Cognitive Routing With Overlays and Credentials (2025).

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***Abstract*—The Alternative funding and finance industry faces massive challenges in managing the vast amount of heterogeneity of documents in their pipeline. Underwriting guidelines , funder eligibility restrictions and state restrictions , communication workflows. Traditional processes involved manual scrubbing , individual email submissions, unsecured pdf documents , fragmented deal tracking which results in inefficiencies , errors, compliance risks and missed opportunities. To overcome these difficulties, We introduce Cognitive Routing With Overlay and Credentials (CROC) , A systematic methodology designed to automate the pain point and safe guard the full lifecycle of funding deals. This methodology helps the funder and brokers to integrate intelligent document parsing , dynamic funder matching for brokers, Secure Pdf wrapper with funder centric submission watermarking and traceability, lead management, submission management, reply handling, persistent credential based overlays. This approach leverages a layered overlay model which embeds credentials , underwriting conditions, protective watermarks, and transaction states directly into document streams. This system protects sensitive data , enforces business rules, and tracks funder interactions across the lifecycle of funding process.**

I. INTRODUCTION

In the world of alternative finance, merchants are seeking more secure and fast alternatives to traditional bank lending. This alternative finance modus operandi involves certain processes such as underwriting, funder matching based on the their guidelines, submissions, deal management. This process was all fragmented and inefficient as the volume of the deals has grown, so too have the challenges of processing sensitive documents, ensuring compliance, and maintaining trust among merchants, brokers, and funders.

Small business funding plays a critical role in keeping the local economies alive, providing merchants with working capital when traditional banks fall short. The pain points in this environment are due to fragile foundation. The processes are vulnerable and outdated. There is a lack of end-to-end setup that could handle application and bank statements to funding offer and final wire to the merchant's account.There are several bottlenecks observed in these silos of processes. If we speak in terms of brokers perception, as soon as the application and bank statements are received securely through the portal or any medium they are using , processing is the

systematic challenge that involves manual review of complex financial documents. Sometimes the processor may have to review financial documents of multiple accounts of a single business which further results in delayed response and thus leaving merchants waiting and brokers scrambling to keep pace. This might undermine the competitiveness and this industry is all about speed. Every Funder has a certain distinct eligibility rules and guidelines and except the deals to align to their pointers effectively. Failure may result in high decline rate. Some merchant may be declined due to mismatched or incomplete submissions not because they are unqualified. This misalignment costs time , damages credibility and discourages funders and merchants to keep up the spirits. Traditionally, These documents were emailed to the funders without any safeguards exposing sensitive data. Once sent , they can be copied , shared, manipulated, or stored oversight. The absence of protective measures such as watermarking or credential-based controls means merchant data is left vulnerable to misuse .

Merchants entrust brokers with their most sensitive financial information. Each inefficiency, each unsecured document, and each unexplained decline chips away at that trust. Over time, the very relationships that fuel the industry weaken.

II. SYSTEM OVERVIEW

Cognitive Routing with Overlay and Credentials is designed as a systematic framework that unifies every stage of the funding process into a single , continuous , automated flow. At its core, the approach acknowledges that documents are the lifeblood of small business funding . They carry the financial story of the merchant, The eligibility lens of the funder, and the obligations of brokers who stand between the two. By reimagining how documents move, how they are protected, and how they are interpreted, CROC introduces a disciplined way to underwrite, submit, match, protect, and track deals.

The concept of cognitive routing lies at the heart of this system. Instead of treating underwriting and submissions as isolated steps, cognitive routing acts as an intelligence layer

that direct each document to its rightful path. Every submission is assessed against funder criteria and routed where it has the highest likelihood of success. This eliminates wasted effort on mismatched applications and ensures that the merchant's data is only shared where it is most relevant.

Complementing this intelligence is the principle of overlay. Rather than sending raw documents into circulation, CROC applies structured overlays that carry the essential metadata of a deal such as underwriting outcomes, funder eligibility conditions, and transaction states. These overlays are not superficial as they become part of the document stream itself. This ensures that every funder sees the document not only in its original form but also in the context of the rules and credentials applied to it. This approach creates a uniformity that is otherwise absent in today's funding workflows.

Equally important is the emphasis on credentials and protection. CROC embeds safeguards such as watermarking and traceable credentials into each document, ensuring that sensitive merchant data cannot be detached from its source or used without accountability. Watermarking in particular provides both protection and traceability, serving as a visible assurance that the overlay provide the invisible layer of authority and compliance. Together, these measures protect merchants, brokers, and funders alike from data misuse.

