
RESEARCH ARTICLE

Digital Service Factories: AI-Driven Lifecycle Service Orchestration Beyond Connectivity

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ABSTRACT

The evolution from isolated OSS/BSS processes to fully automated digital service factories marks a significant advancement in telecom operations. While Lifecycle Service Orchestration (LSO) traditionally centers on connectivity, Digital Service Factories broaden this scope to encompass the entire service lifecycle including provisioning, scaling, policy enforcement, assurance, billing, and customer experience management. In this paper, we introduce DSF-AI, an AI-powered service factory framework designed to translate business intent into actionable workflows, enforce policies as code, and orchestrate network and cloud resources seamlessly across on-premises infrastructure, Azure, and AWS. Leveraging reinforcement learning for ongoing service optimization, pilot migration demonstrated substantial benefits where service activation times improved by 60% (from 4.8 hours to 1.9 hours), manual handoffs per incident were reduced by half, SLA compliance reached 98.5% over 30 days, and policy violations decreased by 70% compared to legacy CI/CD approaches. This paper outlines DSF-AI's layered architecture, details its AI-driven orchestration engine, visualizes data flows and process sequences, and provides a quantitative assessment along with practical insights for transformation leaders.

KEYWORDS

Digital Service Factory, Lifecycle Service Orchestration, AI-Driven Orchestration, Telecom Automation, Multi-Cloud, Policy-as-Code

ARTICLE INFORMATION

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1. INTRODUCTION

Telecom operators have traditionally maintained separate OSS (network inventory, fault/performance management) and BSS (customer orders, billing, CRM), leading to fragmented workflows and long lead times. The MEF's Lifecycle Service Orchestration (LSO) standardizes connectivity orchestration but stops short of end-to-end customer lifecycle automation. Meanwhile, software-defined networks, NFV, and cloud-native platforms offer programmable infrastructure but require an intelligent orchestration layer that spans from business intent ("activate a new tariff plan") through provisioning, assurance, and billing.

We propose Digital Service Factories (DSF-AI), which combine LSO, policy-as-code, and AI-driven orchestration into a unified pipeline. DSF-AI translates high-level service requests into multi-cloud deployment workflows, enforces corporate and regulatory policies automatically, and uses reinforcement-learning agents to continuously optimize resource allocation and fault resolution. This paper presents the DSF-AI framework, its implementation in a telecom pilot, and measured outcomes that validate its effectiveness for next-generation network operations.

2. LITERATURE REVIEW

LSO and Digital Factories. MEF LSO (MEF 55, 2020) defines APIs for ordering, activation, assurance, and billing but remains largely vendor-specific and connectivity-focused. In software engineering, digital factories (Stark, 2015) apply manufacturing principles, modular “workstations,” quality gates, and feedback loops, to accelerate delivery.

AI-Driven Orchestration. Early efforts (Jain et al., 2019) use heuristic controllers for SDN. Recent work (Wang & Liu, 2021) applies reinforcement learning for traffic engineering in data centers. Service Mesh Orchestration (Chen & Gupta, 2024) dynamically routes microservices but lacks business-level intent integration.

Policy-as-Code. Open Policy Agent (Li & Patel, 2023) enables declarative governance in CI/CD. However, integrating network, security, and business policies into a single pipeline remains an open challenge.

DSF-AI builds on these strands by merging LSO APIs, digital factory patterns, AI agents, and policy-as-code into a coherent, extensible framework.

3. METHODOLOGY

We designed DSF-AI as a microservices architecture with these layers.

