Merging Domain and Task Ontology Models Using CGFCA to Combine REA^2 and STREAM

Validating Semantic Integrity for Executable Enterprise Systems

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Problem

Integrating domain and task ontologies while preserving semantic integrity.

Approach

CGFCA integration of REA[2] and STREAM (Conceptual Graphs & Formal Concept Analysis).

Key Findings

- Preserves ontological commitments
- Reveals dependencies and symmetries
- Bridges intuition and explicit knowledge
- Validates potential for ontology weaving

Outline

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Core Challenge

Modern enterprise systems require integrating:

- **Domain ontologies**: What economic phenomena occur? (e.g., REA: Geerts and McCarthy, 2002; Laurier, Horiuchi, and Snoeck, 2021)
- **Task ontologies**: How do transactions evolve? (e.g., STREAM: Laurier and Horiuchi, 2026)
- **Application ontologies**: Combining Domain and Task ontologies for a specific application.

Future Direction

- **Autonomous Agents**: Human and AI collaborative agents governed by contextual norms (Fallon and Polovina, 2016)
- Applying MOVE Framework, including organisational semiotics (Polovina et al., 2026)

Problem

Independent development of REA[2] and STREAM risks semantic incompatibility, loss of ontological commitments, and disconnections between intuition and explicit knowledge (Guarino, 1997; O'Leary, 2004; Geerts, 2011; Kemp and Blood, 2026).

Solution

Apply **CGFCA** to validate Domain and Task ontologies merged into an Application ontology (Andrews and Polovina, 2018; Fallon and Polovina, 2016).

Future work

Future work: Incorporate Human/AI agents with **Stamper's Semiotic Ladder** and the **MOVE Framework** (Stamper, 1973; Polovina et al., 2026).

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Alignment Challenge

REA^2 and STREAM were developed as independent strands of REA, but representing different aspects of the same economic reality.

REA^2: Domain Ontology

- Extends REA with **viewpoint-dependent value flows** (Laurier, Horiuchi, and Snoeck, 2021)
- Enables **AI/human agents** to negotiate business transactions (Mui and McCarthy, 1987)

STREAM: Task Ontology

- Models transaction lifecycles using **synchronized FSMs** (ISO/IEC, 2007)
- Phases: Planning, Negotiation, Actualization, Post-actualization
- Handles **failed negotiations** and **rollbacks**

