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Proof of Process: Collaborative Authorship Extension  
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## Abstract

This document defines an extension to the Proof of Process (PoP) specification for documenting collaborative authorship. The extension enables multiple contributors to independently attest to their individual contributions while maintaining a unified Evidence chain for the combined document. This supports use cases including academic co-authorship, legal document drafting by teams, and creative works with multiple writers.

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## 1. Introduction

This document defines mechanisms for documenting collaborative authorship where multiple contributors produce a single work. The collaborative model enables each contributor to attest to their individual contributions while maintaining a unified Evidence chain for the combined document.

This extension is defined as a companion to the main Proof of Process specification [I-D.condrey-rats-pop].

## 1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

## 2. Motivation

Modern knowledge work is frequently collaborative:

- \* Academic papers with multiple co-authors
- \* Legal documents drafted by teams
- \* Technical documentation with subject matter experts

- \* Creative works with co-writers or editors

The base Proof of Process Evidence model assumes a single author with one signing key. Without explicit collaboration support, teams must either:

- \* Designate one member to generate Evidence, losing attribution for other contributors.
- \* Generate separate Evidence packets and link them via provenance, losing unified document history.
- \* Share a single signing key, compromising individual accountability.

The collaborative authorship model addresses these limitations by enabling multiple contributors to independently attest to their contributions within a shared Evidence structure.

### 3. Collaboration Section Structure

The collaboration section is an optional component of the Evidence packet, identified by integer key 22. It documents the participants and their respective contributions.

```
; Collaboration section for multi-author works
; Key 22 in evidence-packet
collaboration-section = {
    1 => collaboration-mode,          ; mode
    2 => [+ collaborator],            ; participants
    ? 3 => [+ contribution-claim],    ; contributions
    ? 4 => merge-record,              ; merge-history
    ? 5 => collaboration-policy,      ; governance
}

collaboration-mode = &(
    sequential: 1,                    ; One active author at a time
    parallel: 2,                      ; Concurrent editing, merged
    delegated: 3,                     ; Primary author + contributors
    peer-review: 4,                   ; Author + reviewers/editors
)

; Individual collaborator record
collaborator = {
    1 => cose-key,                    ; collaborator-pubkey
    2 => collaborator-role,           ; role
    ? 3 => tstr,                      ; display-name
    ? 4 => tstr,                      ; identifier (ORCID, etc.)
}
```

```
    5 => [+ time-interval],           ; active-periods
    ? 6 => [+ uint],                  ; checkpoint-ranges (indices)
    7 => cose-signature,              ; collaborator-attestation
    ? 8 => contribution-summary,      ; contribution-stats
}

collaborator-role = &(
    primary-author: 1,                ; Main/lead author
    co-author: 2,                     ; Equal contributor
    contributing-author: 3,            ; Section/chapter contributor
    editor: 4,                         ; Editorial contributions
    reviewer: 5,                      ; Review comments incorporated
    technical-contributor: 6,          ; Data, code, figures
    translator: 7,                    ; Translation work
)

; Summary of a collaborator's contributions
contribution-summary = {
    1 => uint,                         ; checkpoints-authored
    2 => uint,                         ; chars-added
    3 => uint,                         ; chars-deleted
    4 => duration,                     ; active-time
    ? 5 => float32,                    ; estimated-contribution-pct
}

; Detailed contribution claims
contribution-claim = {
    1 => contribution-type,            ; type
    2 => cose-key,                     ; contributor-key
    ? 3 => [+ uint],                   ; checkpoint-indices
    ? 4 => tstr,                       ; description
    ? 5 => float32,                    ; extent (0.0-1.0)
}

contribution-type = &(
    original-content: 1,               ; New text/content
    editing: 2,                       ; Revisions to existing content
    research: 3,                      ; Research contribution
    data-analysis: 4,                 ; Data/analysis contribution
    figures-tables: 5,                ; Visual elements
    code: 6,                          ; Code contributions
    review-feedback: 7,               ; Review that influenced content
    structural: 8,                    ; Organization/structure
)

; Record of merge operations
merge-record = {
    1 => [+ merge-event],              ; merges
}
```

```

}

merge-event = {
    1 => pop-timestamp,           ; merge-time
    2 => uint,                    ; resulting-checkpoint
    3 => [+ cose-key],            ; merged-contributors
    ? 4 => merge-strategy,        ; strategy
    ? 5 => tstr,                  ; merge-note
}

merge-strategy = &(
    sequential-append: 1,         ; Sections appended in order
    interleaved: 2,              ; Content merged throughout
    conflict-resolved: 3,        ; Conflicts manually resolved
    automated: 4,                ; Automated merge tool
)

; Collaboration governance policy
collaboration-policy = {
    ? 1 => uint,                  ; min-approvers-for-merge
    ? 2 => bool,                  ; requires-all-signatures
    ? 3 => tstr,                  ; policy-uri
}

```

#### 4. Collaborator Attestation

Each collaborator provides an independent attestation of their contribution. This enables Verifiers to confirm that each participant acknowledged their role.

##### 4.1. Attestation Content

```

collaborator-attestation = COSE_Sign1(
    payload = CBOR_encode({
        1: packet-id,             ; Evidence packet ID
        2: collaborator-pubkey,   ; Attesting collaborator's key
        3: role,                  ; Declared role
        4: active-periods,        ; When contributor was active
        5: checkpoint-ranges,     ; Which checkpoints they authored
        6: contribution-summary,   ; Self-reported contribution stats
        7: attestation-timestamp, ; When attestation was made
    })),
    key = collaborator-private-key
)

```

The attestation binds the collaborator's identity to specific checkpoints and contribution claims, enabling per-contributor accountability.