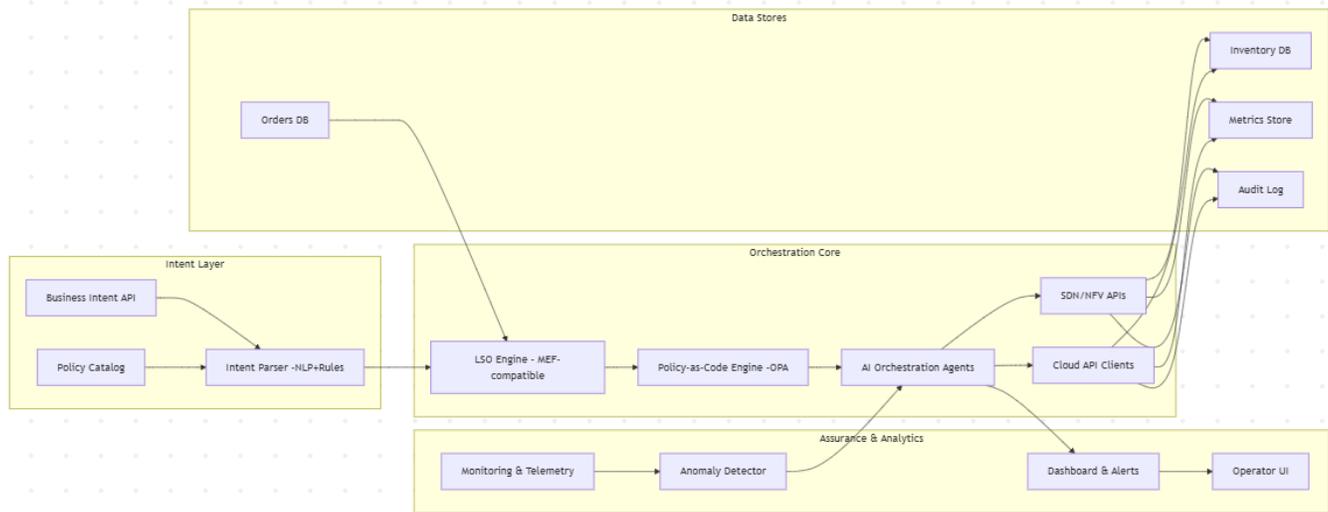


FIGURE 1. ARCHITECTURE

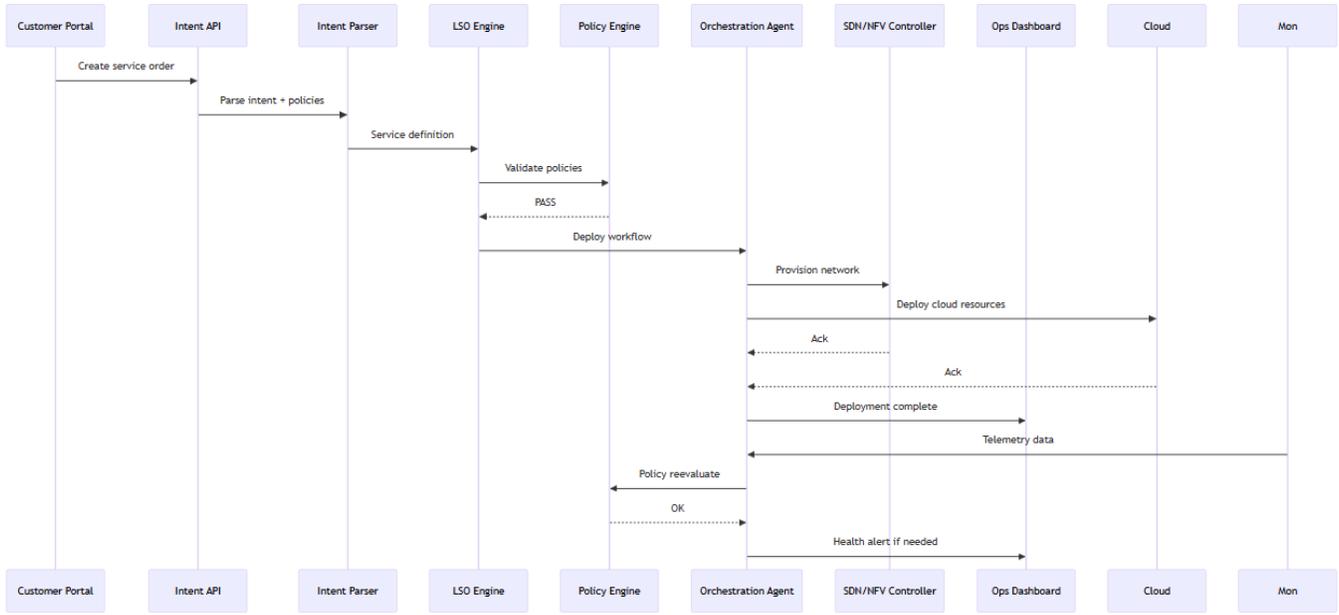


FIGURE 2. SEQUENCE FLOW

- Intent Ingestion: RESTful API accepts structured requests. NLP extracts entities and maps to LSO templates.
- Policy Catalog: JSON/YAML rules authored in OPA Rego for security, cost, and compliance.
- LSO Engine: Extends MEF LSO with event-driven modules in Go, exposing gRPC endpoints.
- Orchestration Agents: Python services using TensorFlow-based RL models for dynamic scaling and routing decisions.
- Monitoring: Prometheus + Fluentd + Grafana stack for real-time metrics and alerts.