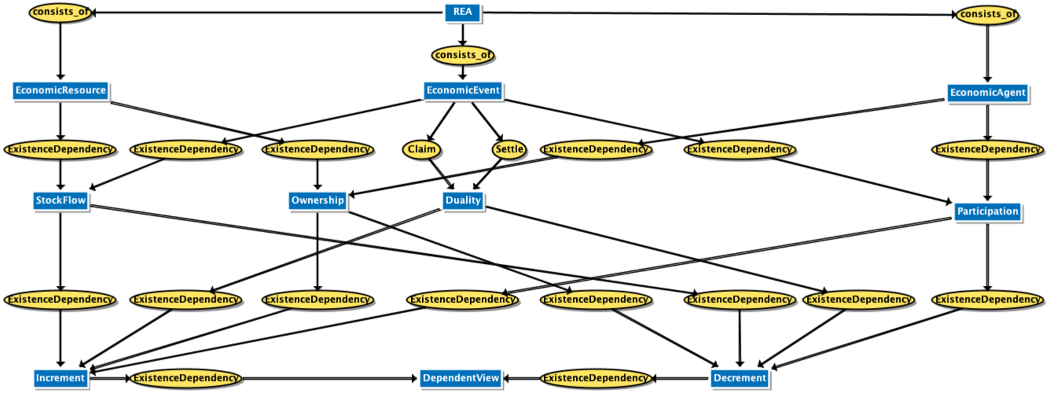

Figure: Conceptual Graph representation for REA^2 domain concepts

FCA Lattice for REA^2

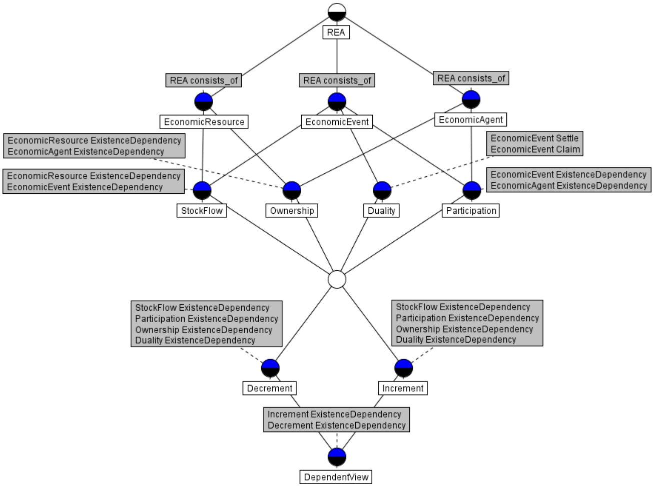

Figure: Formal Concept Analysis (FCA) lattice for REA^2

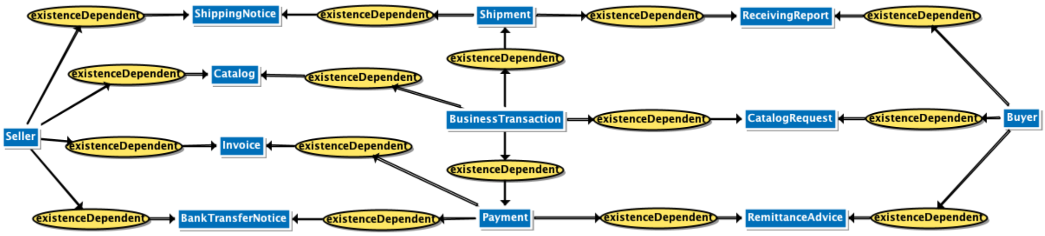

Figure: Conceptual Graph mapping for STREAM task lifecycle

FCA Lattice for STREAM

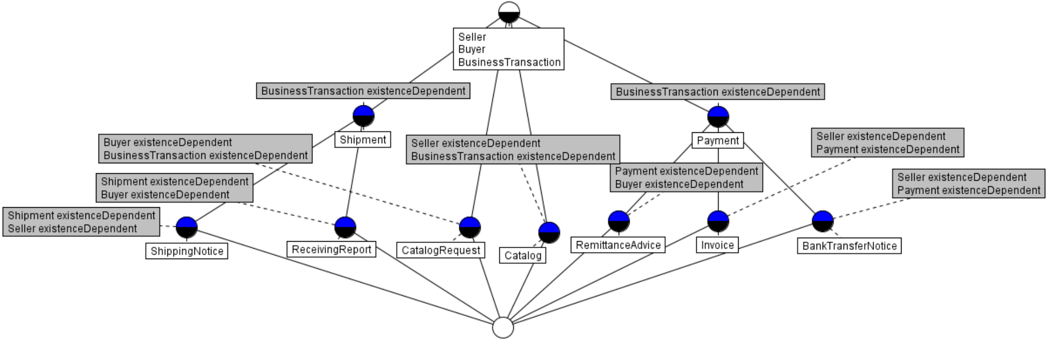

Figure: STREAM FSM phases mapped to FCA lattice

STREAM Analysis Steps

1. Model STREAM static model as **Conceptual Graphs** (Sowa, 2008)
2. Generate **FCA lattice** incorporating transaction milestones (Ganter and Wille, 1999; Andrews and Polovina, 2018)

Key Findings

- **Alignment with ISO/IEC 15944-4**: Planning, Identification, Negotiation, Actualization, and Post-actualization phases
- Coherent structures for BusinessTransaction, Buyer, Seller, Shipment, Payment
- Explicitly defines logical enterprise boundary to eliminate structural redundancies

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Mapping Strategy

REA^2 Concept	STREAM Concept	Alignment Mechanism
EconomicEvent	Shipment	Shipment is an event
EconomicEvent	Payment	Payment is an event
EconomicAgent (incl. AI)	Seller	Roles co-referenced
EconomicAgent (incl. AI)	Buyer	Roles co-referenced

Merged Model Highlights

- Preserves structures while enabling **AI agent integration** (Fallon and Polovina, 2016)
- Reveals key symmetries for robust enterprise modelling (Laurier et al., 2021)
- Merged FCA lattice bridges expert intuition with explicit knowledge (Kemp and Blood, 2026)

Merged FCA Lattice for REA^2 + STREAM

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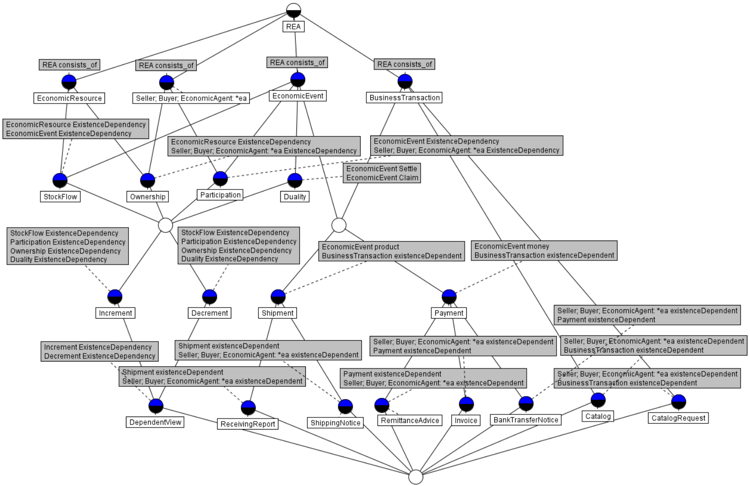

Figure: Merged FCA lattice for REA^2 + STREAM combining domain and task ontologies

Key Symmetries

- **Viewpoint Symmetry**: Partner perspectives (Laurier, Horiuchi, and Snoeck, 2021)
- **Exchange Symmetry**: Balanced flow networks

FCA as a Diagnostic Tool

- Exposes modelling flaws and role distinctions
- Validates syntactic consistency for AI semantics

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Aim

Organisational Semiotics with **AI Agents**, grounded in merged **REA^2-MERODE**.

