

Modeling the Diachronic Evolution of Legal Norms

An LRMoo-Based, Component-Level, Event-Centric Approach to Legal Knowledge Graphs

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Federal Senate of Brazil



AI4Legs 2025 – fifth edition: AI for Legislation

The Challenge for Automated Processing

Standard Texts are usually continuous and static texts

Brazil,^[c] officially the **Federative Republic of Brazil**,^[d] is the largest country in **South America** and a founding member of **BRICS**. It is also the world's **fifth-largest country by area** and the **seventh-largest by population**, with over 213 million people. The country is a **federation** composed of 26 **states** and a **Federal District**, which hosts the capital, **Brasília**. Its most populous city is **São Paulo**, followed by **Rio de Janeiro**. Brazil has the most **Portuguese speakers** in the world and is the only country in the **Americas** where **Portuguese** is an **official language**.^{[11][12]}

Bounded by the **Atlantic Ocean** on the east, Brazil has a **coastline** of 7,491 kilometers (4,655 mi).^[13] Covering roughly half of South America's land area, it **borders all other countries and territories** on the continent except **Ecuador** and **Chile**.^[14] Brazil encompasses a wide range of tropical and subtropical landscapes, as well as **wetlands**, **savannas**, **plateaus**, and low mountains. It contains most of the **Amazon basin**, including the **world's largest river system** and most extensive **virgin tropical forest**. Brazil has diverse **wildlife**, a variety of **ecological systems**, and extensive natural

✗ **Blind to Structure & Time**

The Reality of Legal Norms

Art. 1º A República Federativa do Brasil, formada pela união indissolúvel dos Estados e Municípios e do Distrito Federal, constitui-se em Estado democrático de direito e tem como fundamentos:

- I – a soberania;
- II – a cidadania;
- III – a dignidade da pessoa humana;
- IV – os valores sociais do trabalho e da livre iniciativa; ❶ *Normas correlatas*
- V – o pluralismo político.

Parágrafo único. Todo o poder emana do povo, que o exerce por meio de representantes eleitos ou diretamente, nos termos desta **Constituição**

Art. 2º São Poderes da União, independentes e harmônicos entre si, o Legislativo, o Executivo e o Judiciário.

Art. 3º Constituem objetivos fundamentais da República Federativa do Brasil:

- I – construir uma sociedade livre, justa e solidária;
- II – garantir o desenvolvimento nacional;
- III – erradicar a pobreza e a marginalização e reduzir as desigualdades sociais e regionais;

Structured, Diachronic (Evolves over Time)

Rich in concepts (rights, sovereignty),

poor in Concrete (Named) Entities

Challenge: Blind to Structure

Continuous Text

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Structured Text

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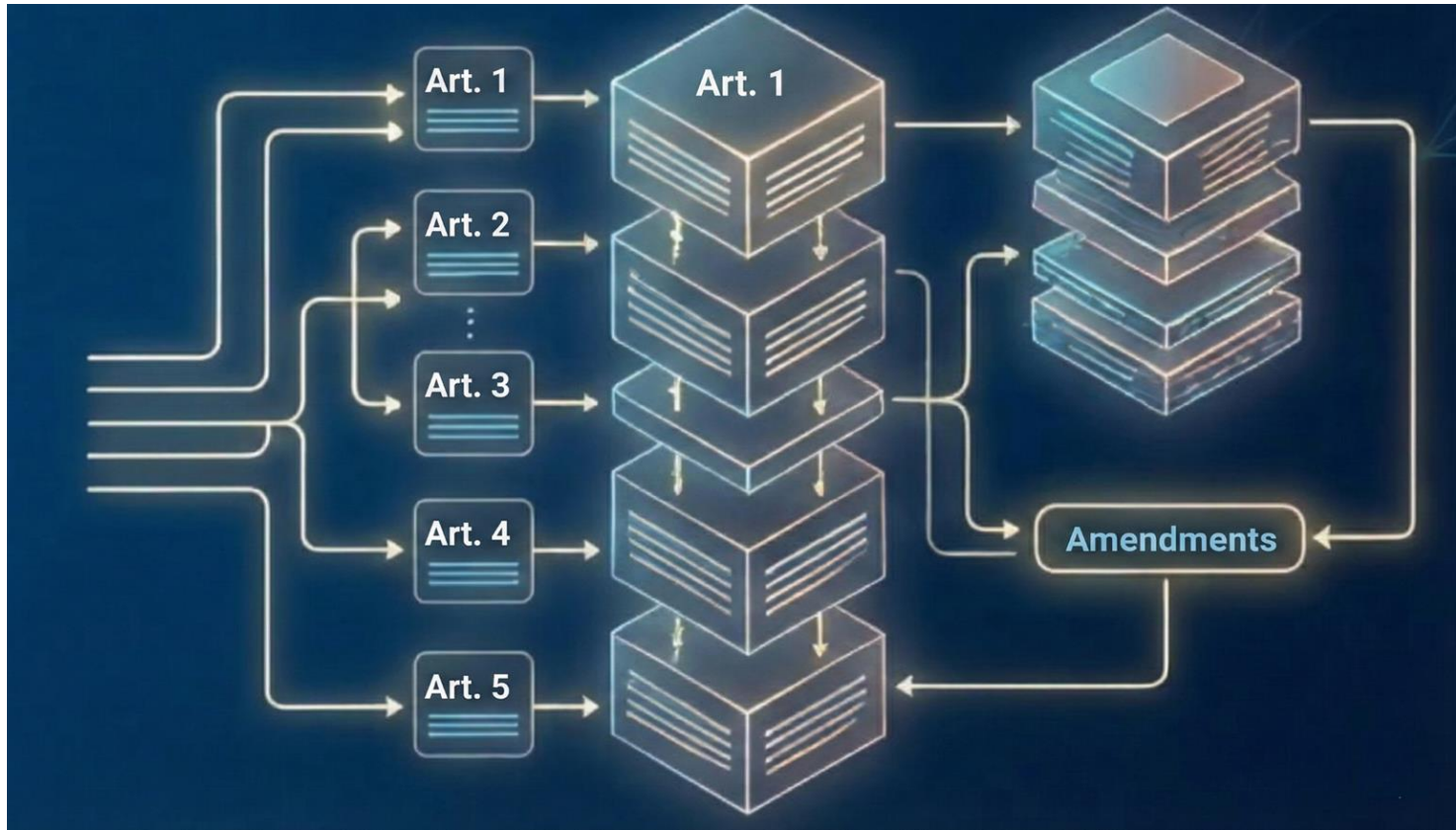
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Challenge: Blind to diachronic evolution



How can we model structural and diachronic evolution of legal norms?

✓ **TÍTULO II - DOS DIREITOS E GARANTIAS FUNDAMENTAIS** (art. 5º a art. 17)

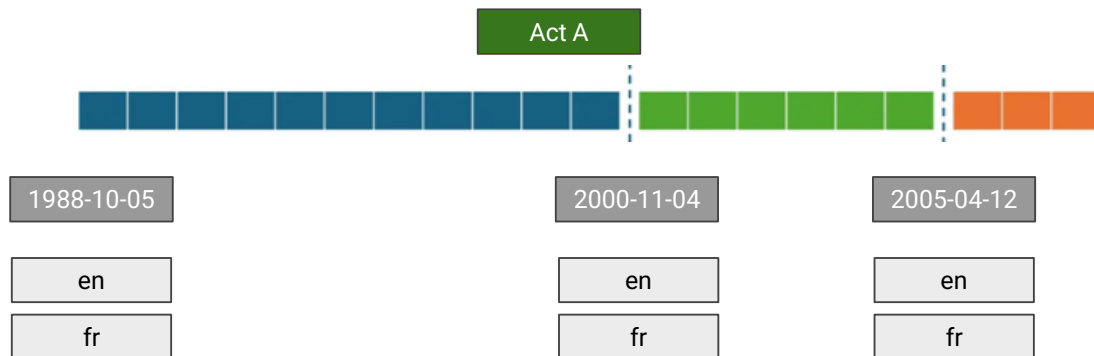
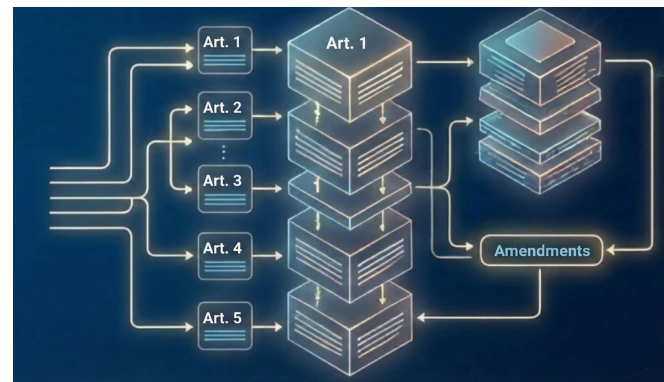
✓ **CAPÍTULO I - DOS DIREITOS E DEVERES INDIVIDUAIS E COLETIVOS** (art. 5º)

