

Semantic Web Rules for Financial Risk Management

Benjamin Grosf*

October 21, 2010

Presentation at
Semantic Web Meetup of Washington, DC
held-at/joint-with RuleML-2010**



Sr. Research Program Manager, Vulcan Inc.; and
Principal Consultant, Benjamin Grosf & Associates, LLC
<http://www.mit.edu/~bgrosf/>

** <http://2010.ruleml.org>

Outline

- **Intro: crisis, problem, new OFR, NSF workshop**
- **How SW, incl. rules, can help overall**
- **Rules: more details on 3 immediate areas**
- **Conclusions and directions**

Creation of: Office of Financial Research in USA

- **Financial Crisis 2008-2009, and Recession continuing**
 - Cost \$Trillions to USA and to non-USA global economies
 - Lost economic output as well as loan/investment losses
 - “An ounce of prevention ...” clearly called for
- **Mandate: Smarter regulation of system risk in financial activities**
- **Office of Financial Research created by big USA financial reform law**
 - Still getting set up, early days yet. (Law passed July 2010.)
 - Within Treasury Dept.
 - With new supervision powers esp. to obtain data
 - Based largely on proposals by the ad-hoc Committee to Establish a National Institute of Finance <http://www.ce-nif.org>
 - Possibly a large annual budget: ? \$100M's \$ within a few years

NSF Workshop on Financial KR in July 2010

- **Title: Knowledge Representation (KR) and Information Integration for Financial Services**
 - Held near Washington, DC, July 21-22, 2010
 - <http://www.ce-nif.org>
 - Discussed research directions
 - Organized by NSF's IT, rather than Social Sciences, side
 - Very strong set of 50+ participants
 - Computer science academe
 - Finance/economics academe
 - Financial industry
 - IT industry
 - Government, esp. regulators

**The rest of this presentation is a
outbrief of the NSF Workshop,
with elaboration**

...

Fundamental Problem addressed in NSF Workshop

- **Huge info integration task**
 - Giant amounts of data flowing
 - Complexity of info “supply chain”
- **Need timely incisive analysis and reactions**
- **Need to model decision making and interactions, dynamically, of the players**

- **System-level dynamic process modeling**
 - Simulation, what-if'ing. Modularity.
 - (Longer-term research needed)

Examples of Complexity

- **~1000 attributes of an ordinary home mortgage**
- **200-page contract (in English) for credit default swap**
 - **Alias financial “weapon of massive destruction” ;-)**

Outline

- **Intro: crisis, problem, new OFR, NSF workshop**
- **How SW, incl. rules, can help overall**
- **Rules: more details on 3 immediate areas**
- **Conclusions and directions**

Some Overall Conclusions of NSF Workshop

- **Status: official workshop report is forthcoming**
 - Ff. is *my understanding* based on drafts & discussion
 - I'm a co-author 😊
- **Huge need and opportunity for semantic web/technology**
 - Tasks: Info integration. Modeling & analysis. Reactive monitoring.
 - Existing sem tech useful. Future sem tech needed.
 - E.g., semantic rules
- **Immediate need for financial and IT R&D communities to come together**
 - Shape technical agenda of OFR (and similar-missioned org.'s)
 - Complement OFR, provide expertise for it to draw upon

What Semantic Web can most offer overall

Sophistication in knowledge representation (KR)

Overall: expressiveness; interoperability; performance optimization

- Data and basic-ontology representation

RDF and OWL better for wide sharing than plain XML

- Semantic rules, e.g., RIF and OWL-RL
 - Better for wide sharing than previous kinds of business rules
 - Many uses specific to business reporting and financial info integration
 - Can handle exceptions, change/updates, reformulations gracefully

SW Rules: Immediate Application Areas & Req.'s

1. Representing financial contracts, esp. instruments
2. Ontological mapping for info integration
3. Representing trust/confidentiality policies

⇒ **Defeasibility and higher-order are required/desired as expressive features**

- Partially supported in SW rules available commercially
- Emerging sem tech: RIF-SILK has strong support
 - (RIF = W3C Rule Interchange format)

Outline

- **Intro: crisis, problem, new OFR, NSF workshop**
- **How SW, incl. rules, can help overall**
- **Rules: more details on 3 immediate areas**
- **Conclusions and directions**