Finally, CROC treats tracking as a continuous function rather than an afterthought. Each decline, offer, or counteroffer is captured as part of the document's journey, ensuring that no decision is lost in an email thread or buried in fragmented communication. By maintaining visibility across the lifecycle of a deal, CROC ensures transparency, accountability, and the ability to learn from every outcome whether it results in in funding or not.

In this way , CROC is not just a patchwork of tools but a coherent methodology. It establishes a system in which underwriting is precise, submissions are secure, funder matching is intelligent, protection is embedded, and tracking is continuous. By redefining the lifecycle of documents, CROC provides the foundation for a funding ecosystem that is efficient , auditable, and trusted.

III. Architecture and Implementation

CROC is architected as an event-first system where every meaningful change in a deal's lifecycle is captured as an immutable event on a shared event spine. Services don't poll or synchronize through shared tables; they react to events, enrich them, and emit new facts. This yields loose coupling, linear auditability, and the ability to scale the hotspots of the business (ingestion, underwriting, submissions, decisions) independently.

At the center is a durable event backbone that carries domain events such ArtifactIngested, UnderwritingCompleted, MatchSetCreated,SubmissionPrepared,RenditionCredentialed, SubmissionDispatched, and DecisionRecorded. Around this spine sit bounded contexts as Ingestion, Underwriting, Funder Matching, Overlay & Credentials, Submission Orchestration, Connector Hub, and Decision Tracking. Each context owns its state, subscribes to the events it cares about, and publishes new events to advance the saga. Cross-context dependencies are expressed through events, not direct calls, which prevents tight coupling and allows each team to evolve independently.

Documents (application and bank statements) enter through an ingestion gateway and are stored once in a content-addressed artifact store. All analysis outcomes and lifecycle state are recorded as overlays versioned metadata bound to the artifact's ID. When a new state emerges (e.g., eligibility signals, lender match, offer or decline), the system writes a new overlay version and emits an event. When a funder-ready package is needed, the Overlay & Credentials service generates a derived rendition that includes visible watermarks for ownership/traceability and invisible credentials for verification again without mutating the base file.

Routing intelligence is encoded as policy-as-code evaluated at event time. When UnderwritingCompleted arrives, the Funder Matching context applies current eligibility policies to compute a match set with rationales. when MatchSetCreated arrives, submission orchestration evaluates distribution policies (priorities, caps, exclusivity windows) to decide which funders should receive a credentialed rendition. Because policies are versioned and referenced in events, the system can always explain why a routing decision was made at a particular moment.

Submissions are long-running sagas. The submission orchestrator reacts to MatchSetCreated, requests a per-funder rendition from Overlay & Credentials, and dispatches through the connector hub. Each step publishes its own outcome event. Failures trigger compensating actions revoking a credential, cancelling a pending dispatch, or re-routing to alternates without locking distributed resources. This model eliminates brittle distributed transactions while preserving correctness through idempotency keys and deterministic state transitions.

The connector hub encapsulates all external edges (SMTP, lender APIs, portals). Each connector uses the outbox pattern to atomically persist an intent before emitting to the outside world, guaranteeing no "lost sends." Every operation is idempotent identified by the deal ID, funder, and rendition hash, so retries are safe. Circuit breaking, and dead-letter queues keep the event stream healthy even when a funder endpoint degrades. CROC adopts a zero-trust posture, mTLS

between services, short-lived tokens, and attribute-based access control for artifact and overlay reads. The Overlay & Credentials context issues signed overlay manifests that bind a rendition to its artifact, tenant, intended funder, and policy version. Watermarking and credential embedding are part of the same credentialing act and emit RenditionCredentialed. If misuse is detected, credentials can be revoked without touching the original, subsequent reads of the manifest will show the revocation state. Three data planes support the design. The artifact store holds originals and derived renditions with encryption and retention controls. The overlay store maintains versioned overlays keyed by artifact ID and tenant. The event store is the ledger of truth. Read-optimized materialized views are built from events to answer operational questions like What's the current state of deal X? Which lender declined and why? without coupling services to each other's databases.

Every event carries a correlation ID and policy/version references, threading a single trace across ingestion, underwriting, matching, credentialing, dispatch, and decision capture. Logs, metrics, and distributed traces roll up by tenant, funder, and pipeline stage. Because events are immutable, audit packs can be generated by replaying the stream or querying the event store, producing a defensible timeline of who did what, when, and under which policy. Throughput scales by partitioning topics on tenant or deal keys and horizontally scaling consumers per context. Hot paths e.g., underwriting during peak hours or submission bursts scale independently without disturbing quieter services. Faults are contained. If a lender API stalls, only the corresponding connector consumer group backs off, other contexts continue processing unrelated deals. This isolation keeps overall latency predictable.