✓ **Art. 5º**

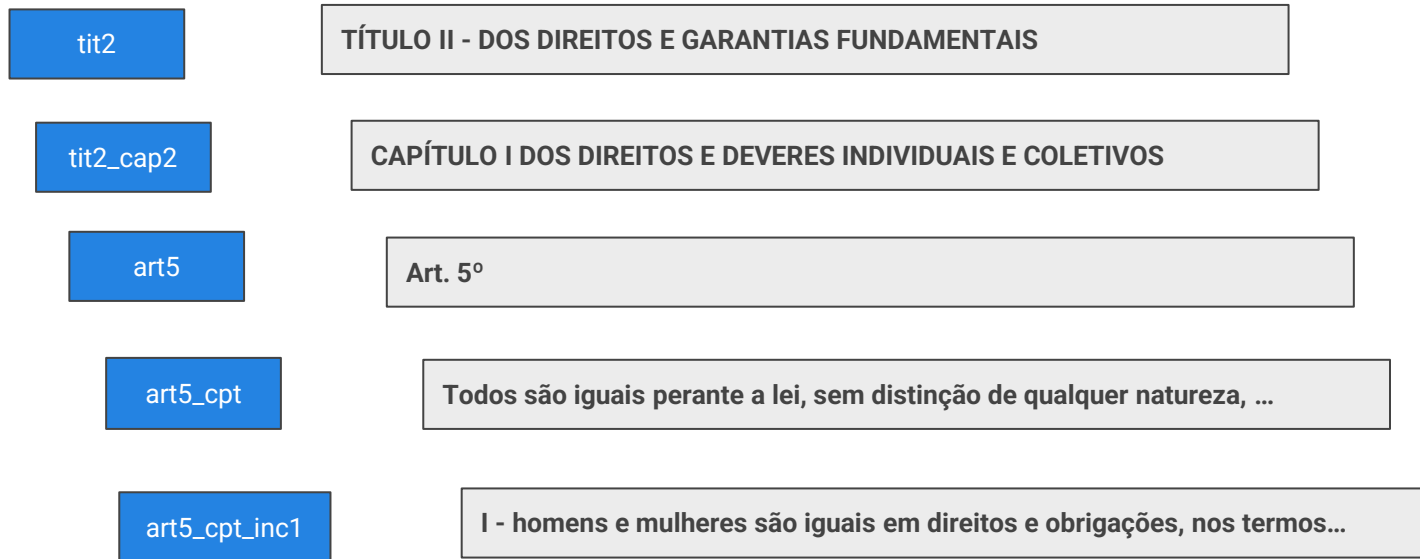
➤ Todos são iguais perante a lei, sem distinção de qualquer natureza, garantindo-se a inviolabilidade do direito à vida, à liberdade, à igualdade, à segurança e à propriedade,

§ 1º As normas definidoras dos direitos e garantias fundamentais têm aplicação imediata

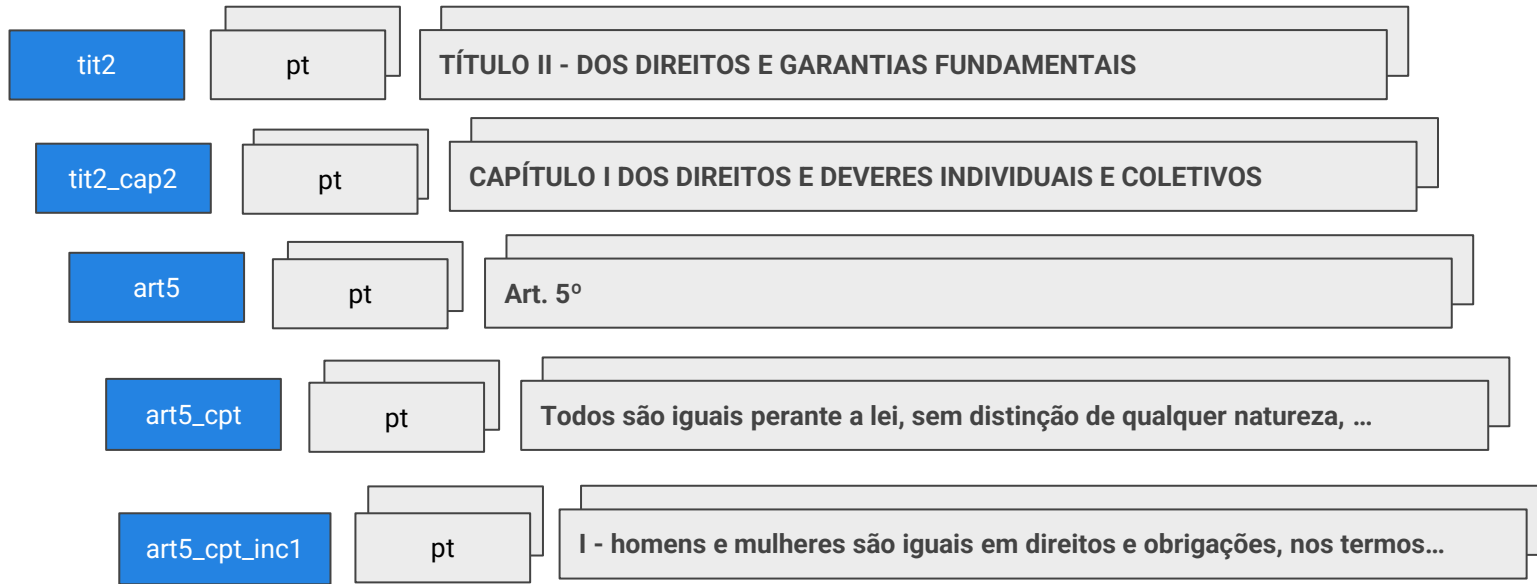
§ 2º Os direitos e garantias expressos nesta Constituição não excluem outros decorrentes do regime e dos princípios que ela estabelece, assim como aqueles decorrentes de tratados e convenções internacionais em que a República Federativa do Brasil seja parte.



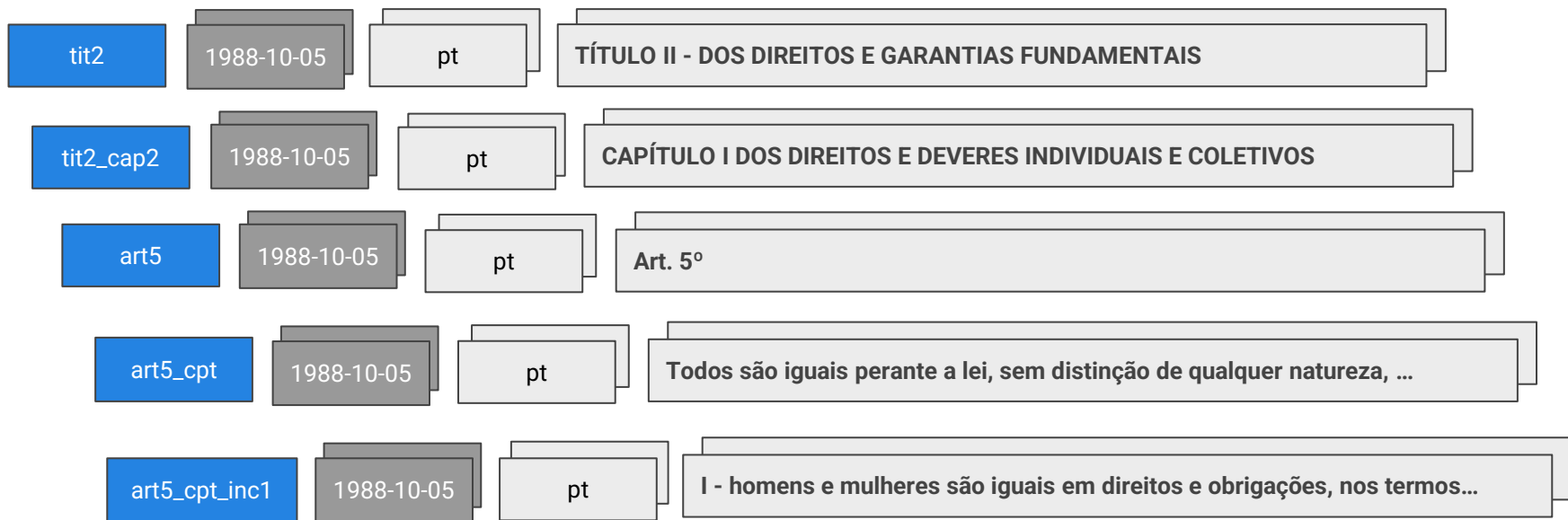
Parsing Raw Text into Structured Representation: The Structural Layer



