, but reduces recurring network expenses.

REAL-WORLD CASE STUDIES

Healthcare (Telemedicine & Remote Monitoring)

- Cloud Issue: Sending all patient data to remote servers can delay emergency alerts.
- Fog Solution: Local fog nodes process ECG, oxygen, and heart rate data within milliseconds → doctors get instant alerts, improving survival rates.
- Case Example: IoT hospital trial showed 40% faster emergency response with fog.

Logistics & Fleet Management

- Cloud Role: Large-scale route optimization, predictive analysis for supply chains.
- Fog Role: Real-time monitoring of cargo temperature, fuel, and vehicle health.
- Case Example: DHL used fog nodes to cut response latency from 300 ms to <100 ms, ensuring reliable deliveries.

Smart Cities (Traffic Management)

- Cloud Challenge: Centralized servers cannot manage traffic signals in real-time → causes congestion.
- Fog Advantage: Local fog nodes at intersections optimize lights with response times <50 ms.
- Case Example: Barcelona’s smart traffic system reduced congestion by 30% using fog.

DATASET SELECTION AND RELEVANCE

We used a cleaned IoT dataset (iot_cleaned.csv) covering Cloud, Fog, Edge, and Device tiers. It enables direct comparison of performance in real-time business scenarios such as healthcare, logistics, and smart cities.

Key Variables

- Workload_Type & Processing_Tier (Cloud, Fog, Edge, Device)
- Performance Metrics: Latency, Jitter, Execution Time, CPU, Memory
- Resource Allocation: Predicted vs Actual (%)

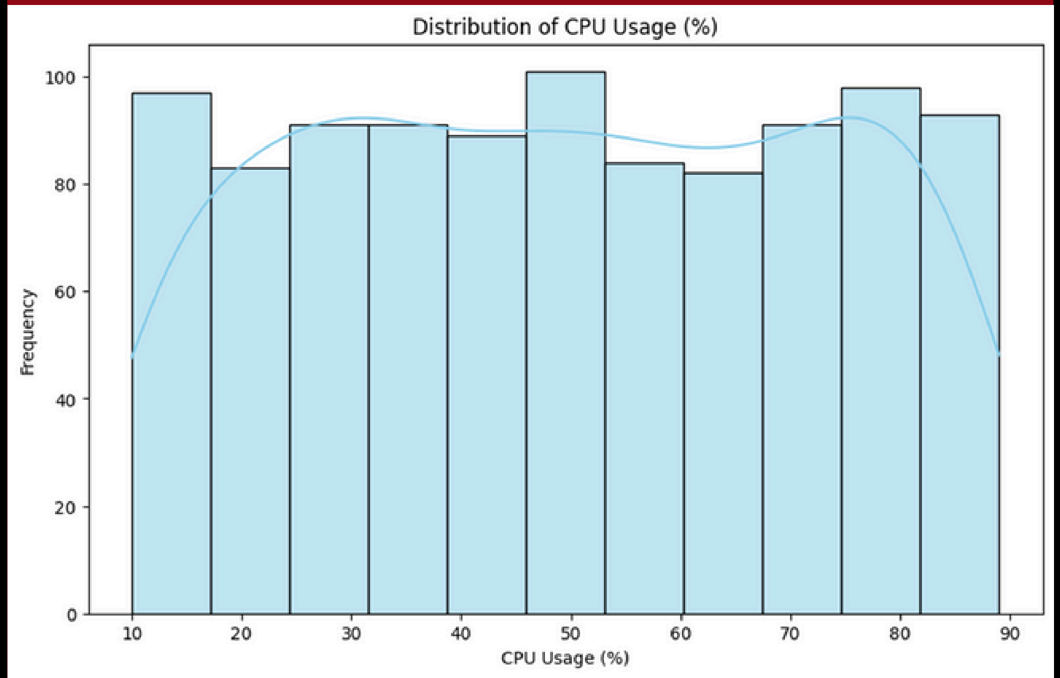
Preprocessing

- Removed inconsistencies/missing values
- Normalized numerical metrics
- Encoded workload & tier categories
- Verified allocation accuracy (0.97 correlation)