#### 4.2. Attestation Timing

Collaborator attestations may be collected:

- \* *\*Incrementally:*\* Each collaborator signs after their contribution period ends.
- \* *\*At export:*\* All collaborators sign when the Evidence packet is finalized.
- \* *\*Post-hoc:*\* Collaborators sign after reviewing the complete Evidence (attestation-timestamp will be later than final checkpoint).

The attestation-timestamp enables Verifiers to determine when each collaborator endorsed the Evidence.

#### 5. Verification of Collaborative Evidence

Verifiers of collaborative Evidence MUST perform additional checks beyond single-author verification:

1. Verify that all collaborator-attestation signatures are valid.
2. Verify that checkpoint-ranges claimed by collaborators do not have unexplained gaps (all checkpoints should be attributed).
3. Verify that checkpoint-ranges do not overlap for modes that prohibit concurrent editing (sequential mode).
4. For merge events, verify that the merge-time falls within the active-periods of the merged contributors.
5. Verify that contribution-summary statistics are plausible given the checkpoint data (e.g., chars-added should not exceed total chars in attributed checkpoints).

The Attestation Result SHOULD document:

- \* Number of collaborators and their roles
- \* Whether all collaborator attestations were verified
- \* Any gaps in checkpoint attribution
- \* Consistency of contribution claims

## 6. Privacy Considerations

Collaborative Evidence inherently reveals information about multiple individuals. Participants SHOULD consider:

- \* Collaborator public keys may be linkable across documents. Contributors may use per-document keypairs for privacy.
- \* Active-periods reveal when each contributor was working, which may be sensitive in some contexts.
- \* Contribution percentages may be contentious; participants SHOULD agree on methodology before Evidence generation.
- \* Reviewer/editor roles reveal the review process, which may be confidential for some publications.

## 7. Collaborative Evidence Example

Academic paper with three co-authors:

```
collaboration-section = {
  1: 2,
  2: [
    {
      1: h'alice-cose-key...',
      2: 1,
      3: "Alice Smith",
      4: "orcid:0000-0001-2345-6789",
      5: [
        {1: 1(1704067200), 2: 1(1706745600)},
      ],
      6: (0, 45),
      7: h'alice-attestation...',
      8: {
        1: 46,
        2: 12500,
        3: 800,
        4: 14400.0,
        5: 0.45
      }
    },
    {
      1: h'bob-cose-key...',
      2: 2,
      3: "Bob Jones",
      5: ({1: 1(1705276800), 2: 1(1706140800)}),
      6: (46, 82),
    }
  ]
}
```

```

      7: h'bob-attestation...',
      8: {1: 37, 2: 8900, 3: 450, 4: 10800.0, 5: 0.32}
    },
    {
      1: h'carol-cose-key...',
      2: 3,
      3: "Carol Lee",
      5: ({1: 1(1706400000), 2: 1(1706745600)}),
      6: (83, 105),
      7: h'carol-attestation...',
      8: {1: 23, 2: 5200, 3: 200, 4: 7200.0, 5: 0.23}
    }
  ],
  3: [
    {1: 1, 2: h'alice-key...', 4: "Introduction, Methods"},
    {1: 4, 2: h'bob-key...', 4: "Results, Data Analysis"},
    {1: 5, 2: h'carol-key...', 4: "Figures and Tables"}
  ],
  4: {
    1: [
      {
        1: 1(1706659200),
        2: 100,
        3: (h'alice-key...', h'bob-key...', h'carol-key...'),
        4: 3,
        5: "Final integration of all sections"
      }
    ]
  }
}

```

## 8. Security Considerations

Collaborative authorship introduces additional security considerations beyond single-author Evidence:

- \* **\*Key compromise scope:** Compromise of one collaborator's key affects only their claimed checkpoints, not the entire document Evidence.
- \* **\*Collusion attacks:** Multiple collaborators could collude to fabricate a document history. Verifiers SHOULD consider the number of independent attestations.
- \* **\*Contribution disputes:** This format documents claims but cannot resolve disputes about who truly authored content. External arbitration may be needed.

- \* \*Replay of attestations:\* Attestations are bound to specific packet-ids to prevent reuse across documents.

Collaborator attestations use COSE signatures as defined in [RFC9052]. Full security considerations for the Proof of Process format are specified in [I-D.condrey-rats-pop].

## 9. IANA Considerations

This document has no IANA actions. The collaboration section uses key 22 as defined in the main architecture document.

## 10. References

### 10.1. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997, <<https://www.rfc-editor.org/info/rfc2119>>.
- [RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.
- [RFC9052] Schaad, J., "CBOR Object Signing and Encryption (COSE): Structures and Process", STD 96, RFC 9052, August 2022, <<https://www.rfc-editor.org/info/rfc9052>>.

### 10.2. Informative References

- [I-D.condrey-rats-pop] Condrey, D., "Proof of Process: An Evidence Framework for Digital Authorship Attestation", Work in Progress, Internet-Draft, draft-condrey-rats-pop-00, <<https://datatracker.ietf.org/doc/html/draft-condrey-rats-pop-00>>.

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