From Monolingual to Multilingual: The Language Layer

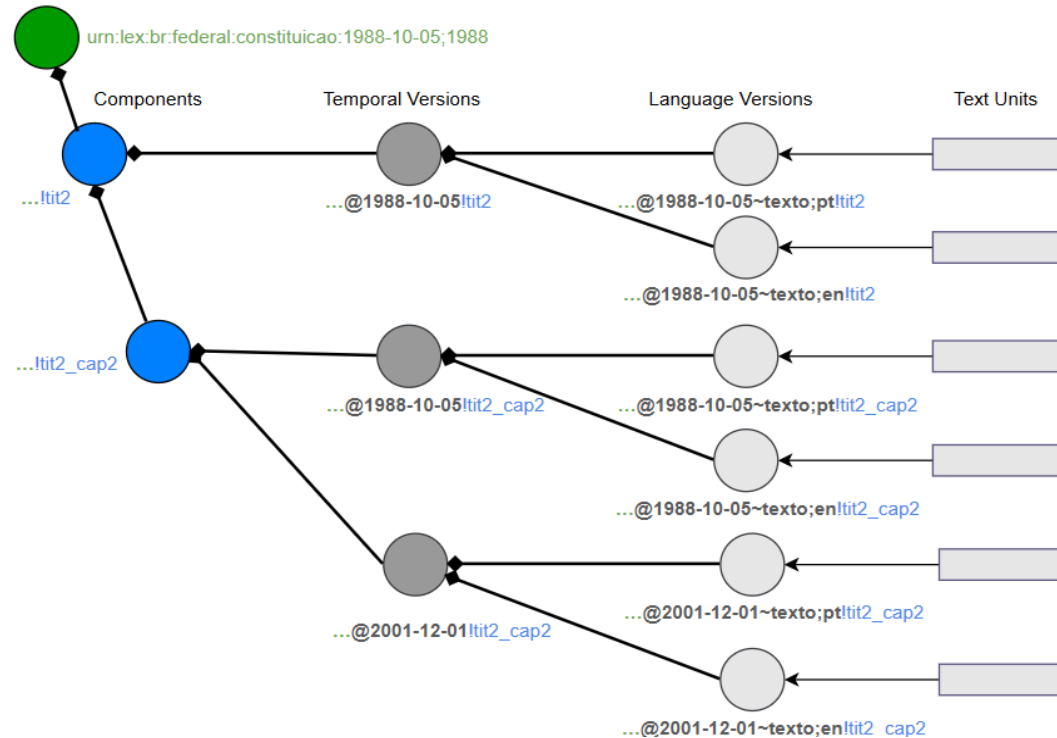


Modeling Diachronic Evolution: Temporal Layer

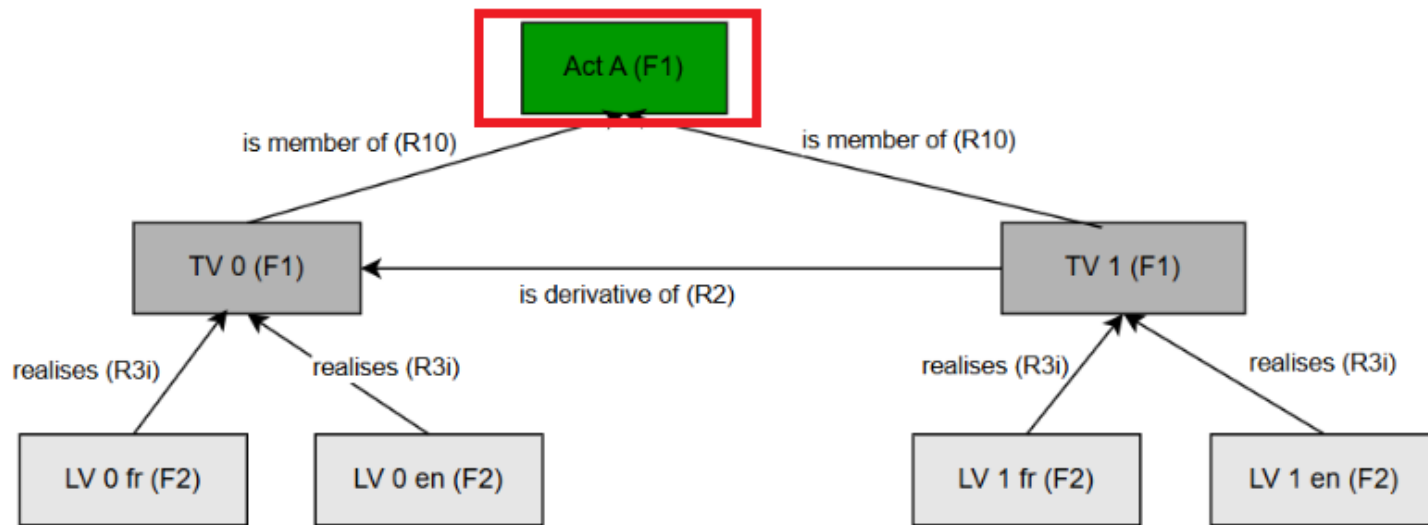


The Structural, Temporal and Language Representation

Norm (as a whole)