Relevance

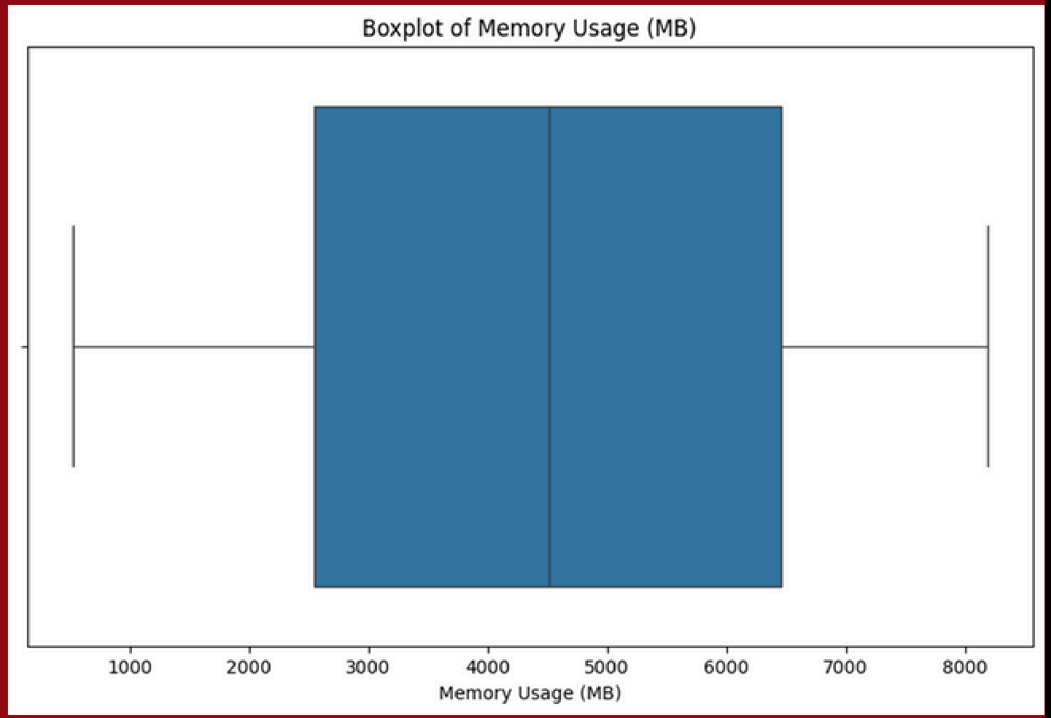
- Supports Fog vs Cloud comparison on latency, cost, and efficiency
- Reliable for visualizations, dashboards, and scenario testing

EXPLORATORY DATA ANALYSIS (EDA)



CPU Usage:

Balanced across workloads, mostly between 30–80% → system avoids overload.



Memory Usage:

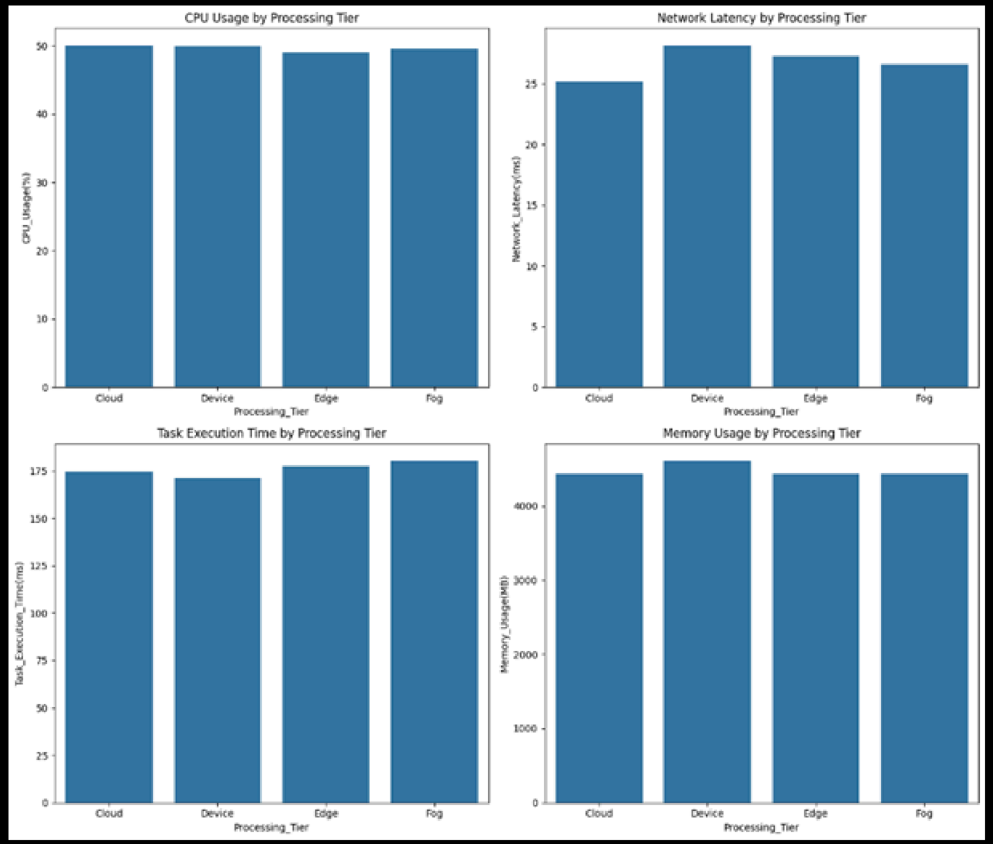
The boxplot shows that IoT devices have widely varying memory usage (500–8200 MB) with a median around 4500 MB, highlighting the need for flexible resource allocation strategies.