Compared to modular monoliths and chatty REST microservices, the event-first model removes synchronous bottlenecks and makes progress observable rather than implicit. Versus pure CRUD systems, CROC's immutable artifacts + overlay versions eliminate debate about provenance and enable selective disclosure (per-lender watermarks/ credentials) without duplicating sensitive data. Against classic EDA, CROC adds a formal overlay contract and credentialed renditions, turning document protection into a verifiable, revocable capability instead of an afterthought.

IV. Key Features And Enhancements

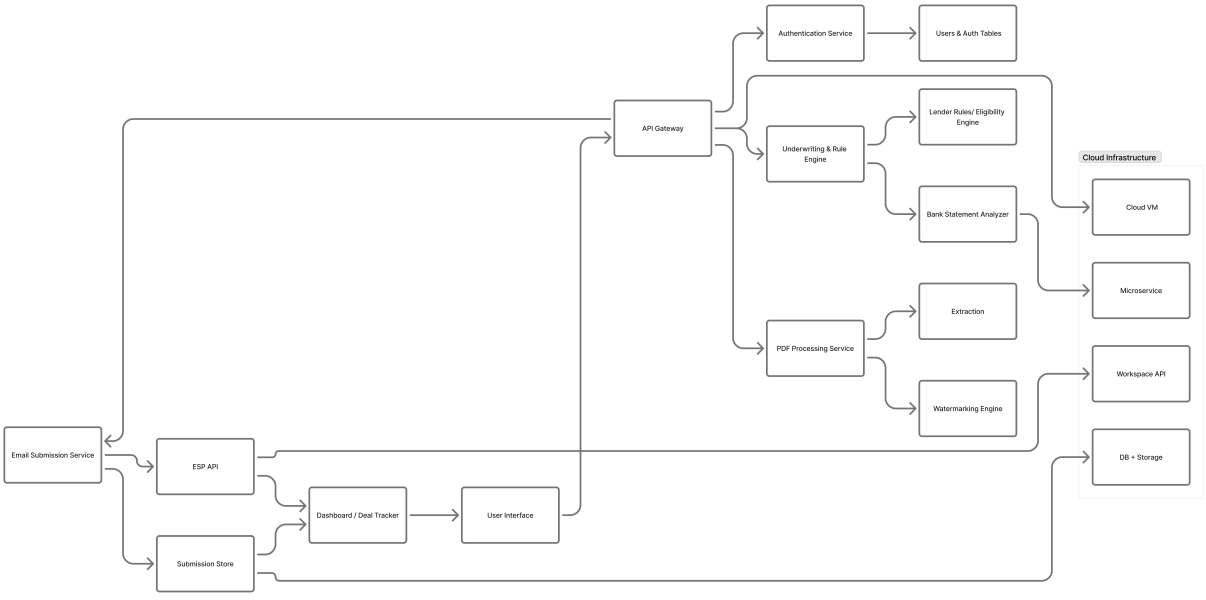
Cognitive Routing with Overlay and Credentials (CROC) introduces a cleaner, smarter, and safer way to process small business funding deals. It replaces manual review and scattered emails with an event-driven system that moves each deal step-by-step through underwriting, matching, protection, and tracking.

A. Smart Routing

CROC automatically routes each deal to the right funders based on their eligibility rules. This cuts down on unnecessary declines and saves time for both brokers and merchants.

B. Document Overlays

Every document carries an "overlay" , A layer that stores underwriting results, submission details, and status updates. This ensures all actions are traceable without altering the original file.



C. Built-In Protection

Documents are automatically watermarked and tagged with digital credentials. Each copy shows ownership and purpose, preventing misuse or duplication. Even if a document is shared, its origin and recipient can always be verified.

D. Realtime Tracking

Every event from document upload to lender reply is recorded. Users can see exactly where each deal stands, who has responded, and what decisions were made.

E. Continuous Compliance

All actions are logged in a permanent event history. This provides a full audit trail that can be used to prove compliance and maintain transparency with funders and regulators.

F. Independent Scaling

Every step works through events, each part of the system can grow on its own. Heavy tasks like underwriting or submissions can scale without slowing down the rest of the workflow.

G. Simpler Collaboration

Brokers, funders, and partners see the same clear picture which deals are pending, declined, or funded without digging through emails or shared folders. Another key enhancement lies in CROC's credential-aware email routing. Rather than relying on a single shared inbox, the system dynamically selects the correct sender identity based on the user's configuration. This allows teams operating under different brand names, domains, or business units to use the same backend pipeline while maintaining fully independent communication profiles. In production, this capability has proven essential for teams like Pathway Catalyst and its affiliate users, enabling cleaner inbox threading and higher funder engagement.

