

AI-Augmented Business Process Automation: Architecture and Implementation in Regulated Industries

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Abstract: Contemporary business environments within regulated industries experience transformative changes through artificial intelligence integration into traditional process automation frameworks. Advanced machine learning capabilities enable organizations to transcend conventional rule-based automation limitations by implementing intelligent systems capable of contextual decision-making, pattern recognition, and adaptive learning mechanisms. Healthcare sectors demonstrate substantial operational improvements through AI-augmented prior authorization processes, where natural language processing extracts clinical information while machine learning algorithms predict approval likelihood with enhanced accuracy. Financial services organizations deploy sophisticated fraud detection systems utilizing ensemble learning techniques, behavioral analytics, and real-time transaction monitoring to identify suspicious activities while maintaining regulatory compliance standards. Architectural frameworks incorporating process orchestration layers, AI services integration, compliance mechanisms, and comprehensive monitoring systems provide robust foundations for intelligent automation deployment. Implementation challenges, including data privacy concerns, model explainability requirements, regulatory approval complexities, and technical integration obstacles, necessitate strategic solutions encompassing federated learning architectures, interpretability frameworks, parallel manual review pathways, and modular deployment strategies. Model governance frameworks establish systematic monitoring protocols for performance drift detection, automated retraining schedules, and version control enforcement across distributed AI components. Upcoming advancements include generative artificial intelligence features for automated document generation, self-optimizing processes using reinforcement learning methods, federated AI techniques for inter-institutional cooperation, edge computing implementation for instantaneous decision-making, quantum computing uses for intricate optimization issues, and integration of regulatory technology for automated compliance oversight. Effective executions demand synchronized actions among technical teams, compliance staff, and business stakeholders to fulfill organizational goals while upholding rigorous regulatory compliance standards.

Keywords: Artificial Intelligence, Business Process Automation, Regulated Industries, Machine Learning, Regulatory Compliance, Intelligent Automation.

INTRODUCTION

Business process automation evolution has reached a pivotal moment where conventional rule-based systems demonstrate inadequacy for complex requirements within regulated industries. Traditional BPA solutions, while streamlining routine operations through workflow engines and decision rules, encounter fundamental limitations regarding adaptability, learning capabilities, and contextual decision-making processes. Rigid automation creates bottlenecks when processes face exceptions or require nuanced judgment extending beyond predefined parameters (Sire, T. 2025). Artificial intelligence integration into BPA represents a paradigm shift toward intelligent process automation, where machine learning, natural language processing, and computer vision augment traditional workflow orchestration. AI-powered systems transform business operations by enabling organizations to automate complex tasks requiring human-like decision-making capabilities. Advanced algorithms analyze vast datasets, identify patterns, and make intelligent decisions with minimal human intervention (Sire, T. 2025). Contemporary AI agents demonstrate sophisticated autonomous functionality, possessing reasoning capabilities and environmental adaptability while maintaining contextual awareness throughout

process execution (Techtic Solutions, 2025). Modern AI-enhanced automation systems achieve remarkable performance improvements across regulated sectors. Healthcare organizations experience substantial reductions in processing delays alongside enhanced compliance adherence rates, while financial services sectors demonstrate significant improvements in fraud detection accuracy with decreased false positive alerts. Intelligent automation systems navigate complex regulatory frameworks while delivering operational efficiency improvements across patient care workflows and financial transaction processing (Sire, T. 2025). AI agents represent the next evolution in business process automation, functioning as intelligent entities capable of perceiving environments, processing information, and executing decisions autonomously. Advanced natural language processing enables these systems to understand complex instructions, interpret unstructured data, and communicate effectively with human users. Machine learning capabilities allow continuous improvement through experience accumulation, while computer vision technology processes visual information for comprehensive automation solutions (Techtic Solutions, 2025). The merging of artificial intelligence and

conventional automation offers organizations the chance to reach unmatched efficiency levels while adhering to regulatory compliance standards. AI-driven systems exhibit greater flexibility than traditional rule-based methods, managing exceptions and unusual situations through advanced decision-making skills. Integration of intelligent automation technologies addresses unique challenges within compliance-intensive sectors, including auditability requirements, data security protocols, and regulatory adherence standards (Sire, T. 2025). Contemporary implementations showcase the transformative

potential of AI-augmented business process automation across various regulated industries. Advanced systems provide real-time process optimization, sophisticated exception handling, and dynamic decision-making capabilities while preserving reliability and auditability standards essential for regulated environments. The architectural framework addresses critical success factors, including comprehensive audit trail maintenance, robust data security compliance, and enhanced stakeholder satisfaction across diverse organizational implementations (Techtic Solutions, 2025).