CPU Usage:

Mostly 100–250 ms, Video Processing heavier than others.

Takeaway: IoT workloads show diverse intensity, confirming the need for tier-specific allocation (Fog vs Cloud).

ANALYTICAL COMPARISON - FOG VS CLOUD



Performance Differences:

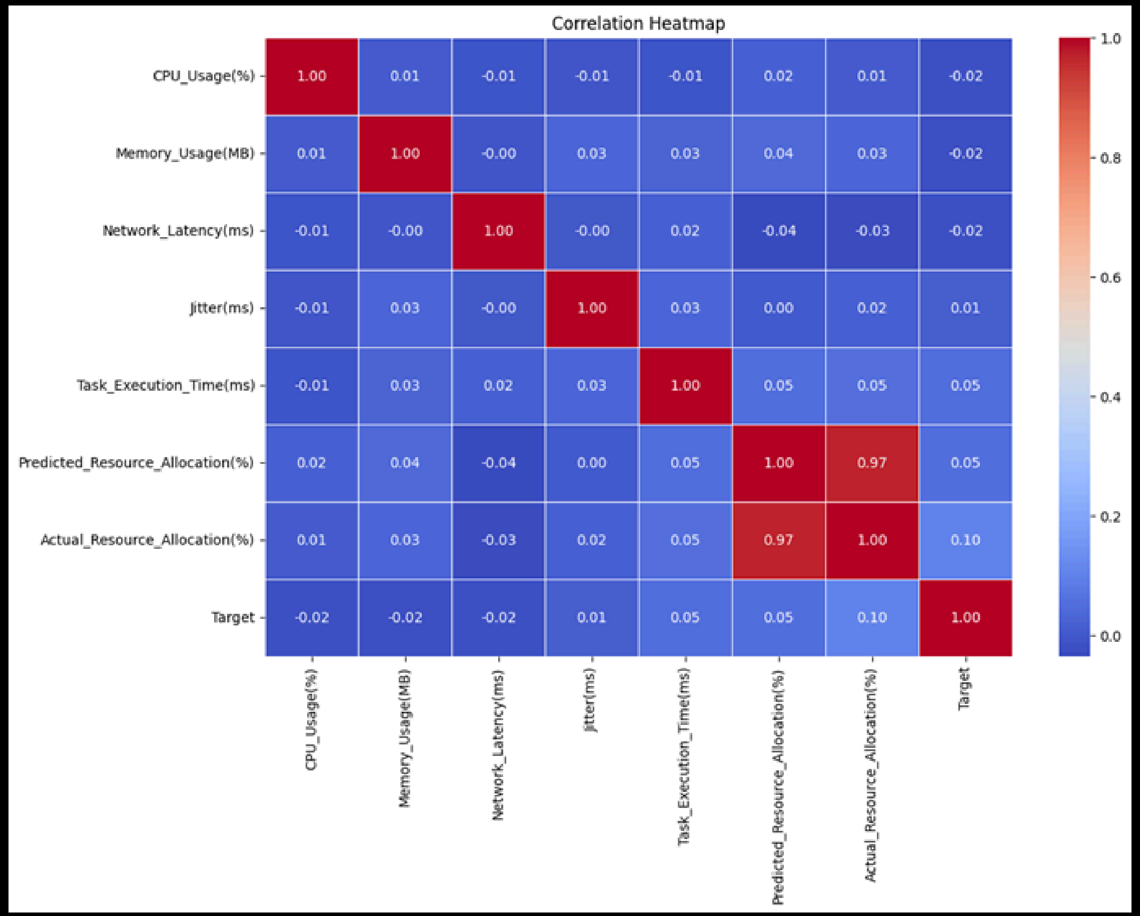
- Latency: Cloud ~25 ms, Fog ~27 ms (close, Fog better under high traffic).
- Execution Time: Cloud faster (~174 ms vs Fog 180 ms).
- Memory: Nearly identical (~4430 MB).