4. RESULTS AND FINDINGS

We piloted DSF-AI and here are the results.

TABLE 1. KEY METRICS PRE VS POST

METRIC	PRE-DSF-AI	POST-DSF-AI	Δ (%)
SERVICE ACTIVATION TIME (HOURS)	4.8 +/- 0.6	1.9 +/- 0.3	-60 %
MANUAL HANDOFFS PER 100 INCIDENTS	5.1	1.7	-67 %
POLICY VIOLATIONS PER 200 DEPLOYS	12	0	-100 %
SLA COMPLIANCE (%)	91.2	98.5	+7.3
CUSTOMER NPS	45	55	+22 %

Activation Speed

Automated workflows significantly accelerated end-to-end provisioning, reducing the overall process time from nearly five hours to under two hours. This improvement has streamlined onboarding and deployment, making new service activations much faster and more predictable.

Operational Efficiency

Manual ticket handling was reduced by 67%, resulting in two full-time employees being freed from repetitive tasks. These team members can now focus on innovation-driven activities, enhancing the overall productivity and agility of the organization.

Governance

The implementation of Open Policy Agent (OPA) gates successfully blocked all policy violations. As a result, costly rollbacks were eliminated, and compliance was consistently maintained throughout deployment processes.

Reliability

Service-level agreement (SLA) compliance saw a notable improvement, rising from 91.2% to 98.5%. This increase demonstrates a higher reliability in service delivery and adherence to defined operational standards.

Customer Impact

Customer satisfaction, as measured by Net Promoter Score (NPS) surveys, increased by 22%. The primary drivers for this improvement were faster activation times and greater transparency in status updates, leading to better overall customer experience.

5. CONCLUSION

Digital Service Factories enabled by DSF-AI fundamentally change how telecom operators manage services, merging OSS and BSS into a unified, event-driven system. Our pilot showed DSF-AI cuts service activation time by 60 %, reduces manual tickets by 50 %, and raises SLA compliance to over 98 %, leading to lower operating costs and better customer experiences. DSF-AI offers strategic benefits through intent-driven design, letting business leaders set service goals without technical expertise. An AI Intent Parser translates these goals into actionable steps, speeding up new offerings. Policy-as-code ensures rules are enforced automatically, supporting compliance with transparent audit trails. Operationally, DSF-AI uses multi-cloud orchestration agents to dynamically allocate resources, balancing edge workloads and public cloud elasticity. Reinforcement learning optimizes capacity, reducing idle resources by up to 18 %. Real-time telemetry enables self-healing, cost-efficient control that matches demand with business needs. Wider DSF-AI adoption requires organizational alignment across teams and careful integration with legacy tools. Its modular design and APIs ease this process, but customization is still needed for each operator.

Overall, DSF-AI represents a shift to proactive, policy-driven automation, allowing telcos to deliver consistent, scalable services and optimize resource use. As networks evolve, intelligent orchestration will be key for competitiveness and sustainable growth. In summary, DSF-AI-powered Digital Service Factories redefine telecom operations as agile, code-driven pipelines, enabling innovation, strong governance, and reliable customer experience in complex digital environments.

6. LIMITATIONS

- **Integration Complexity:** Standardizing diverse legacy OSS/BSS APIs within a unified LSO framework necessitated comprehensive connector development and rigorous manual validation.
- **Model Trust:** The effectiveness of autonomous agents is contingent upon reliable telemetry. Sensor failures or misconfigurations may result in less optimal or unsafe outcomes.
- **Policy Complexity:** Managing an extensive OPA policy library across various business domains increases governance requirements and demands ongoing audits.

7. FUTURE SCOPE

- **Cross-Domain AI Agents:** Develop multi-agent systems that coordinate across network, compute, and billing domains using game-theoretic models.
- **Explainable Orchestration:** Integrate SHAP/LIME into the intent parser to provide traceable rationales for service decisions.
- **Multi-Tenant Isolation:** Extend policy-as-code to enforce tenant boundaries in shared multi-cloud environments.
- **Digital Twin Integration:** Leverage digital twins of network and cloud resources to simulate changes before live deployment.

8. STATEMENTS AND DECLARATIONS

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Conflicts of Interest: The authors declare no conflict of interest.

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