Organisational Semiotics & Autonomous AI

- REA^2 bridges with **Stamper's Semiotic Ladder** embedding norms into interactions (Stamper, 1991; Kemp and Blood, 2026).
- Supports the **Autonomous Enterprise** via human-AI collaboration (Fallon and Polovina, 2016).

Organizational Semiotics:

- Socio-technical systems
- Norms, affordances, and intent

REA^2-MERODE Integration:

- Object-oriented business semantics
- Economic exchange networks

Operationalising norms via REA^2-MERODE structures to drive autonomous enterprise AI.

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Current Message

Merging REA² and STREAM via CGFCA creates a semantically rigorous application ontology.

Key Contributions

1. **Validation of semantic integrity**: CGFCA confirms logical coherence (Andrews and Polovina, 2018)
2. **Discovery of symmetries**: Viewpoint and exchange symmetries (Laurier, Horiuchi, and Snoeck, 2021)
3. **Consideration of Organisational Semiotics**: MOVE Framework (Polovina et al., 2026)

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Current Limitations

- **Operational validation**: Required for complex AI scenarios
- **Scalability**: Evaluating CGFCA performance across larger ontology networks

Future Application & Impact

- **Executable systems**: MERODE and AI integration will enable automated architectures (Fallon and Polovina, 2016; Snoeck and Sedrakyan, 2013).
- **Semiotic depth**: Grounded with Organisational Semiotics via MOVE Framework (Stamper, 1973; Polovina et al., 2026).

Future Research Directions

- Scale CGFCA and provide operational validation
- Map models to foundational upper ontologies (e.g., UFO) (Guarino, 1997)
- Operationalise MOVE Framework for the autonomous enterprise (Polovina et al., 2026)

Room Discussions & Questions

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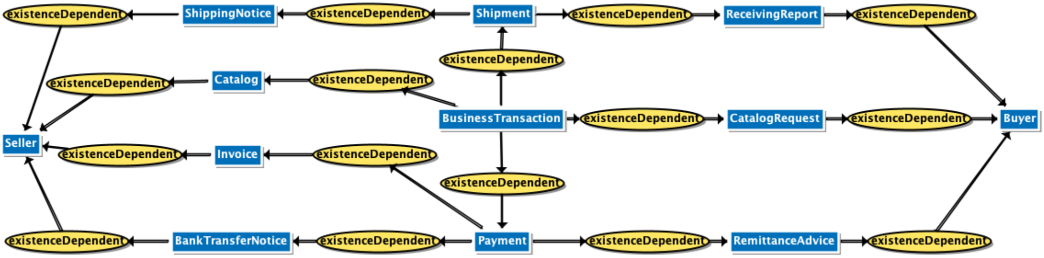

Figure: CG for directe STREAM model

FCA Lattice for directed STREAM

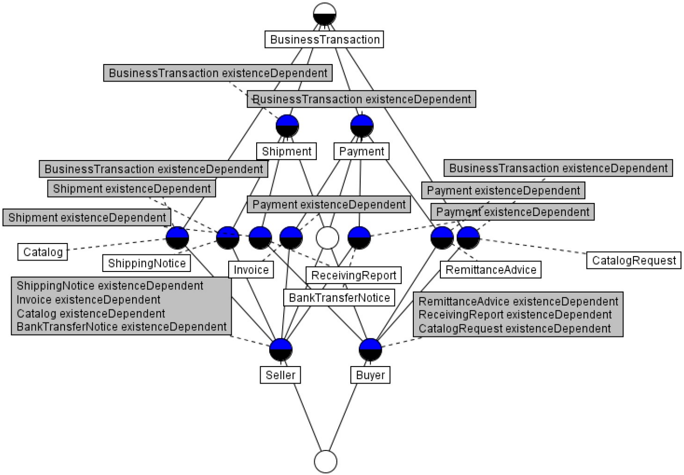

Figure: Lattice for directe STREAM model

Discussion points

- What constitutes genuine integration between a domain ontology and a task/process ontology?
- Is integration of their static structures sufficient, or must events, states, transitions, and behavioural constraints also be integrated?
- How should dynamic business-process elements be represented within the integrated ontology?
- What additional elements are required before the integrated structure can become executable?
- Which aspects of semantic compatibility can CGFCA validate, and which still require expert ontological analysis?
- Can symmetry, layering, and anonymous-concept proliferation become defensible evaluation criteria for ontology integration?
- How could the integrated REA–STREAM architecture eventually support executable enterprise systems involving human and AI agents?

Thank you!

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