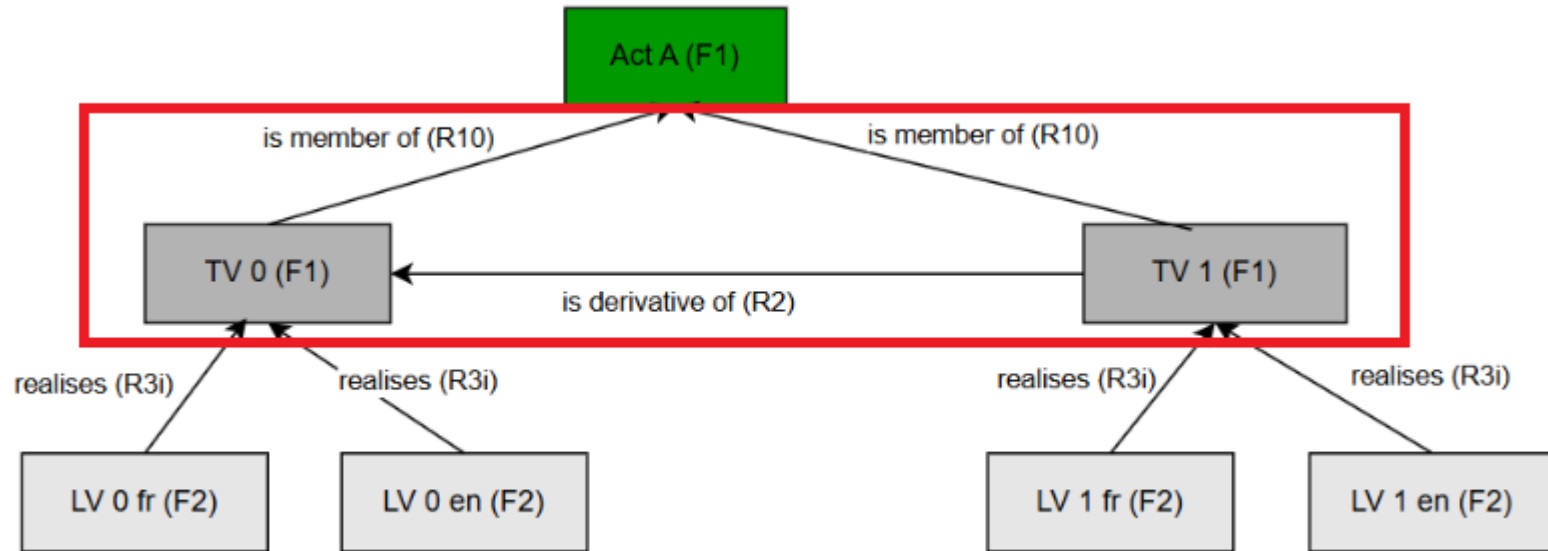


The Foundation: An LRMoo-Based, Event-Centric, Component-Level Approach



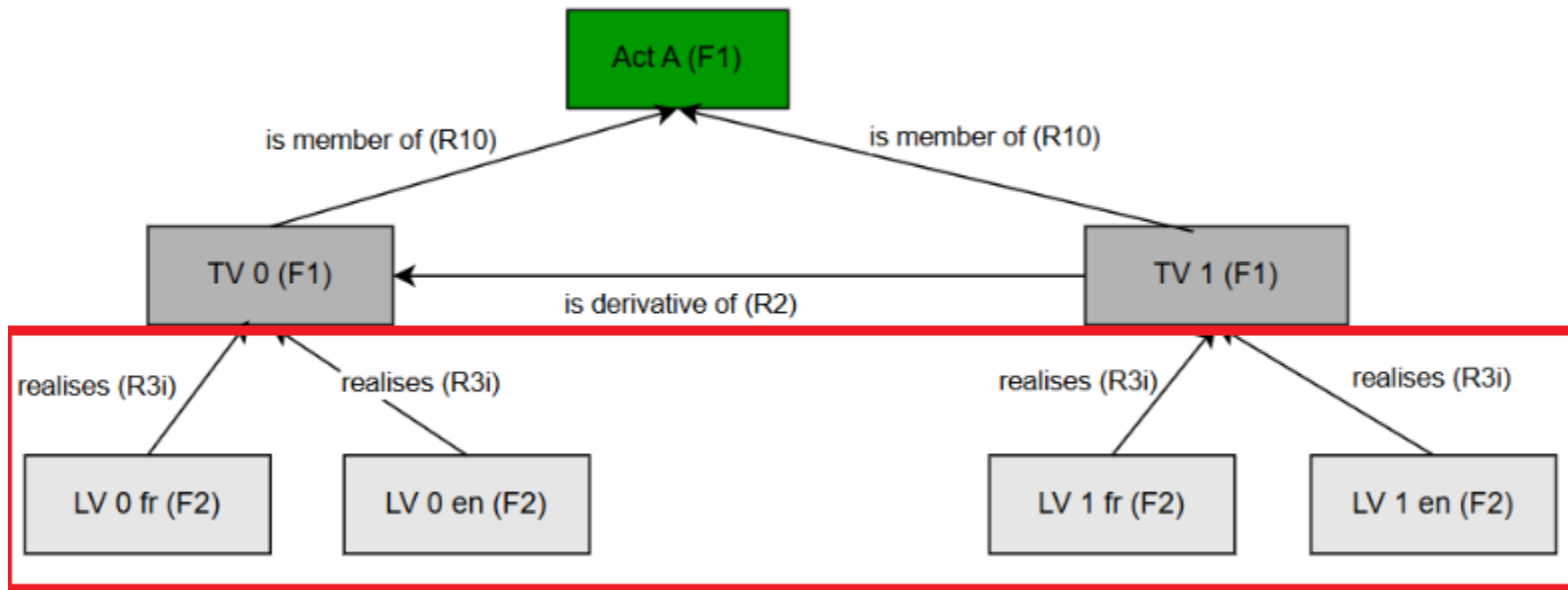
<urn:lex:br:federal:constituicao:1988-10-05;1988>

Temporal Version: distinct normative identity at a specific point in time



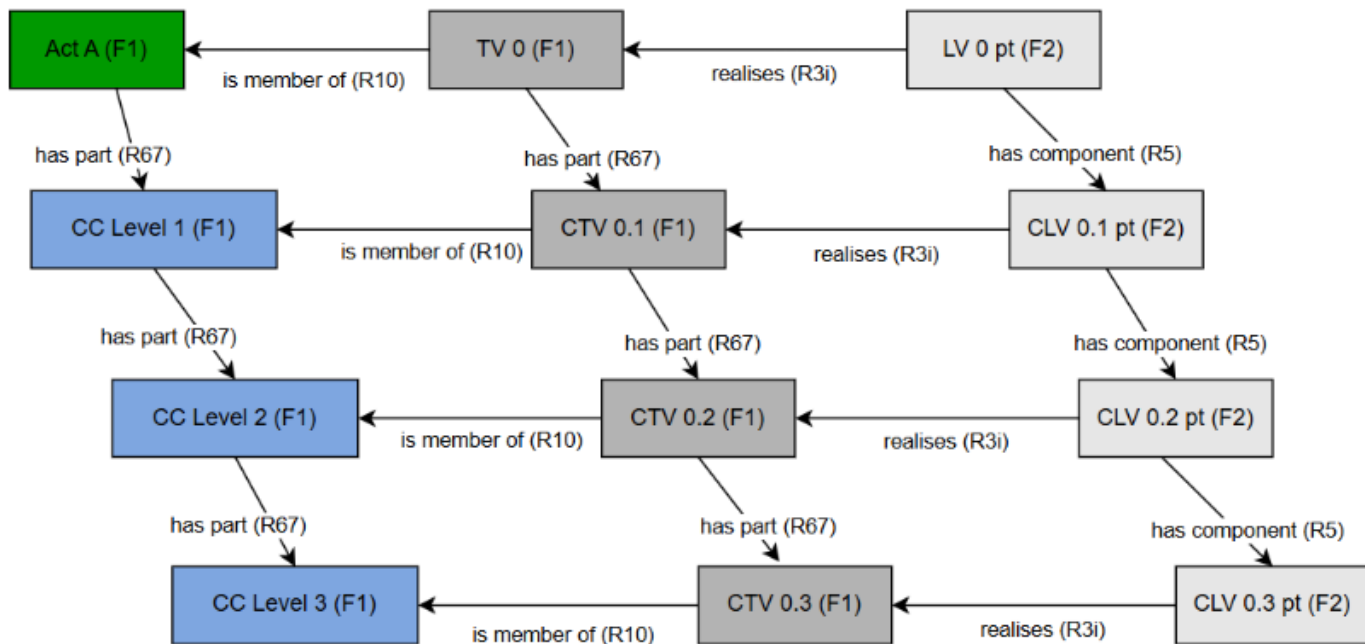
- [urn:lex:br:federal:constituicao:1988-10-05;1988@1988-10-05](#)
- [urn:lex:br:federal:constituicao:1988-10-05;1988@1992-03-31](#)