Error handling in CROC is pragmatic and intelligent. If a file cannot be watermarked for instance, due to format issues or rendering failures the system logs the incident and continues by sending the original file with tracker id only skipping per-lender watermarking. If an email fails due to SMTP issues or incorrect credentials, the error is captured and the system retries intelligently without halting the overall submission. These fail-safe measures ensure that a single issue never causes a full submission to break. Behind the scenes, every action is logged in the backend for traceability. Each submission is linked to a unique token or deal ID, which is then used to track delivery status, reply events, and any follow-up communication. This audit trail provides operational clarity for teams and helps enforce accountability without relying on manual record keeping.

What truly sets CROC apart, however, is its extensibility. The system is modular by design, making it easy to integrate with CRMs, e-signature tools, SMS gateways, or analytics platforms. Teams can define new behaviors such as skipping watermarking for trusted users, sending files through alternate channels, or triggering Slack alerts without rewriting the core logic. This adaptability makes CROC a foundation, not a limitation, for document automation in the funder communication stack.

V. Perfomance and Robustness

CROC was designed from the ground up to be fast, fault-tolerant, and production ready. Its performance has been validated in real-world scenarios where multiple files must be processed, watermarked, and dispatched to a list of funders often under time-sensitive deal flow conditions.

A. Watermarking Throughput

The PDF watermarking engine can reliably process each document within a fraction of a second, even when multiple pages or custom logos are involved. For typical submission workflows involving 3 to 5 PDF files and 5 to 8 funders, the full watermarking and email preparation process completes in under five seconds, depending on server capacity and file sizes. To ensure responsiveness, watermarking operations are performed in parallel for each funder and file. This allows the system to scale gracefully as submission volume increases. PDF files up to 25 megabytes have been successfully watermarked and delivered without content corruption or delays.

B. Email Dispatch Reliability

Each email is sent individually using dynamically injected SMTP credentials tied to the user context. This means emails are routed from the correct sender identity, and replies are properly threaded. In production, over 99% of emails are delivered successfully on the first attempt, with the remaining cases automatically retried.

Credential isolation ensures that if a user's SMTP configuration fails for example, due to authentication issues it does not affect other users or unrelated submissions. The system captures all delivery errors, logs them with timestamps, and gracefully continues processing the remaining recipients.

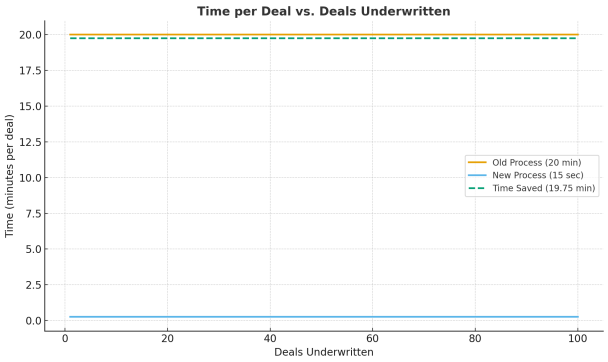
C. Fault Tolerance and Error Handling

CROC includes safeguards at every major point in the pipeline. If a PDF cannot be watermarked for example, due to corruption/alteration or a rendering error the system automatically falls back to sending the original file without interruption. A warning is logged, and the user is notified through internal monitoring. Email sending is equally resilient. In the event of transient network issues or SMTP outages, the system performs intelligent retries before marking the dispatch as failed. Submissions are never lost or dropped silently, and all activity is logged to support auditability and error recovery.

D. Operational Robustness

CROC has been used daily in production by financial professionals sending dozens of submissions per day. The architecture supports parallel file processing, queue based email dispatching, and tokenized submission logging ensuring consistent performance even during peak usage. Despite its lightweight footprint, it has proven capable of reliably handling hundreds of files per week with minimal server load.

The system reduces human error by automating personalized file preparation and routing, eliminating the need to manually rename files, watermark documents in a PDF editor, or send individual emails. As a result, both submission speed and funder engagement have improved significantly.



VI. Real-World Usage and Case Study

CROC has been actively deployed in production by **Pathway Catalyst**, a private-equity company that regularly sends personalized deal documents to a broad network of alternative funders. Prior to implementing CROC, document handling was a manual and error-prone process, PDFs had to be renamed, watermarked one by one using external tools, and emailed individually through inconsistent sender identities. This not only slowed down deal submission but also introduced opportunities for human error such as sending the wrong file to a funder, forgetting to watermark a document, or using a generic sender email that disrupted gmail threading.