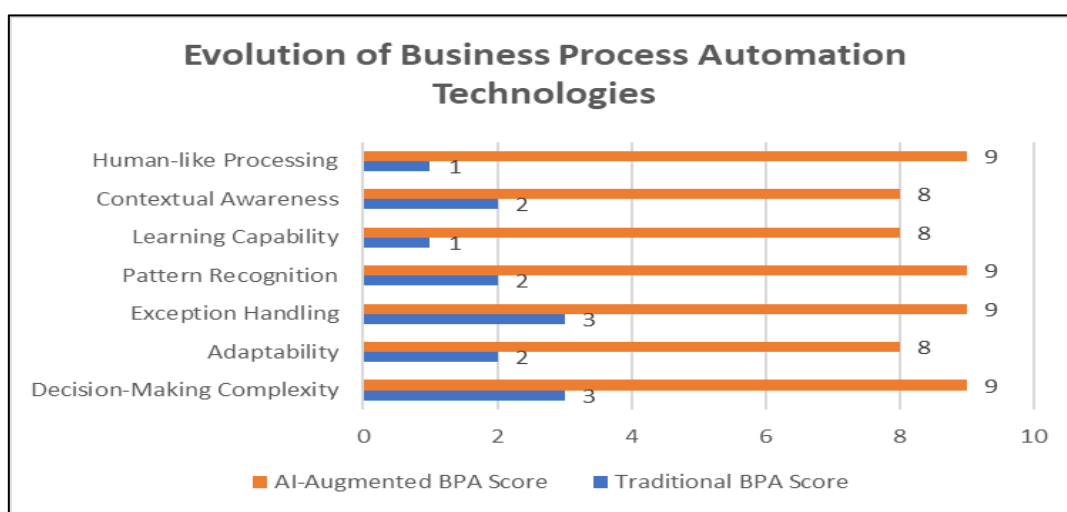


Figure 1: Comparison of Traditional vs AI-Augmented Automation Capabilities across Key Performance Dimensions (Sire, T. 2025; Techtic Solutions, 2025)

ARCHITECTURAL FRAMEWORK FOR AI-AUGMENTED BPA

Successful implementation of AI-augmented BPA demands carefully structured architectural approaches integrating artificial intelligence capabilities with existing process orchestration systems. Emerging technologies like blockchain systems, robotic process automation, and machine learning are causing significant changes in modern corporate process management. The human factor within business process management undergoes significant evolution as technological advances reshape traditional workflow paradigms (Mendling, J. *et al.*, 2018). Reference architecture development requires a comprehensive understanding of technology impacts on organizational structures and human-machine collaboration patterns. Process Orchestration Layer establishment utilizes proven BPA platforms, including Pega PRPC, Camunda, and Appian for workflow execution management, human-in-the-loop interactions, and business rule enforcement. Modern organizational environments experience fundamental shifts in human roles as automation

technologies assume responsibility for routine tasks while human workers focus on complex decision-making activities. Machine learning integration transforms traditional process execution by enabling systems to learn from historical data patterns and adapt workflows dynamically (Mendling, J. *et al.*, 2018). Advanced orchestration capabilities support sophisticated process modeling while maintaining flexibility for human intervention when exceptional circumstances arise. AI Services Layer encompasses machine learning models deployed through established platforms alongside natural language processing services utilizing contemporary frameworks. Robotic process automation lifecycle improvements demonstrate enhanced efficiency through systematic methodology application during initial implementation phases. Early-stage optimization strategies significantly impact overall automation success rates by addressing potential challenges before full deployment (Jimenez-Ramirez, A. *et al.*, 2019). Advanced document processing capabilities extend

automation reach across diverse organizational functions while maintaining accuracy standards essential for regulated environments. Integration Layer facilitates seamless communication between traditional BPA components and AI services through standardized interfaces and event-driven architectures. Methodical strategies for implementing robotic process automation identify key success elements in the initial phases of technology integration. Methodology development focuses on identifying optimal automation candidates and establishing robust integration frameworks supporting long-term scalability (Jimenez-Ramirez, A. *et al.*, 2019). Contemporary integration patterns emphasize modular design principles, enabling organizations to expand automation capabilities incrementally while maintaining system stability. Compliance and Security Layer addresses regulated environment requirements through comprehensive access control models, auditing mechanisms, and model interpretability tools supporting explainable AI decisions. Human factor considerations become increasingly important as business process