Language Version: concrete monlingual textual realization of a TV



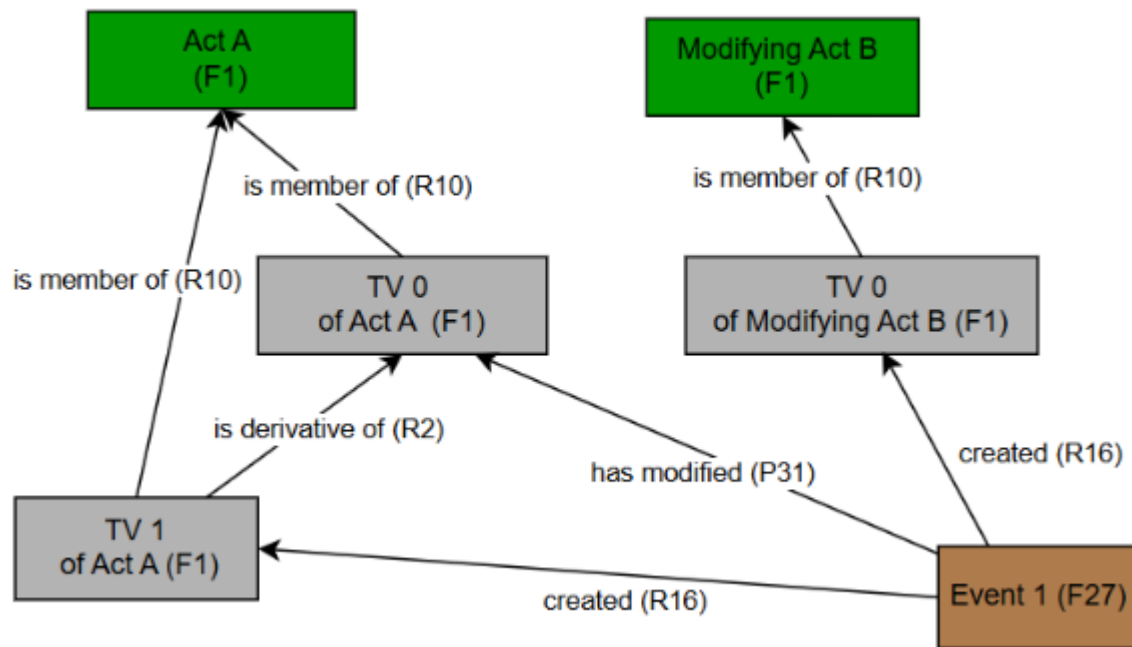
- <urn:lex:br:federal:constituicao:1988-10-05;1988@1988-10-05~texto;fr>
- <urn:lex:br:federal:constituicao:1988-10-05;1988@1988-10-05~texto;en>

Temporal Evolution and Event Granularity of Components

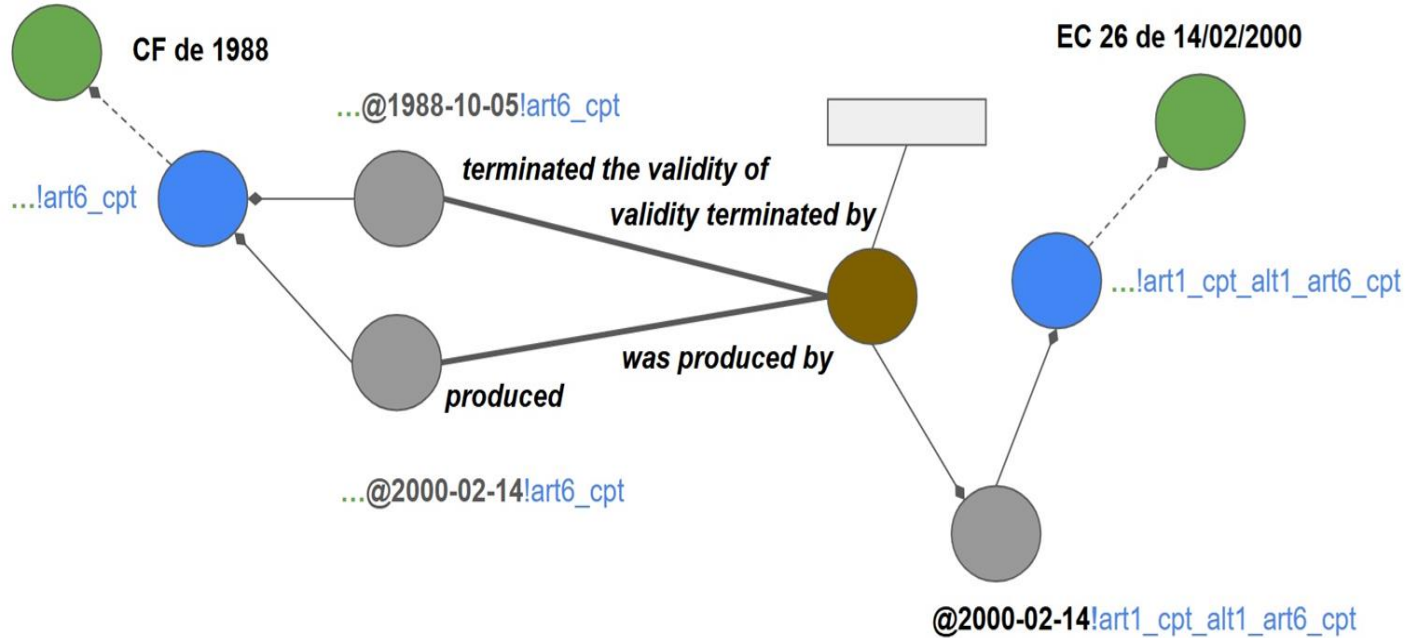


- [urn:lex:br:federal:constituicao:1988-10-05;1988!art5](#)
- [urn:lex:br:federal:constituicao:1988-10-05;1988@1988-10-05!art5](#)
- [urn:lex:br:federal:constituicao:1988-10-05;1988@1988-10-05~texto;pt!art5](#)

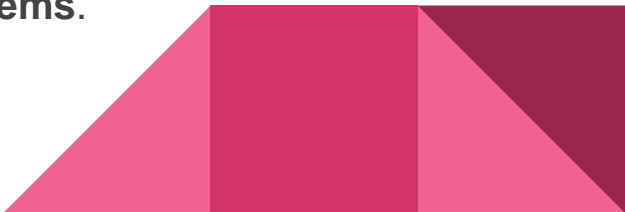
Modification Event



Micro-event

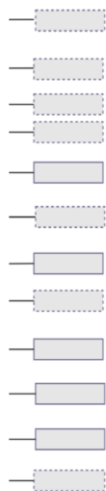


Conclusion

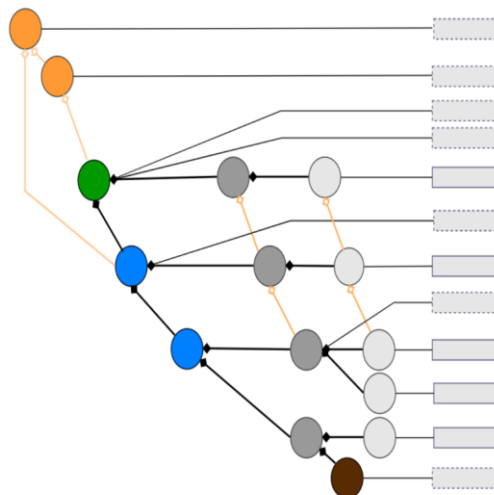
- We introduced an **Ontology** specifically designed for the complexities of **legal norms**.
 - A **Multi-Tier Model**: a clear distinction between a normative **Concept**, **Temporal Version (TV)** and its **Language Versions (LV)**.
 - A **recursive application** to internal components using parallel hierarchies for **Component Concepts** and **Component Temporal Versions**.
 - Modeling of the **micro-events** enables to answer precisely **how, when, and why**
 - A formal structure that provides an **unambiguous, verifiable ground truth**, in direct contrast to probabilistic generative AI.
 - A foundational prerequisite for effective computational law, providing the **deterministic and auditable factual layer** required for **trustworthy legal AI systems**.
- 