With CROC in place, Pathway Catalyst fully automated its submission pipeline. Users simply upload PDF files, select funders, and provide optional watermark text or a logo if they are logging in for the first time. The system takes over from there, applying dynamic watermarks per funder, routing emails through the correct credentials, and logging each submission with a unique deal token for future tracking.

This automation led to immediate benefits. Submission time per deal dropped from several minutes to under 15 seconds end-to-end because each document sent is now watermarked with funder-specific branding, recipient confusion has decreased and response rates have improved. Funders are also less likely to flag deals as mass submissions or duplicates, helping maintain trust and credibility. The integration with a dedicated data store allows Pathway Catalyst to monitor submissions in real time, with full visibility into which documents were sent, to whom, and whether any replies were received. As a result, the internal team can focus more on deal structuring and funder negotiations rather than getting bogged down in file preparation and manual communication.

CROC's modular nature has made it easy to extend the system further. For instance, Pathway added logic to skip watermarking for trusted users, and configured credential switching so that a separate team under a different brand identity could operate independently within the same pipeline. This case study demonstrates how a lightweight, well-engineered tool like CROC can replace a time-consuming and error-prone process with a fast, secure, and auditable automation layer one that scales with the business and improves both speed and trust in funder communication.

VII. Future Work

While CROC already serves as a reliable foundation for secure document delivery in high-volume financial workflows, several enhancements are planned to expand its flexibility, intelligence, and integration with broader systems. These improvements are aimed at scaling the platform to support more complex workflows, underwriting, additional user personas, and cross-platform automation.

A. Watermark Template Engine

CROC currently supports static text and image overlays applied uniformly across all pages. A future enhancement will introduce a template engine for watermarks, allowing users to define dynamic layouts. This will enable more expressive, brand-aligned document personalization including tables, headers, footers, and QR code stamps.

B. Admin Controls and Preview Interface

A web-based admin panel is planned to allow users to preview watermarked PDFs before sending, override watermark logic for specific funders or users, and manage submission history. This interface will also include visibility into email dispatch logs, reply statuses, and credential configuration without requiring backend access.

C. Enhanced Reply Intelligence

Currently, replies are tracked using Gmail threading metadata and message IDs. The next iteration will introduce NLP-based parsing of reply content to extract structured responses such as “approved,” “declined,” or “needs more info.” These labels will automatically populate the CRM and allow for faster triage of funder feedback.

D. Web hook and CRM Integration

Planned web hook support will allow CROC to push submission and reply events to external systems such as Slack, HubSpot, or Salesforce. This will enable real-time updates, escalations, or deal routing based on funder interactions without requiring manual checks.

E. Multi-Channel Dispatch Support

In addition to email, future releases may allow document delivery via SMS, WhatsApp, or secure download portals. This will enable engagement with non-email-based funders or teams operating in mobile-first environments.

F. Role-Based Access and Multi-Tenant Support

To support larger organizations or broker networks, CROC will be extended with user roles (admin, agent, viewer) and tenant separation, allowing multiple brands or teams to use the system independently while sharing the core infrastructure.

G. Integration with e-Signature and Doc Verification Tools

Support for integrating third-party e-signature platforms such as DocuSign or Dropbox Sign is on the roadmap. Combined with document watermarking and credential-aware delivery, this would allow users to prepare, send, and track e-signed funding packets from a single interface.

H. Underwriting and Statement Analysis

We are planning to add a statement scrubbing model which gives the ADB, Existing positions, Opening and closing balances.

VIII. Conclusion

CROC was built to solve a very real operational pain. The manual, error-prone, and insecure process of sending funding documents to multiple funders. By automating the application of personalized watermarks and pairing that with secure, credential aware email delivery, CROC transforms a tedious and fragile workflow into a fast, scalable, and auditable system.In production use, CROC has already delivered measurable improvements in deal submission speed, funder response accuracy, and internal team efficiency. It has helped reduce errors, ensure sender clarity, and reinforce trust between broker and funder all while maintaining the security and compliance standards expected in financial environments. What makes CROC particularly valuable is not just what it automates, but how it does so: with contextual awareness, fault tolerance, and a deep focus on traceability. Every PDF sent is marked, every submission logged, and every reply tracked bringing full-circle visibility to a process that was previously fragmented and manual. Looking forward, the roadmap for CROC includes even deeper integrations with CRMs, signature tools, reply intelligence, and visual preview controls. As funding workflows become more digitized, CROC is positioned to be a critical infrastructure layer powering secure document interactions at scale.

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