Workload Sensitivity:

- Fog excels in Network Traffic (lowest latency).
- Cloud excels in Video & Image Processing (heavy memory).

Forecast Accuracy:

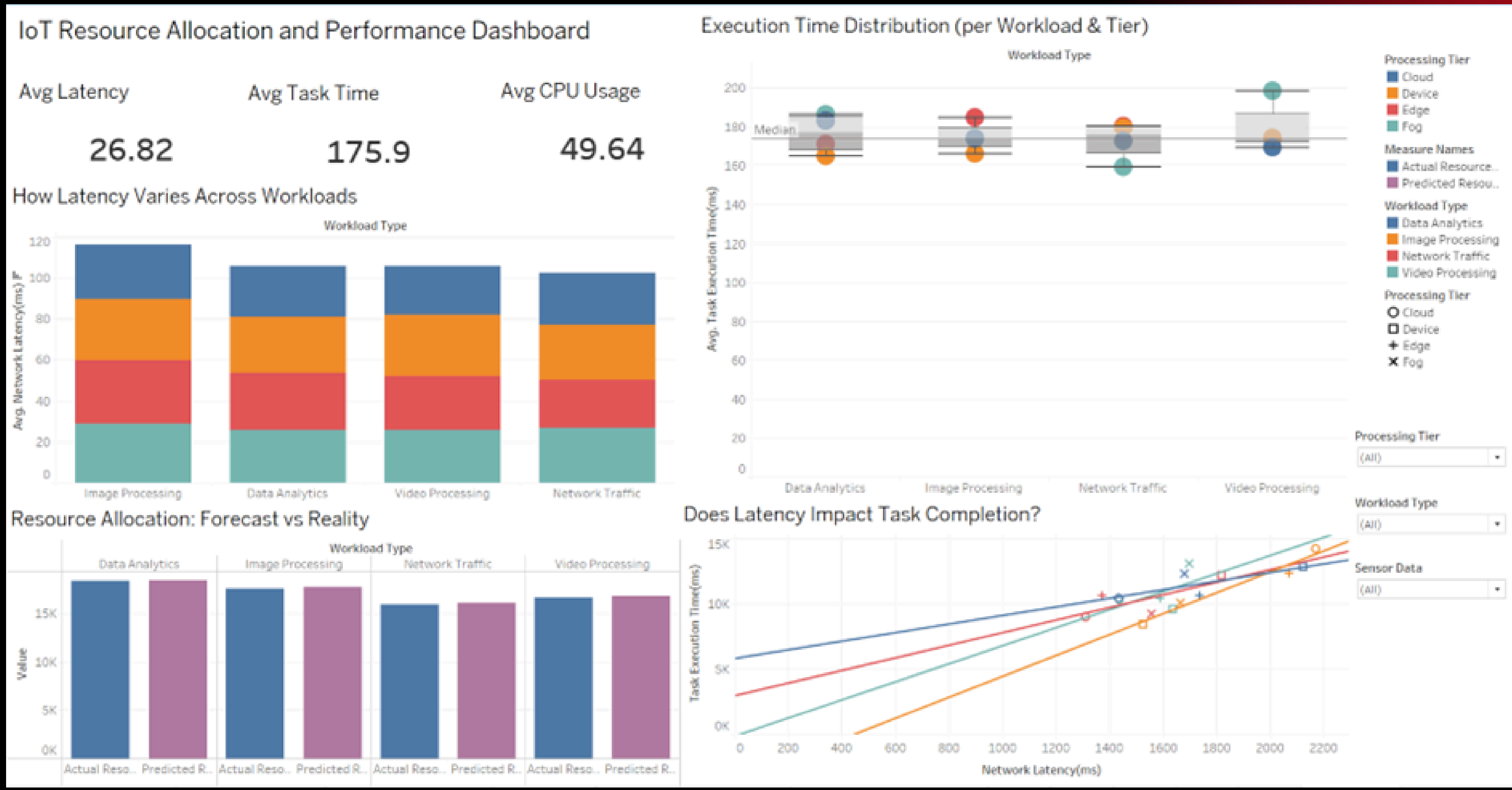
- Predicted vs Actual Resource Allocation correlation = 0.97 → reliable planning.



