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# Towards Re-defining Relation Understanding in Financial Domain

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- Challenge Task Definition
- Our Approach
- Semantic Complexities in Challenge Task Definition
- Relation Validation based Task Definition
- Conclusion and Discussion

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## – Tuple

(Context, Filing Entity, Mentioned Entity, Role)

Example	Context	Filing Entity	Mentioned Entity	Role	Label
E1	<i>For example, because Ally controls Ally Bank, Ally is an affiliate of Ally Bank for purposes of the Affiliate Transaction Restrictions.</i>	Ally Financial Inc	Ally Bank	affiliate	Relevant
E2	<i>Item 5. Market for Registrant's Common Equity, Related Stockholder Matters and Issuer Purchases of Equity Securities. M&amp;T's common stock is traded under the symbol MTB on the New York Stock Exchange.</i>	M&T BANK CORP	Equity Securities	Issuer	Irrelevant

- **Tuple** (Context, Filing Entity, Mentioned Entity, Role)
- **Relationship Triple** (Filing Entity, Mentioned Entity, Role)

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- **Relationship Triple Ranking:** Rank the relationship triples such that the triples with the context that best supports that role assignment and contains (financially) relevant knowledge are at the top of the ranking.

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- **Relationship Triple Ranking:** Rank the relationship triples such that the triples with the context that best supports that role assignment and contains (financially) relevant knowledge are at the top of the ranking.
- Labeling Scheme
  - Highly Relevant, Relevant, Neutral, Irrelevant

- Complex financial relationships
  - Context describes **multiple relationships** through an entity chain
  - **Triple validated by inferring** across the entity chain

*Multiple relationships with five entities and two roles*

*U.S. Bank, in its role as trustee of CHL Mortgage Loan Trust 2006-4SL, filed a lawsuit against Bank of America and affiliates, including Countrywide and Merrill Lynch*

- Labeling guideline challenges
  - **Definition of financial entity**, e.g., “USA”
  - **Ambiguous entity mentions**, e.g. does “PNC” refer to “PNC Financial Services Group Inc.” or “PNC Bank”
- Ambiguities in labeled data
  - The two experts who labeled the training data **did not agree on labels in 15%** of the case

# Domain Features!



- Ranking models
  - Millions of training samples vs. 900+ samples
  - The label scheme naturally provides category information
- Classification models
  - No model is perfect across domains
  - Different kinds of model have different properties/advantages

Ensemble Classification Model!

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## **Domain Features + Ensemble Classification Model**

Feature types	
Generic features	Token unigrams and bigrams
Domain features	<p><b>Financial Vocabulary Features:</b> Identify candidate entity mentions and candidate role mentions in the text</p> <ul style="list-style-type: none"> <li>Semantic roles of the entities</li> </ul>
	<p><b>Financial Relationship Pattern Features:</b> Represent proximity based patterns across the candidate entities and roles</p> <ul style="list-style-type: none"> <li>Parts of speech for the tokens in the gaps</li> <li>Whether entities and roles match elements of the triple</li> </ul>