management evolves to accommodate intelligent automation technologies. Traditional organizational hierarchies adapt to incorporate human-AI collaboration models, requiring new skill sets and operational procedures (Mendling, J. *et al.*, 2018). Security framework implementation ensures regulatory compliance while maintaining operational efficiency across diverse industry sectors. Monitoring Layer provides real-time visibility into business processes and AI model performance through comprehensive dashboards and drift detection systems. Continuous improvement methodologies enable organizations to refine automation implementations based on performance data and operational feedback. Early-stage methodology application ensures robust monitoring capabilities supporting long-term automation success and regulatory compliance requirements (Jimenez-Ramirez, A. *et al.*, 2019). Advanced monitoring solutions detect performance variations and trigger appropriate responses while maintaining system reliability across complex operational environments.

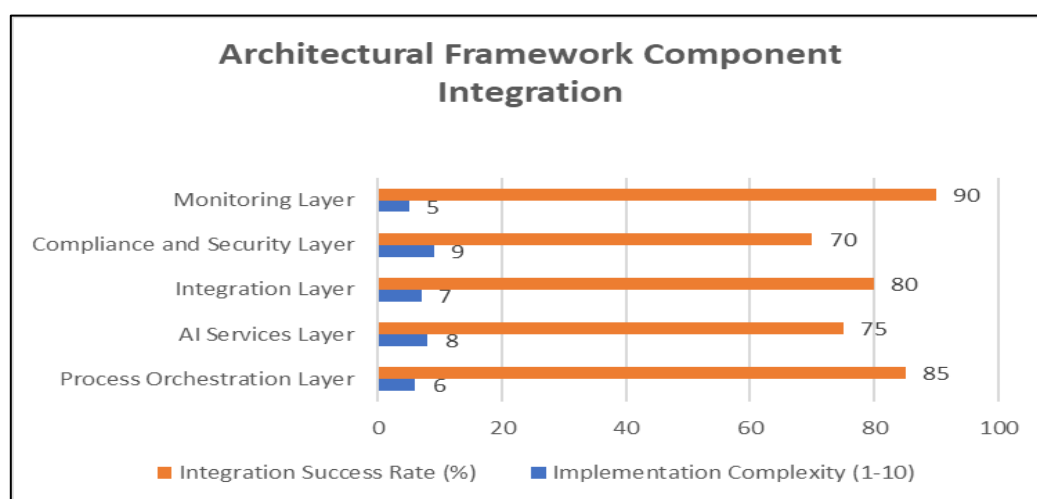


Figure 2: Implementation Complexity and Integration Success Rates across AI-BPA Architecture Layers (Mendling, J. *et al.*, 2018; Jimenez-Ramirez, A. *et al.*, 2019)

IMPLEMENTATION IN HEALTHCARE: AI-AUGMENTED PRIOR AUTHORIZATION

Healthcare industry transformation through AI-augmented BPA creates compelling opportunities within prior authorization processes. Traditional authorization workflows experience significant delays, manual review bottlenecks, and inconsistent decision-making patterns, impacting patient care delivery. AI-powered solutions demonstrate revolutionary changes in healthcare authorization procedures by transforming traditional manual processes into intelligent

automated systems. Prior authorization implementations utilizing artificial intelligence technologies streamline approval workflows while maintaining clinical accuracy and regulatory compliance standards (Putty, C. 2025). Enhanced systems deploy natural language processing capabilities for extracting medication codes, diagnosis information, and clinical context from physician documentation and electronic health records. Advanced NLP models undergo specialized training for medical terminology recognition, achieving superior accuracy in identifying clinical indicators influencing