Dashboard Layout & Design

Dashboard Sections:

- Top: KPIs → Avg Latency, Execution Time, CPU Usage
- Middle: Comparative visuals → Latency Across Workloads (Stacked Bar), Execution Time by Tier (Boxplot)
- Bottom: Deep insights → Forecast vs Reality (Bar Chart), Latency vs Task Completion (Scatter)



Design Principles:

- Clarity (structured flow top → bottom)
- Interactivity (filters for Tier, Workload, Sensor Data)
- Usability (hover tooltips, dynamic updates)

Benefit: Supports both executives (cost-performance trade-offs) & engineers (technical optimization).

STRATEGIC RECOMMENDATION & CONCLUSION

Business Scenario:

- Healthcare Remote Patient Monitoring (RPM).

Findings:

- Fog ensures real-time alerts & local processing (saves lives).
- Cloud provides scalability, predictive analytics, storage (long-term efficiency).

Recommendation:

- Adopt Hybrid Fog-Cloud Architecture →
- Fog Layer: Real-time emergency response & reduced bandwidth.
- Cloud Layer: Long-term analytics, predictive models, scalability.

Conclusion:

- Hybrid model balances responsiveness + scalability, ensuring safety, performance, and sustainability.

BUSINESS SCENARIO
REMOTE PATIENT MONITORING (RPM)

- **Healthcare provider uses IoT-enabled wearable devices & sensors (ECG, pulse oximeter, glucose monitors).**

- **Data requirements:**
  - Real-time anomaly detection (e.g., arrhythmia, oxygen drop).
  - Instant communication to doctors/caregivers within milliseconds.
  - Secure archiving for long-term trend analysis & EHR integration

- **Constraints:**
  - Ultra-low latency, high reliability, scalability.
  - Strict compliance

- **Core Question**

  Which infrastructure suits best — Fog vs Cloud computing?

PERFORMANCE INSIGHTS & TRADE-OFFS

Latency

- Cloud: ~25 ms average.
- Fog: ~26 ms, but more stable under high traffic → safer in emergencies.

Workload Suitability

- Cloud: Best for memory-heavy tasks (video/image analytics).
- Fog: Best for real-time streaming & emergency alerts

Execution Time & Jitter

- Cloud: Faster (~174 ms).
- Fog: Slightly slower (~180 ms), but less jitter → more reliable.

Workload Suitability

- Cloud = large-scale growth & predictive analytics.
- Fog = immediate local responsiveness

Insight

Cloud = scale & efficiency
Fog = safety & immediacy

STRATEGIC RECOMMENDATION HYBRID FOG-CLOUD

Fog Layer (Local Gateways)

- Process vitals in milliseconds, trigger emergency alerts.
- Reduce bandwidth load & ensure local compliance.

Cloud Layer (Central Data Centers)

- Store & analyze long-term patient records.
- Enable AI-driven predictive healthcare & scalability.

Strategic Rationale

- Fog = patient safety, real-time reliability.
- Cloud = sustainability, advanced analytics, cost efficiency.

Final Recommendation:

Adopt a hybrid Fog-Cloud architecture → ensuring life-critical responsiveness + long-term scalability.


THANK YOU