Features are extracted using IBM Research SystemT

**Candidate Entities**

- PNC
- Market Street Funding LLC

**Candidate Roles**

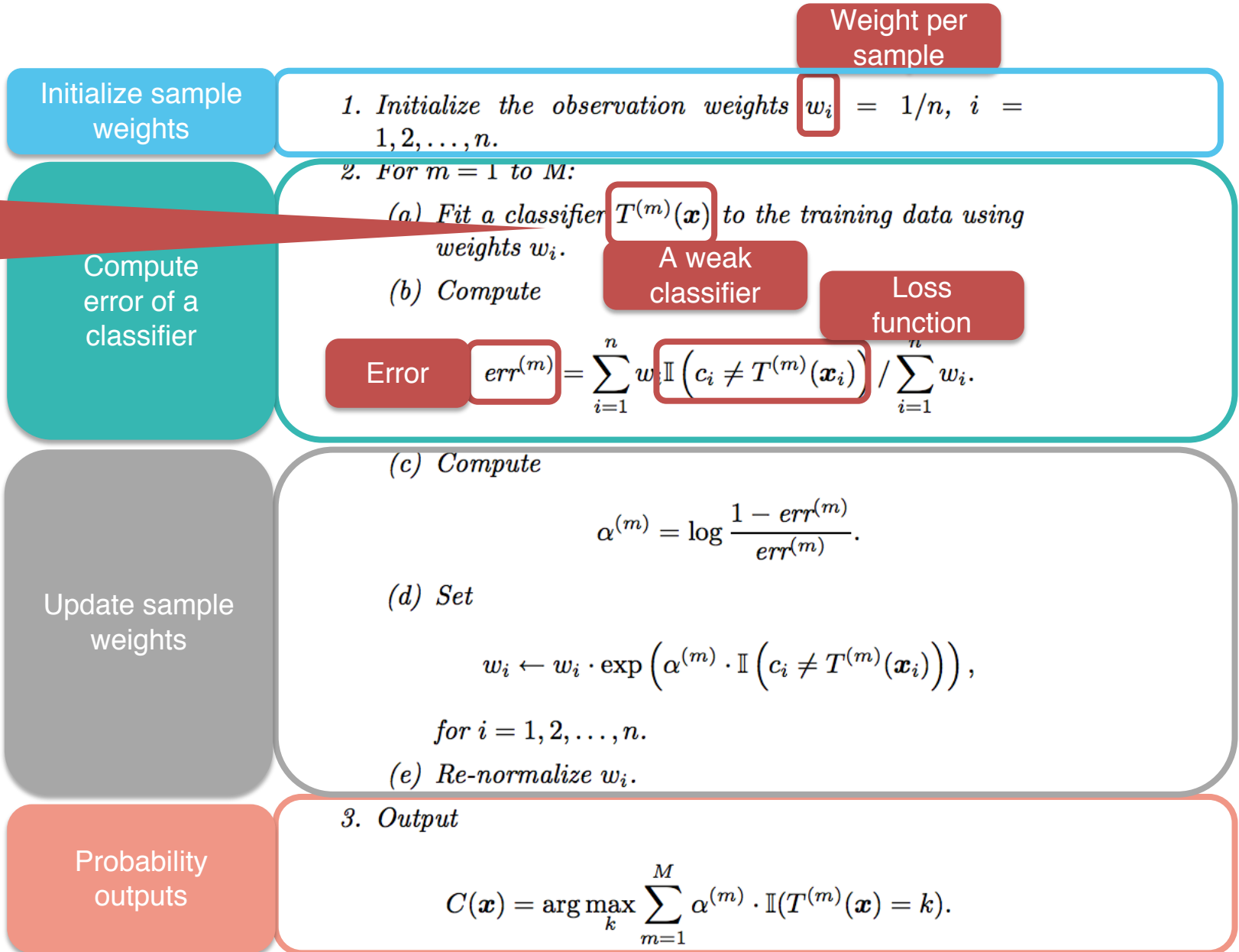
- seller

**Entity token\_POS Role**

- Entity NP\_NP\_DET\_ADJ Role

During the fourth quarter of 2013, PNC finalized the wind down of Market Street Funding LLC (Market Street), a multi-seller asset-backed commercial paper conduit administered by PNC Bank, N.A

**Base classifiers:**  
 1. Logistic Regression  
 2. SVM  
 3. Learning to Rank



- NDCG
  - Standard ranking metric yields score between 0~1, **the higher the better**
  - Competition provides different weighting method
- Results
  - **Highest scores in 4 out of 6** evaluation metrics

	gt1	gt1_500	gt2	gt3	gt4	gt5
Our score P17	<b>0.9223</b>	<b>0.8209</b>	<b>0.9593</b>	0.7270	<b>0.9431</b>	0.8029
Min score	0.7107	0.3347	0.8852	0.6228	0.8575	0.7682
Max score	0.9223	0.8209	0.9593	0.7917	0.9431	0.8581
Mean score	0.8281	0.618	0.9252	0.6991	0.8973	0.8127

- Top important features in ensemble model

Feature types	Number of features among top 1,000	Percentage among all features in the type
Generic	464	9.23%
Domain-specific	536	89.33%

Percentage of domain features is substantially larger than the generic features among most important ones

## – Domain features are effective

- Complex financial relationships, Labeling guideline challenges, Ambiguities in labeled data

- Precision, recall and F1

Method		Train			Dev		
Base		P	R	F1	P	R	F1
	Logistic Regression	1.00	0.75	0.86	0.25	0.14	0.18
	Support Vector Machine	1.00	1.00	1.00	0.31	0.71	0.44
	Learning to Rank	1.00	1.00	1.00	0.50	0.43	0.46
Ensemble	AdaBoost	1.00	0.75	0.86	1.00	0.30	0.46


