Semantic Web Rules for Financial Risk Management

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** http://2010.ruleml.org

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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” ;(-)
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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
  • 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

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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
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)
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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 → **higher-order** as expressive feature is very useful
  • Context usually partly implicit → 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
    • ⇒ **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  \[\Rightarrow \text{RIF-SILK}\]

• 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
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](http://silk.semwebcentral.org)
  • Defeasible: permit exceptions, handle conflicts. Cope with knowledge quality and context.
  • 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
  - 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
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

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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

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