authorization decisions. Machine learning algorithms process historical authorization patterns, clinical outcomes, and regulatory guidelines to predict approval likelihood with exceptional precision. Contemporary AI applications within healthcare demonstrate remarkable capabilities in automating complex administrative tasks while preserving clinical decision-making quality (Putty, C. 2025). Intelligent workflow orchestration manages entire authorization processes through automated routing systems, directing straightforward cases toward AI-driven approval mechanisms while triggering manual clinical review for complex exceptions or low-confidence predictions. Business process automation implementations across healthcare organizations showcase substantial operational improvements through technology integration. AI-powered systems enhance efficiency, reduce processing times, and improve accuracy rates across diverse healthcare administrative functions while maintaining strict compliance requirements (Takyar, A.). Data security protocols incorporate end-to-end encryption, personally identifiable information tokenization, and role-based access controls, ensuring HIPAA compliance throughout workflow execution. Implementation outcomes demonstrate transformative operational improvements with substantial increases in automated approval rates while maintaining

clinical accuracy standards. Average processing times experience dramatic reductions from traditional timeframes, enabling faster patient access to necessary treatments and medications. Healthcare organizations report significant decreases in administrative burden on clinical staff, allowing medical professionals to focus on direct patient care activities rather than routine administrative processing (Putty, C. 2025). Advanced automation technologies provide comprehensive benefits, including enhanced decision consistency, reduced manual intervention requirements, and improved resource allocation efficiency across healthcare organizations. AI implementation within business process automation delivers measurable value through cost reduction, operational efficiency improvements, and enhanced service quality across multiple industry sectors. Healthcare applications particularly benefit from intelligent automation capabilities supporting complex regulatory environments while maintaining high accuracy standards (Takyar, A.). Patient satisfaction improvements result from expedited approval processes, reduced treatment delays, and enhanced communication throughout authorization workflows, demonstrating tangible benefits of AI integration within healthcare administrative operations.

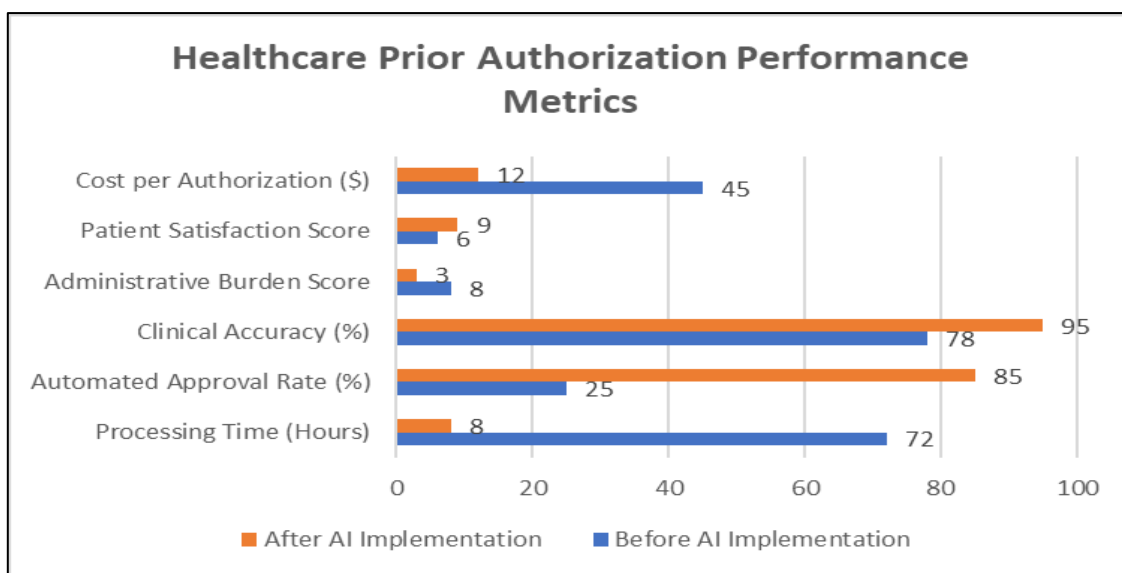


Figure 3: Operational Efficiency Improvements Through AI-Augmented Prior Authorization Systems (Putty, C. 2025; Takyar, A.)