From a Scalable Model to Deterministic Agents

Baseline RAG
A Single, Flat Index



SAT Graph RAG
A Scoped, Semantic Navigation



Future (Currently) Work

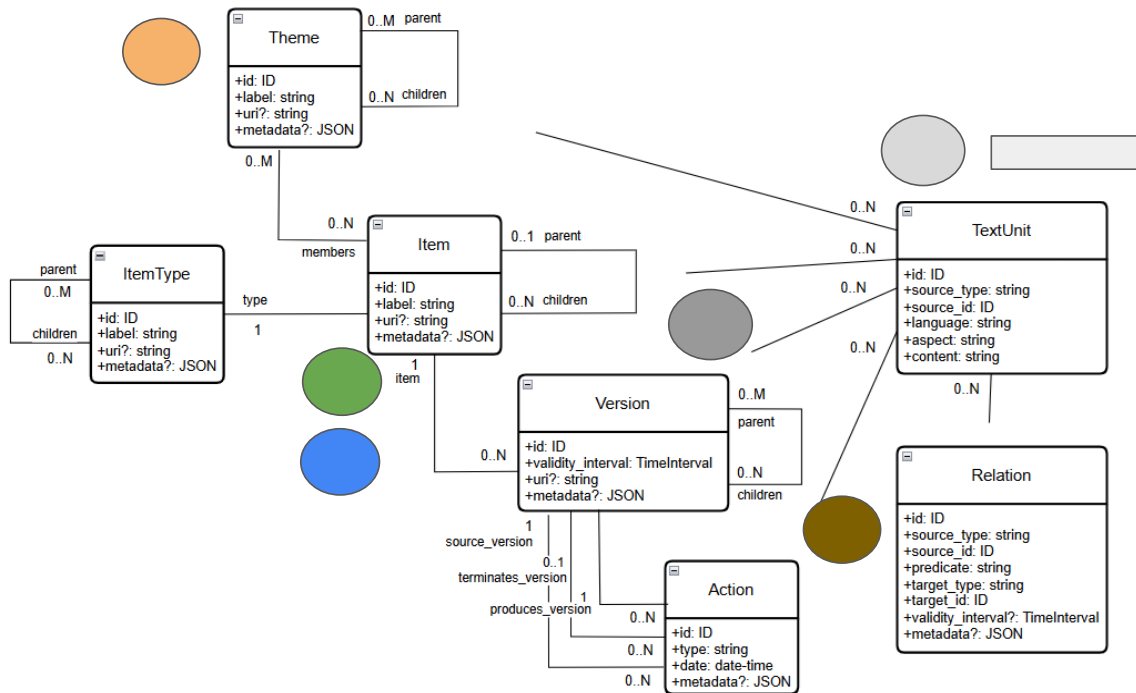
An Ontology-Driven Graph RAG for Legal Norms: A Structural, Temporal, and Deterministic Approach

(<https://arxiv.org/abs/2505.00039>)

(The Federal Senate of Brazil has already modeled over 3,000 federal norms with full Structure, Temporality, and Causality – they can be visualized at <https://normas.leg.br/>)

(On average, 600 new norms are modeled each year: 300 from the current year and 300 from a legacy year)

From a Scalable Model to Deterministic Agents

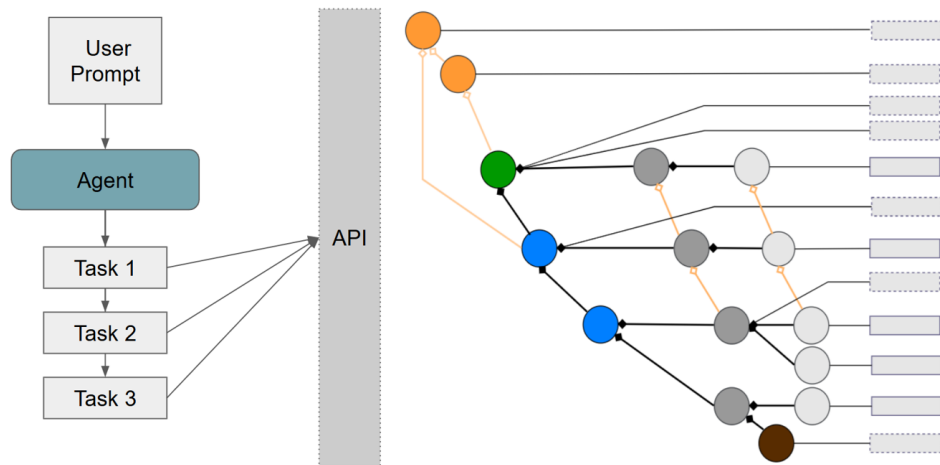


Future (Currently) Work

***Deterministic Legal Agents: A
Canonical Primitive API for Auditable
Reasoning over Temporal Knowledge
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(<https://arxiv.org/abs/2510.06002>)

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Future (Currently) Work

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✅ **The Goal:** A secure, auditable toolkit for building trustworthy legal agents.

Thank You!

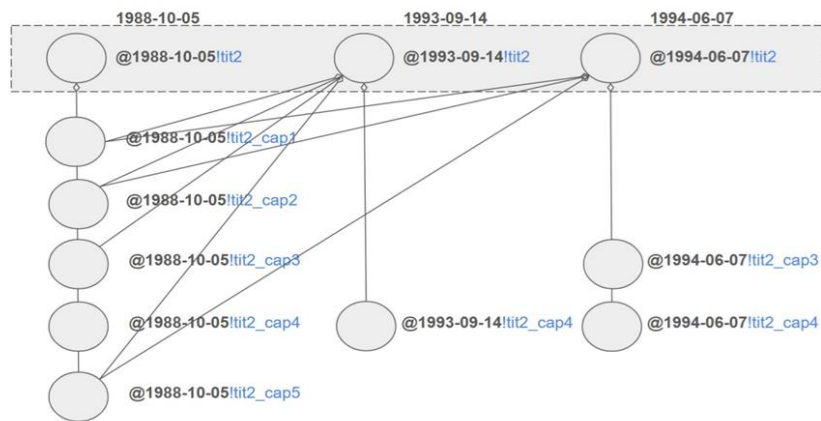
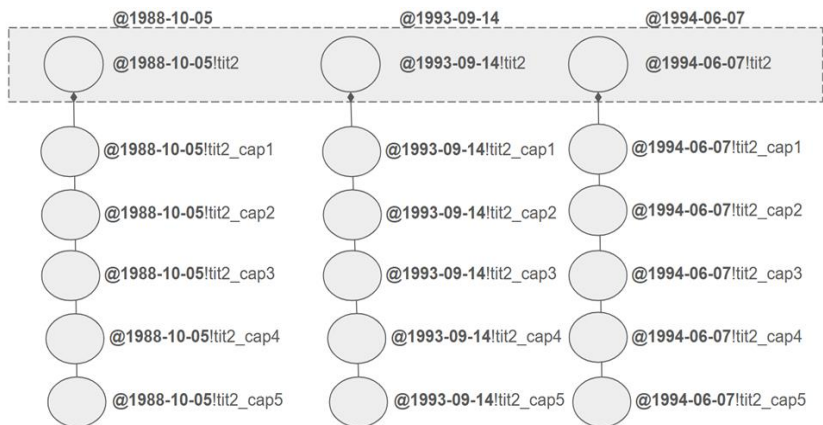
- **Hudson de Martim**
- **Federal Senate of Brazil**
- **Email:** HUDSONM@SENADO.LEG.BR
- **Questions?**



Graph Optimization Techniques

Problem: When one article changes, how do we update its parent chapter without creating massive data redundancy?

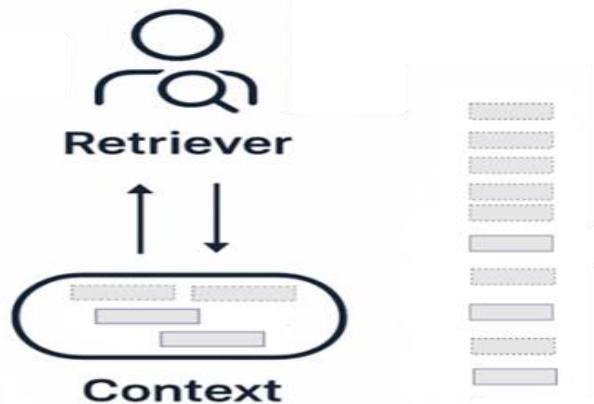
Solution: A new parent version **reuses** the existing, unchanged child versions.