Representing financial contracts, esp. instruments

- **These are the heart of financial transactions and the financial system**
 - Crucial: represent what is supposed to happen in various contingencies, e.g., when players are under stress and cannot pay/fulfill on time
 - Within context of pertinent regulations/laws and business/govt. policies & processes
 - Need effective automated KR. Lack of that greatly contributed to the crisis.
 - Complex fixed-income derivatives
- **Markets are organized around standardized parametrized contracts**
 - Usually 1 or a few such contract templates per type of market
 - Much common structure. Complex contracts composed from more elementary ones.
 - E.g., very roughly a few hundred elementary contract templates would probably suffice for all major publicly traded markets (if done “right”)
- **Critical requirement: represent exceptions and overrides**
 - In the contracts and pertinent regulations, laws, policies, processes
 - In the causal aspects of the pertinent processes

Ex.: Simple Collateralized Loan, e.g., Mortgage

- If it's date X , then lender must pay borrower the principal and gets lien on the collateral asset of the borrower
- If it's date $X+k*M$, then borrower must pay interest and principal slice for latest period of length M

Exception/override case rule:

- If borrower does not pay on time, then lender has 2 options:
 1. Impose additional penalty payments on a particular schedule
 2. Foreclose the loan: seize the collateral (which is a whole process)

Nested exception/override case rule:

- If borrower is in bankruptcy, then in foreclosure the lender claims, rather than seizes

Examples of Ontological Mapping for Info Integration

- **Your vs. my ontology, generally**
 - Reformulate \Rightarrow higher-order as expressive feature is very useful
 - Context usually partly implicit \rightarrow must often make explicit to map
 - E.g., use a typical definition of revenue.
- **Financial reporting**
 - Profit with vs. without depreciation
 - Earnings last 4 qtrs vs. {last 3 qtrs + forecast next qtr}
 - Historicals when statutory treatment (definition) changes over time
 - Footnotes – “where the real action is”: revenue includes sale of HQ building
 - \Rightarrow Defeasibility as expressive feature is very useful, for exceptions/overrides
- **Your vs. my pro-forma or analytic view**
 - Between companies, governmental jurisdictions

Example: Exception in Ontology Translation (in SILK)

/* Company BB reports operating earnings using R&D operating cost which includes price of a small company acquired for its intellectual property. Organization GG wants to view operating cost more conventionally which excludes that acquisition amount. We use rules to specify the contextual ontological mapping. */

@normallyBringOver ?categ(GG)(?item) :- ?categ(BB)(?item);

@acquisitionsAreNotOperating neg ?categ(GG)(?item) :-

acquisition(GG)(?item) and (?categ(GG) ## operating(GG));

overrides(acquisitionsAreNotOperating, normallyBringOver); /* exceptional */

acquisition(GG)(?item) :- price_of_acquired_R_and_D_companies(BB)(?item);

R_and_D_salaries(BB)(p1001); p1001[amount -> \$25,000,000];

R_and_D_overhead(BB)(p1002); p1002[amount -> \$15,000,000];

price_of_acquired_R_and_D_companies(BB)(p1003); p1003[amount -> \$30,000,000];

R_and_D_operating_cost(BB)(p1003); /* BB counts the acquisition price item in this category */

R_and_D_operating_cost(GG) ## operating(GG);

Total(R_and_D_operating_cost)(BB)[amount -> \$70,000,000]; /* rolled up by BB cf. BB's definitions */

Total(R_and_D_operating_cost)(GG)[amount -> ?x] :- ... ; /* roll up the items for GG cf. GG's definitions */

As desired: |= R_and_D_salaries(GG)(p1001); ...

neg R_and_D_operating_cost(GG)(p1003); /* GG doesn't count it */

Total(R_and_D_operating_cost)(GG)[amount -> \$40,000,000];

Notation: @... declares a rule tag ? prefixes a variable. :- means if. X ## Y means X is a subclass of Y. overrides(X,Y) means X is higher priority than Y.