Ai-Augmented Fraud Detection in Financial Services: Performance Analysis and Regulatory Compliance

Financial institutions are increasingly utilizing advanced artificial intelligence systems to prevent

fraud while adhering to compliance regulations. Advanced machine learning algorithms demonstrate remarkable capabilities in identifying suspicious transaction patterns through comprehensive behavioral analysis and risk

assessment methodologies. IBM research indicates artificial intelligence applications in banking fraud detection achieve significant operational improvements through automated pattern recognition and real-time transaction monitoring capabilities (Flinders, M. *et al.*, 2025). Contemporary fraud detection systems incorporate ensemble learning techniques, combining multiple algorithmic approaches to enhance detection accuracy while reducing false positive occurrences. Random Forest algorithms paired with gradient boosting methods create robust classification models capable of processing large-scale transaction datasets. Financial organizations report substantial improvements in investigation efficiency when implementing AI-driven case management workflows alongside traditional security protocols. Machine learning models analyze customer behavioral patterns, transaction velocities, and merchant category relationships to establish comprehensive risk profiles for individual accounts. Real-time processing architectures enable instantaneous transaction scoring during peak operational periods while maintaining system performance standards. Modern fraud detection platforms incorporate temporal feature analysis spanning extended timeframes to identify anomalous spending patterns and account takeover scenarios. Device fingerprinting technologies combined with behavioral biometrics provide additional authentication layers beyond traditional verification methods. Geographic anomaly detection algorithms flag transactions occurring outside established customer location patterns, triggering automated investigation protocols. Risk scoring frameworks utilize extensive feature sets encompassing transactional attributes, behavioral indicators, contextual elements, and network-based characteristics. Explainability mechanisms generate detailed reasoning pathways for investigative personnel, supporting decision-making processes while meeting regulatory transparency requirements. Adaptive threshold optimization continuously adjusts detection parameters based on evolving fraud methodologies, ensuring sustained effectiveness against emerging threats. Rouhollahi and colleagues emphasize proactive financial crime prevention through integrated RegTech solutions combining artificial intelligence with regulatory compliance automation (Rouhollahi, Z. *et al.*, 2021). Regulatory compliance management incorporates automated SOX reporting capabilities alongside the implementation of PCI DSS security

standards. Data lineage tracking ensures thorough audit trails via cryptographic validation techniques, aiding in fulfilling internal control documentation obligations. Suspicious Activity Report generation streamlines regulatory reporting processes while reducing manual investigation timeframes. Security Information and Event Management integration provides enhanced visibility across organizational security infrastructure, enabling correlation between fraud events and broader threat patterns. Threat intelligence sharing platforms facilitate rapid distribution of emerging fraud indicators across industry networks, enhancing collective defense capabilities. Event correlation algorithms identify coordinated attack patterns targeting multiple customer accounts simultaneously, supporting organized fraud ring detection efforts (Flinders, M. *et al.*, 2025). Incident response automation triggers appropriate containment procedures based on threat classification methodologies, minimizing potential financial losses. Operational impact assessments reveal substantial cost reductions through decreased false positive rates and improved investigation efficiency metrics. Customer experience improvements result from reduced legitimate transaction blocking incidents and streamlined fraud resolution processes. Average fraud loss per incident decreases significantly through enhanced early detection capabilities and automated response mechanisms (Rouhollahi, Z. *et al.*, 2021). Financial institutions report measurable return on investment within implementation timeframes, primarily attributed to fraud prevention effectiveness and operational cost optimization.

Implementation Challenges and Strategic Solutions for Ai-Augmented Bpa in Regulated Industries

Contemporary organizations encounter substantial obstacles when deploying artificial intelligence solutions within regulated business environments, necessitating comprehensive strategic approaches to overcome implementation barriers. Data privacy concerns represent primary challenges requiring sophisticated protection mechanisms during model development phases. Advanced tokenization methodologies combined with federated learning architectures enable organizations to maintain regulatory compliance while preserving data utility across distributed training environments. Asch emphasizes the critical importance of strategic planning frameworks when implementing AI augmentation, noting significant risks associated with inadequate preparation and oversight

mechanisms during technology deployment phases (Asch, A. 2025). Model explainability requirements create additional complexity layers for regulated industry implementations, particularly where decision transparency mandates exist. Organizations deploy interpretability frameworks, including SHAP value analysis and LIME explanation systems, to provide stakeholders with a comprehensive understanding of automated decision processes. Hybrid approaches combining artificial intelligence recommendations with rule-based override capabilities ensure human oversight and maintenance throughout critical business workflows. Contemporary implementations demonstrate successful integration of explainable AI components within existing compliance frameworks, enabling regulatory approval while maintaining operational efficiency standards. Regulatory approval procedures often introduce substantial implementation delays as organizations navigate complex compliance landscapes. Mitigation strategies incorporate parallel manual

review pathways during transition periods, enabling gradual automation increases while maintaining operational continuity. Comprehensive audit documentation development alongside early regulatory engagement significantly reduces approval timelines through proactive consultation and iterative feedback incorporation. Organizations report improved approval success rates when implementing structured documentation approaches covering system architecture, validation protocols, and risk assessment methodologies. Technical integration challenges emerge when connecting artificial intelligence capabilities with established business process automation infrastructure. API gateway implementations provide abstraction layers managing integration complexity while supporting standardized data formats across heterogeneous system components. Modular architectural approaches enable incremental deployment strategies, allowing organizations to validate AI component performance before full-scale implementation.