The Payoff: Reconstructing History: Provenance & Causal-Lineage

Prompt: "Trace the legislative lineage that introduced the term 'housing' in Article 6 of Brazilian Constitution"

Standard RAG (Probabilistic Guesswork)

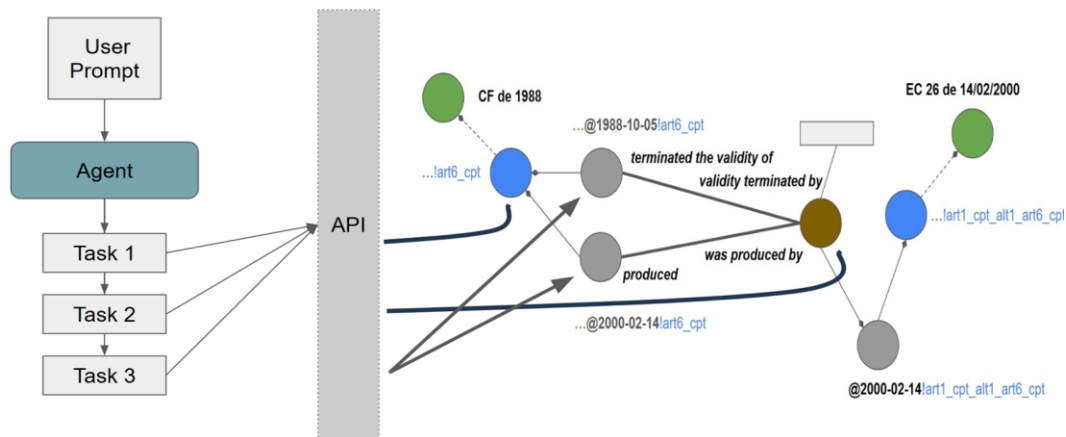


Process: Semantic search for "housing" near "Article 6...", retrieving a list of text chunks.

Result: • "...Amendment No. 26/2000 ...changed the Art 6..."
• "...social rights are ...work, housing, leisure..."

✗ Probabilistic & Relies on Inference

Our Approach (Deterministic Plan)



The Agent's Plan: **1. Resolve:** Find the canonical ID for "Article 6, caput of Brazilian Constitution".

2. Retrieve History: Get the full causal chain of Action nodes for that ID. **3. Pinpoint Event:** Inspect the history to find the specific Action that introduced the term "housing" and compare the versions.

Result: (A clean, structured "Provenance Report")

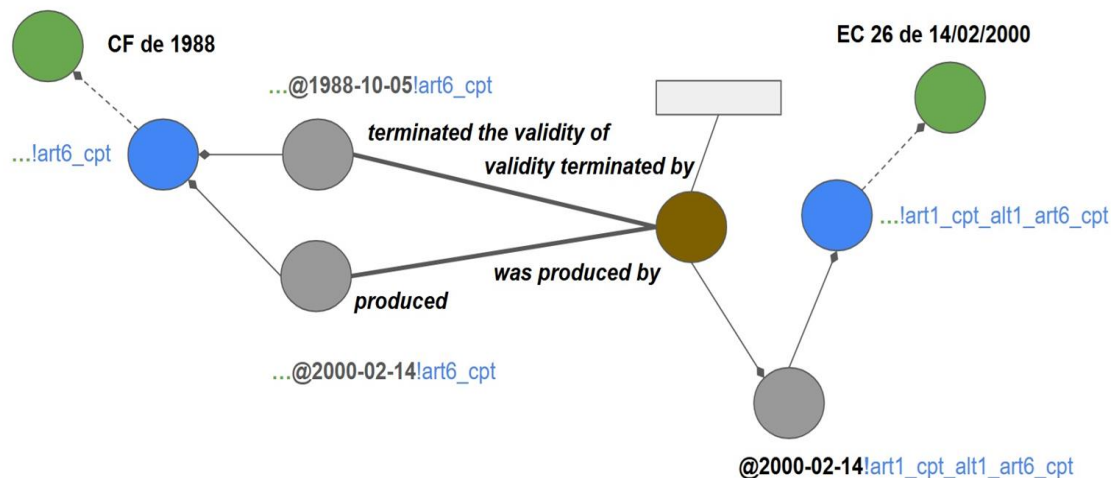
- **Causal Event:** Action from original Art 1, caput of EC No. 26/2000
- **Before:** "...work,, leisure..."
- **After:** "...work, **housing**, leisure..."

✓ Auditable & Factually Correct

The Causal Graph: An Event-Centric Approach

Problem: How do we know *why* a text changed? Which specific amendment caused it?

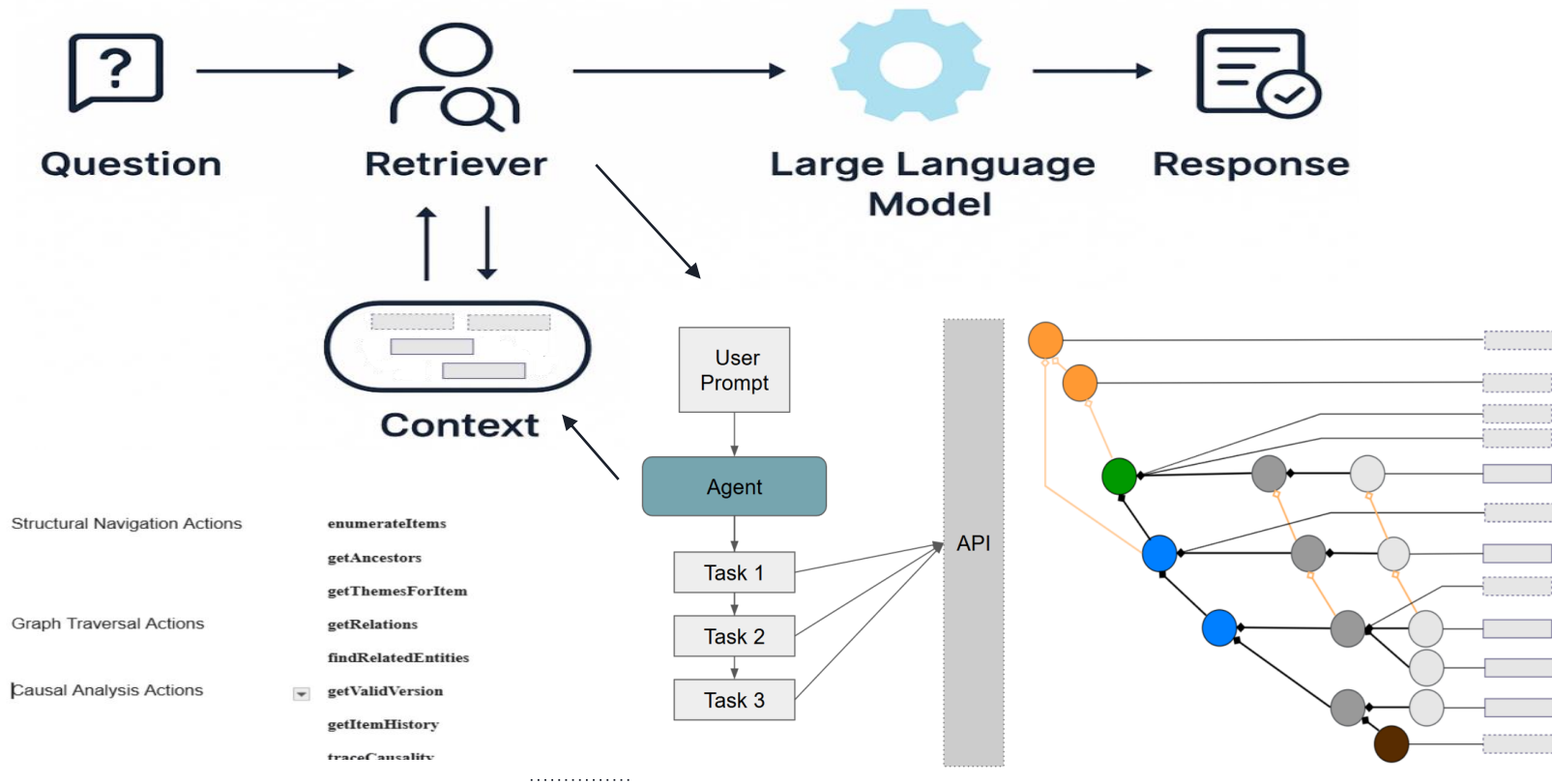
Solution: We model the legislative event itself as a queryable **Action Node**.