Representing Trust/Confidentiality Policies

- Access to info by and from various players
- Authorization of transactions and other actions
- Well represented by rules
- Many exceptions/overrides \Rightarrow need defeasibility.
- **Example:**
 - Regulator not permitted to see trading info of type X from a broker-dealer
 - But: Regulator is permitted to access it “on-site” at the broker if a (declared) Investigation of type Y is in progress.

Summary

- **Intro: crisis, problem, new OFR, NSF workshop**
- **How SW, incl. rules, can help overall**
 - KR sophistication
- **Rules: more details on 3 immediate areas**
 - Representing financial contracts, esp. instruments
 - And pertinent regulations, laws, policies, processes
 - Ontology mapping for info integration
 - Representing trust/confidentiality policies
 - *Require defeasibility and higher-order* \Rightarrow *RIF-SILK*
- **Conclusions and directions**

Overall Challenges -- i.e., Directions

- **Social and technical:**

- Bring together communities, expertise, and technology

- Finance and IT; industry, government and academe

- Great place where SW Meetups could be involved! ← ← ← ← ← ← ← ← ←

- Develop practical focus

- Standards and ontologies: integrate and develop

- **Purely technical:**

- Scale. Lots and lots and lots of data.

- Combining quantitative + logical methods: math, stat, equations

- Current SW standards and tech weak on this



A Historic Opportunity!

Thank You

Disclaimer: The preceding slides represent the views of the author only.
All brands, logos and products are trademarks or registered trademarks of their respective companies.

OPTIONAL SLIDES FOLLOW

Declarative Logic Programs (LP) is the Core KR in today's world ... including the Semantic Web

- **LP is the core KR of structured knowledge management today**
 - **Databases**
 - Relational, semi-structured, RDF, XML, object-oriented
 - SQL, SPARQL, XQuery
 - Each fact, query, and view is essentially a rule
 - **Semantic Rules**
 - Rule Interchange Format (RIF): -BLD, -Core
 - RuleML standards design, including SWRL
 - **Semantic Ontologies**
 - RDF(S)
 - OWL-RL (= the Rules subset). E.g., Oracle's implementation of OWL.
- **The Semantic Web today is mainly based on LP KR**
 - ... and thus essentially equivalent to semantic rules
 - **You might not have realized that!**



Semantic Web Rules: Standards Roadmap

- **Rules + Facts = Structured Knowledge**

- Phase I: Basic database schemas (RDF, OWL-DL). Filled industry vacuum.
- Phase II: Database queries and simple rules (SPARQL, OWL-RL, RIF)

- **Direction: Raise Knowledge Representation (KR) abstraction level underlying structured data/knowledge management**

- Unchanged since relational databases and business rule systems invented in 1980s

- **Next: RIF-SILK – Rules that extend RIF-BLD and SPARQL**

- <http://silk.semwebcentral.org>
- Defeasible: permit exceptions, handle conflicts. Cope with knowledge quality and context.
- Higher-order: knowledge about knowledge. Ontology mapping, provenance, KR macros.
- Reactive too: take actions, based on event flows. Activate knowledge.
- Applications: policies/regulations, agile workflows, info integration, trust, causality

- **Longer-Term: Deep Probabilistic and Statistical KR**

- Shareable data mining and inductive learning. Natural language processing.

Advantages of Standardized SW Rules

- Easier Integration: with rest of business policies and applications, business partners, mergers & acquisitions
- Familiarity, training
- Easier to understand and modify by humans
- Quality and Transparency of implementation in enforcement
 - Provable guarantees of behavior of implementation
 - Improved compliance and governance
- Reduced Vendor Lock-in
- Expressive power
 - Principled handling of conflict, negation, priorities

NEXT SLIDES ARE FROM MY NSF WORKSHOP IDEAS DECK

Use Semantic Web and other KR Technology

- **Represent and Integrate**

- Financial data
- Instrument descriptions
- Regulations and laws
- Business/government policies
- Economic statistics
- Other relevant aspects of business/government processes

- **New building blocks beyond conventional data mgmt.**

- Semantic Web: rules, query; naming, vocabulary, ontologies, schemas
 - Recent progress esp. in rules, ontologies, querying
 - Higher-order defaults. Monitoring event flows. Parallelization. Tools. Standards.
- Probabilistic and Strategic AI
 - Machine learning, data mining, statistics
 - Game theory, “mechanism design”, utilities, decision theory