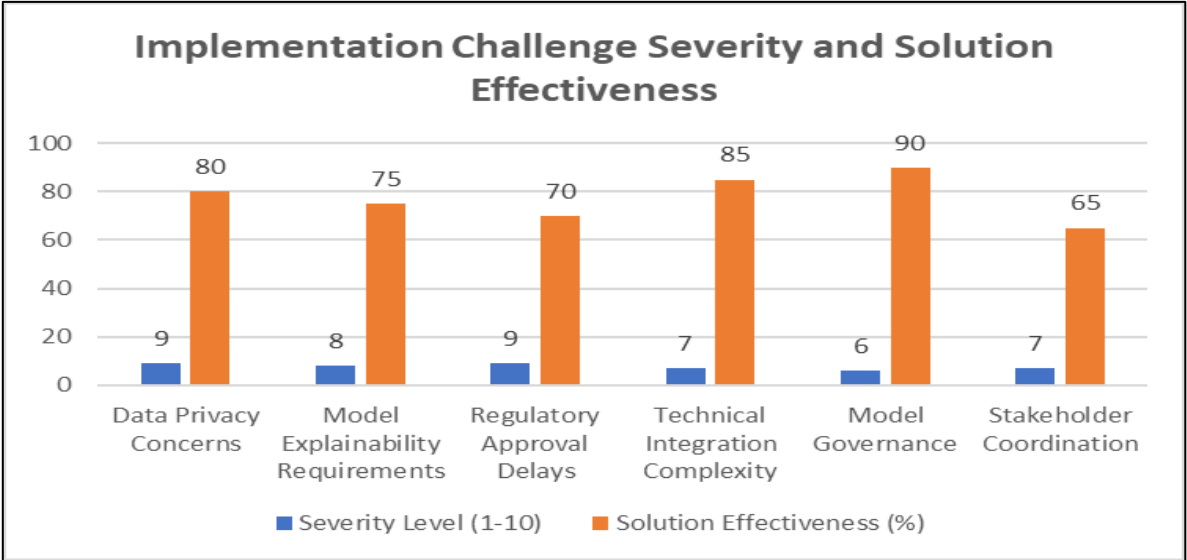


Figure 4: Strategic Solution Impact on Major Implementation Barriers in Regulated Industries (Asch, A. 2025; 8 allocate, 2025)

8 allocate research indicates artificial intelligence integration fundamentally transforms business process automation capabilities for modern enterprises, creating new opportunities for operational optimization while introducing novel technical challenges requiring specialized expertise (allocate, 2025). Model governance frameworks establish systematic approaches for monitoring performance drift, implementing regular retraining schedules, and enforcing version control across AI component deployments. Comprehensive monitoring systems track performance metrics, detect degradation patterns,

and trigger automated retraining processes, maintaining system reliability standards. Organizations implement drift detection algorithms to identify statistical distribution changes exceeding predefined thresholds, typically calibrated based on model sensitivity and data volatility characteristics. Version control systems maintain model lineage tracking across development environments, supporting rollback capabilities and experimental testing protocols. Model registries catalog distinct versions while implementing automated retirement policies for deprecated implementations. Performance

monitoring dashboards offer immediate insight into precision metrics, resource usage, and equity indicators throughout decentralized deployment systems. Effective implementations necessitate collaboration among technical teams, compliance staff, and business stakeholders to confirm consistency with organizational goals and regulatory standards.