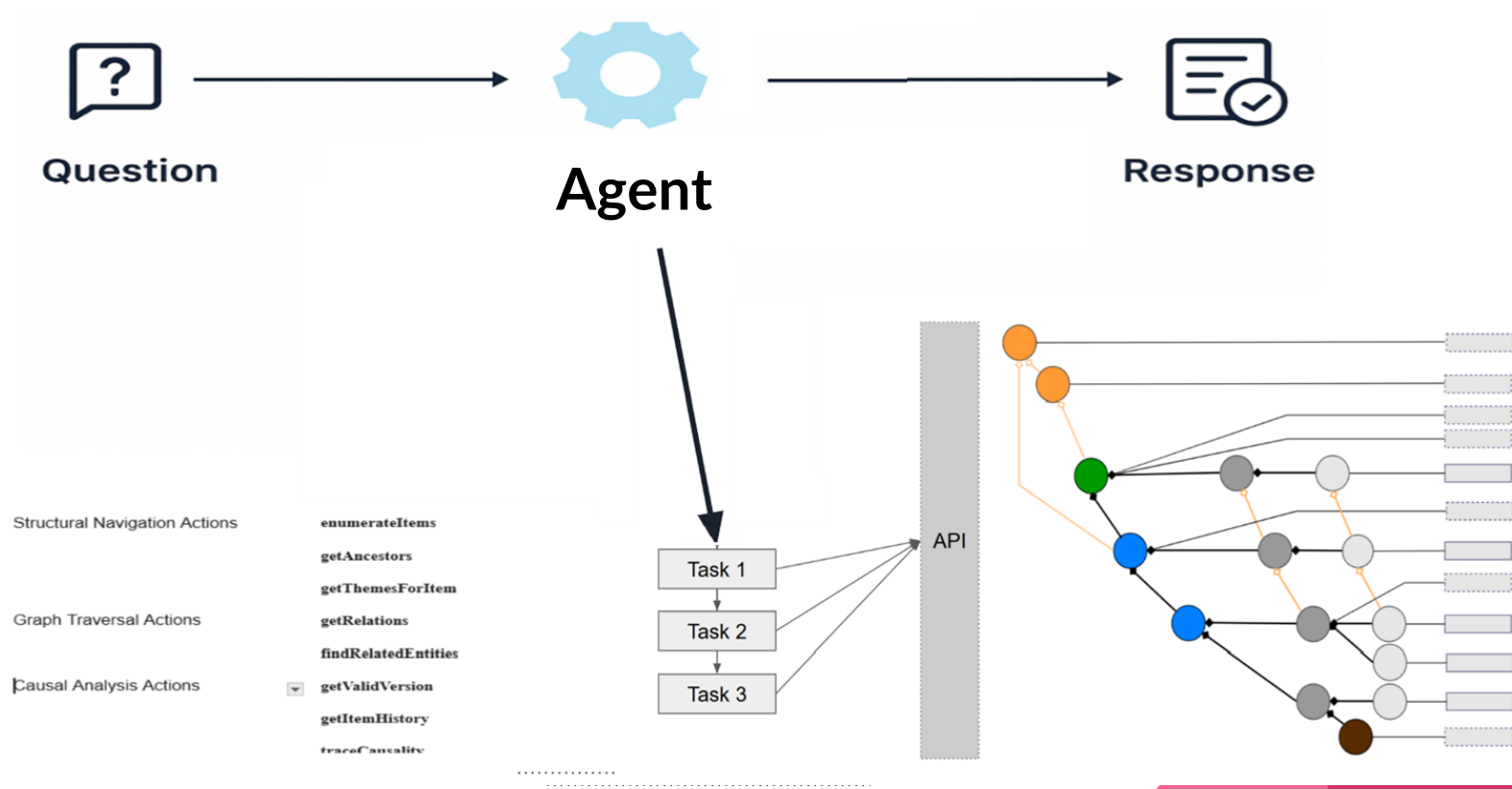
Constitutional Amendment No. 26, of February 14, 2000, through the caput of its Article 1, provided a new wording for the caput of Article 6 of the Federal Constitution of Brazil of 1988. This alteration terminated, on February 14, 2000, the validity of the original wording of this provision (in force since October 5, 1988) and established a new version, effective as of February 15, 2000, whose text became: "The social rights are education, health, work, housing, leisure, security, social security, the protection of maternity and childhood, and assistance to the destitute, as provided by this Constitution."

✓ **Makes Causality Explicit and Searchable**

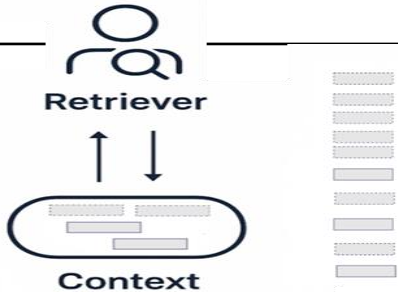
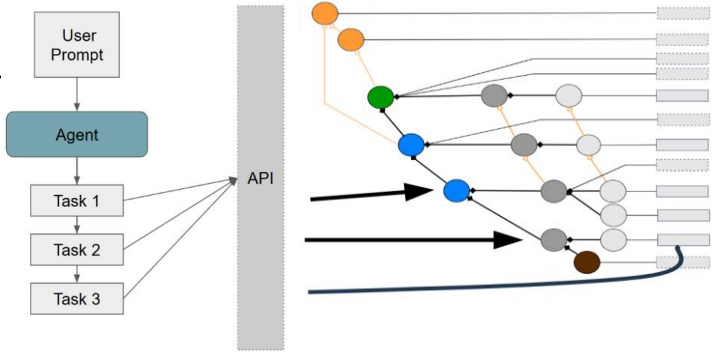
SAT-Graph RAG (Explainable, Auditable Context Retrieval)



SAT-Graph RAG (Agentic Reasoning)



The Payoff, Part 1: Deterministic Point-in-Time Retrieval

Standard RAG (Probabilistic Search)	Our Approach (Deterministic Plan)
<p>Query: "What were the social rights in Article 6 of Brazilian Constitution on May 20th, 1999?"</p>  <p>The diagram shows a 'Retriever' icon (a person with a magnifying glass) interacting with a 'Context' box (a rounded rectangle containing text blocks). Arrows indicate a bidirectional flow between the retriever and the context. To the right, a vertical stack of text blocks represents the document corpus.</p>	<p>Query: "What were the social rights in Article 6 of Brazilian Constitution on May 20th, 1999?"</p>  <p>The diagram illustrates a deterministic workflow. It starts with a 'User Prompt' box leading to an 'Agent' box. The 'Agent' then generates a sequence of tasks: 'Task 1', 'Task 2', and 'Task 3'. These tasks are directed towards an 'API' (represented by a vertical grey bar). To the right, a complex graph shows nodes (colored circles) and edges (arrows) representing the state space of the search, with specific paths highlighted in orange and blue.</p>
<p>Process: Semantic search over <i>all</i> text chunks, retrieving the most similar, which is the current text.</p> <p>Result: "...housing, leisure, security..."</p>	<p>The Agent's Plan: 1. Resolve: Find the canonical ID for "Article 6, caput of Brazilian Constitution" 2. Scope Time: Get the <i>single version</i> valid on "1999-05-20". 3. Fetch: Retrieve the exact text for that version ID.</p> <p>Result: "...leisure, security, social protection..." (No 'housing')</p>
<p>✗ Anachronistic & Factually Incorrect</p>	<p>✓ Auditable & Factually Correct</p>

The Payoff, Part 2: Reconstructing History: Provenance & Causal-Lineage

Standard RAG (Probabilistic Guesswork)	Our Approach (Deterministic Investigation)
Prompt: "Trace the legislative lineage that introduced the term 'food' in Article 6 of Brazilian Constitution"	Prompt: "Trace the legislative lineage that introduced the term 'food' in Article 6 of Brazilian Constitution"
Process: Keyword semantic search for "food" near "Article 6 of Brazilian Constitution", retrieving a jumbled list of text chunks.	The Agent's Plan: 1. Resolve: Find the canonical ID for "Article 6, caput of Brazilian Constitution". 2. Retrieve History: Get the <i>full causal chain</i> of <code>Action</code> nodes for that ID. 3. Pinpoint Event: Inspect the history to find the specific <code>Action</code> that introduced the term "food".
Result: (<i>A box with text snippets</i>) • "...the right to food, housing..." • "...Amendment No. 64 ...changes the..." • "...social rights are ...food..."	Result: (<i>A clean, structured "Provenance Report" box</i>) • Causal Event: Action from CA 64/2010 • Before (v_old): "...work, leisure, security..." • After (v_new): "...work, food , leisure, security..."
✗ Probabilistic & Relies on Inference	✓ Auditable Proof of Causality