E-contracts and E-law

- *Background*
 - *Advanced semantic rules well represent most logical aspects of contracts and regulations*
 - *Technically: Involves conflict handling and exceptions (prioritized defaults)*
 - *Technically: Involves meta-knowledge, e.g., about provenance (higher-order)*
- **Represent logical content of contracts and legal provisions, in:**
 - Financial instruments and transactions
 - Regulations and other laws
 - Finer-grain representation of investment strategies, instruments, and vehicles
- **Derivatives and structured finance**
- **Analyze and aggregate**

Open-Source Model of Financial System (“Finux”)

- **Collaboratively developed**
- **Simulation and what-if analysis**
- **Agent-based cognition to transcend “math-based” blindnesses**
 - Business/government processes and contracts/laws
 - Gaming strategy and herd behavior
 - Stochastics and lags
 - Use machine learning to estimate parameters, lags
- **Combine “in the small” with “in the large” risk management**

New Govt. Funding Org. for Financial KR/IT R&D

- **Potential org. models: more NIH and DARPA than NSF**
 - Relationship to Office of Financial Research?
- **Finance is primarily a cyber-industry**
- **In the arms race, the public and the regulators are technologically way behind**
- **Budget scale that's justifiable**
 - **~~ \$25M in yr 1 could have considerable impact initially**
 - Accelerate development of uncontroversial information models
 - Analyze KR requirements and attack soft spots; proof of concepts
 - Grow fast, e.g. **~~ \$50M yr 2, \$100M yr 3, \$150M yr 4, ...**
 - Long-term: grow to, e.g., **~~ 1 basis point on US financial assets**
 - thus **~~ \$1B/yr. Cheap insurance against another \$multi-trillion hit.**

KR Challenges Needing Applied Research

- **Combine numerical reasoning, more closely**
 - Equalities and equations; Inequalities, “constraints”; Integrals
 - Money, utility; Time (and dates)
 - Probabilities, statistics
- **KR context mappings (reformulations)**
- **Representing contracts, regulations, policies, legal aspects**
- **Bring spreadsheets into the semantic KR world**
- **Combine probabilistic reasoning, more closely**
- **Combine processes descriptions**
- **Map English to and from KR, for knowledge entry and explanation**

Smaller Ideas

Converge XBRL etc. with main Semantic Web KR

- “Etc.” here means roughly-similar-flavor financial/economic data
- **Converge XBRL with main Semantic Web**
 - Focus on Rules, leverage recent web rule standards
 - W3C RIF, W3C OWL RL, OMG SBVR
- **Develop (more) financial vocabulary and rules**
- *Background on XBRL (“eXtensible Business Reporting Language”)*
 - *Standardized web format for financial reporting data – “the main game in town”*
 - *Usage already required by SEC and many other countries’ regulatory/tax agencies*
 - *Primarily for public companies. Used also internally for compliance and CFO function.*
 - *Data is in XML. Includes vocabulary and rules of accounting definitions.*
 - *Grew up in parallel with Semantic Web standards and technology*
 - *Developed by accountants more than computer scientists*

Public debate wiki about financial public policies

- **Prime topic: Regulatory reform**
- **Tool opportunities:**
- **Semantic wiki software as infrastructure**
 - e.g., Semantic MediaWiki+ with plugins for office productivity, semantic web
- **Argumentation systems**
 - e.g., cf. MIT Ctr. for Collective Intelligence, plus default rule systems

Other Ideas

- **Track closed/merged/acquired co.'s/funds**
- **Apply game-theoretic dynamics and incentives**
 - Analyze market decomposition. Automated mechanism design.
- **Analyze co./fund control, pay practices not just ownership**
- **Expose "invisible" leverage**
 - Systemic, as well as per-deal
 - undercapitalized insurers (AIG), single-movers (sovereign dollars)
- **Expose opacity**
- **Expose securitization-based liquidity amplifications, flows**
- **Company "living wills"**

**END OF
OPTIONAL SLIDES**

Thank You

Disclaimer: The preceding slides represent the views of the author only.
All brands, logos and products are trademarks or registered trademarks of their respective companies.