FUTURE DIRECTIONS

Contemporary business process automation evolution demonstrates significant advancement potential across multiple technological dimensions within regulated industry environments. Generative artificial intelligence capabilities enable automated creation of comprehensive case summaries, regulatory compliance documentation, and customer communications while maintaining contextual awareness of industry-specific regulatory requirements. Advanced language models demonstrate sophisticated understanding of compliance terminology, enabling automated form completion and policy interpretation across complex regulatory frameworks. Lo emphasizes emerging trends in business process automation, highlighting the transformative potential of intelligent automation technologies in reshaping organizational workflows and operational efficiency standards (Lo, K. 2024). Self-optimizing workflow systems leverage reinforcement learning algorithms, providing continuous process refinement through performance feedback analysis. Automated systems adjust routing protocols, resource allocation strategies, and decision thresholds without requiring human intervention, creating adaptive automation capabilities demonstrating measurable improvement over operational timeframes. Digital twin integration enables comprehensive process simulation before implementation phases, significantly reducing deployment risks while maximizing optimization potential across enterprise environments. Organizations report substantial efficiency gains through intelligent workflow adaptation, particularly in complex regulatory compliance scenarios requiring dynamic response capabilities. Federated artificial intelligence approaches revolutionize cross-institutional collaboration while preserving data privacy standards and regulatory compliance requirements. Healthcare consortium networks leverage federated learning methodologies, improving diagnostic accuracy and treatment recommendation systems across multiple participating institutions without compromising sensitive patient data security. Financial services

organizations implement collaborative fraud detection and risk assessment models while maintaining competitive confidentiality and regulatory isolation standards. Advanced federated architectures demonstrate successful implementation across diverse industry verticals, enabling knowledge sharing without data exposure risks. Edge artificial intelligence deployment facilitates real-time decision-making capabilities at service delivery points, reducing processing latency while improving response times for mission-critical operational processes. Mobile device integration and Internet of Things connectivity extend AI-augmented automation capabilities to field operations, enabling intelligent automation in previously inaccessible environments, including remote patient monitoring systems and distributed financial service delivery platforms. Contemporary edge computing implementations demonstrate significant performance improvements in time-sensitive regulatory compliance applications. Quantum computing's emergence fundamentally enhances computational capabilities that are available for complex optimization challenges within regulated industry environments. Advanced quantum algorithms enable sophisticated risk modeling, portfolio optimization strategies, and molecular simulation applications supporting pharmaceutical research initiatives. Techmahindra research indicates AI-driven automation significantly transforms business process management approaches in contemporary enterprise environments, creating unprecedented opportunities for operational enhancement and competitive differentiation (Techmahindra, 2025). Regulatory technology integration automates compliance monitoring and reporting through intelligent systems that continuously track regulatory modifications and automatically adjust process parameters accordingly. Advanced RegTech implementations provide real-time compliance dashboards, automated audit trail generation capabilities, and predictive compliance risk assessment, enabling proactive regulatory management strategies. The convergence of technological innovations establishes intelligent, adaptive, and entirely compliant automation ecosystems, fundamentally altering operations in regulated industries, service delivery methods, and approaches to risk management in increasingly intricate global regulatory landscapes.

CONCLUSION

The incorporation of artificial intelligence into business process automation signifies a crucial

change in approach, enhancing operational capabilities within regulated sectors. Conventional rule-based systems exhibit fundamental constraints when faced with intricate decision-making situations that demand contextual comprehension, adaptive learning, and advanced pattern recognition skills. Contemporary AI-augmented frameworks address these limitations through advanced architectural designs incorporating machine learning algorithms, natural language processing capabilities, and computer vision technologies within established process orchestration environments. Healthcare organizations achieve remarkable operational improvements through intelligent prior authorization systems, while financial institutions deploy sophisticated fraud detection mechanisms utilizing ensemble learning techniques and behavioral analytics. Implementation success depends upon comprehensive strategic approaches addressing data privacy concerns, model explainability requirements, regulatory approval complexities, and technical integration challenges through federated learning architectures, interpretability frameworks, and modular deployment strategies. Model governance mechanisms ensure sustained performance through systematic monitoring protocols, automated retraining schedules, and version control enforcement across distributed AI components. Future technological developments encompassing generative artificial intelligence, self-optimizing workflows, federated learning approaches, edge computing deployment, quantum computing applications, and regulatory technology integration create unprecedented opportunities for operational enhancement within regulated environments. The convergence of these technological advances establishes intelligent, adaptive, and fully compliant automation ecosystems, fundamentally transforming organizational operations, service delivery methodologies, and risk management approaches. Successful implementations require coordinated collaboration between technical personnel, compliance specialists, and business stakeholders, ensuring alignment with organizational objectives while maintaining strict regulatory adherence standards essential for sustained competitive advantage within increasingly complex global regulatory landscapes.

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