Base classifiers overfitting

- Perfect on training data
- Poor on test data

– AdaBoost ensemble model is robust

- No single model is perfect
- We use ensemble outputs in our submission



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**Tuple (Context, Filing Entity, Mentioned Entity, Role)**



**Relationship triple**

Definition Dimensions	Challenge Definition
1. Validate financial relationships	✓
2. Identify interesting and relevant knowledge about financial entities	✓

Example	Context	Filing Entity	Mentioned Entity	Role
E3	During the fourth quarter of 2013, PNC finalized the wind down of Market Street Funding LLC (Market Street), a multi-seller asset-backed commercial paper conduit administered by PNC Bank, N.A.	PNC Financial Services Group Inc.	PNC Bank, N.A.	Seller
E4	4.1 Indenture, dated as of October 21, 2010, between JPMorgan Chase & Co. and Deutsche Bank Trust Company Americas, as Trustee (incorporated by reference to ...	JPMorgan Chase & Co.	Deutsche Bank Trust Company Americas	Trustee

Challenge definition

**Highly Relevant**

**Neutral**

Satisfy Dim. 2 but not 1

Satisfy Dim. 1 but not 2

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Definition Dimensions	Challenge Definition	Relation Validation Definition
1. Validate financial relationships	✓	✓
2. Identify interesting and relevant knowledge about financial entities	✓	

Concentrate on Dim. 1

Labeling Scheme	Challenge Definition	Relation Validation Definition
	<b>Highly Relevant</b> <b>Relevant</b> <b>Neutral</b> <b>Irrelevant</b>	<b>Validated:</b> Context validates the relationship <b>Partial Validated:</b> One of the entities is confirmed to be in the relationship <b>Invalidated:</b> Context invalidates the relationship <b>Irrelevant:</b> One of the entities is not financial entity, or neither of them confirms the role

Example	Context	Filing Entity	Mentioned Entity	Role	Challenge definition
E3	During the fourth quarter of 2013, PNC finalized the wind down of Market Street Funding LLC (Market Street), a multi-seller asset-backed commercial paper conduit administered by PNC Bank, N.A.	PNC Financial Services Group Inc.	PNC Bank, N.A.	Seller	Invalidated
E4	4.1 Indenture, dated as of October 21, 2010, between JPMorgan Chase & Co. and Deutsche Bank Trust Company Americas, as Trustee (incorporated by reference to ...	JPMorgan Chase & Co.	Deutsche Bank Trust Company Americas	Trustee	Validated

- NDCG Results

	gt1	gt2	gt3	gt4	gt5
Score	0.9105	0.9411	0.7259	0.9681	0.8379

Scores closely track our challenge results

- Our approach (domain features + ensemble classification model) is robust
  - Works for very different labeling schemes
- Size of RV labels: 345 out of 975 instances

- Top important features in ensemble model

Feature types	Number of features among top 1,000	Percentage among all features in the group
Generic	883	17.57%
Domain-specific	117	19.50%

- Domain features are effective

Percentage of domain features is larger than the generic features


- Precision, recall and F1 measure

	Method	Train			Dev		
		P	R	F1	P	R	F1
Base	Logistic Regression	0.90	0.83	0.86	0.75	0.46	0.57
	Support Vector Machine	0.90	0.87	0.88	0.77	0.77	0.77
	Learning to Rank	0.98	1.00	0.99	0.46	0.92	0.61
Ensemble	AdaBoost	0.92	0.82	0.86	0.77	0.77	0.77

LR and LTR overfit the training data

SVM and AdaBoost are similar, both robust

- AdaBoost ensemble model is robust

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- Precise labeling guidelines
  - Labeling could be done across multiple dimensions, e.g., relationship validation and interestingness from financial perspective
- Expand task definition
  - Document-at-a-time analysis: Allow additional information such as document structure and metadata to be provided as context
  - Collection-level analysis: analyze, reason and validate financial relationships across a corpus, going beyond document-at-a-time analysis
- Unified framework for deep-domain semantic tasks such as financial domain relation understanding
  - Labeling: precise guideline
  - Model: domain features + ranking or classification model pool
  - Evaluation: alternative evaluation metrics
  - Overall: system and platform includes the above components



- **Our Approach**
  - Domain features + Ensemble classification model
- **Our Result**
  - Our approach achieves the highest score in four out of six evaluation criteria
- **Our Exploration**
  - *Concentration is the secret of strength* - Ralph Waldo Emerson
  - A more simplified and precise challenge problem definition:
    - E.g., our relation validation definition: concentrating on relation validation