

# Agent-oriented Ontology for Monitoring and Detecting Money Laundering Process<sup>#</sup>

Yingfeng Wang

Department of Information Systems  
City University of Hong Kong  
Hong Kong (SAR), China

[gilbert.wang@student.cityu.edu.hk](mailto:gilbert.wang@student.cityu.edu.hk)

Huaiqing Wang

Department of Information Systems  
City University of Hong Kong  
Hong Kong (SAR), China

[iswang@cityu.edu.hk](mailto:iswang@cityu.edu.hk)

Shijia Gao

UQ Business School  
University of Queensland  
St Lucia, Brisbane, Australia

[c.gao@business.uq.edu.au](mailto:c.gao@business.uq.edu.au)

Dongming Xu

UQ Business School  
University of Queensland  
St Lucia, Brisbane, Australia

[d.xu@business.uq.edu.au](mailto:d.xu@business.uq.edu.au)

Kang Ye

Department of Information Systems  
City University of Hong Kong  
Hong Kong (SAR), China  
Department of Statistics & Finance  
University of Science and  
Technology of China, Anhui, China

[kye@mail.ustc.edu.cn](mailto:kye@mail.ustc.edu.cn)

## ABSTRACT

Criminal elements in today's technology-driven society are using every means available at their disposal to launder the proceeds from their illegal activities. To effectively and efficiently prevent and detect such diverse and complex activity, an Anti-Money Laundering (AML) solution should establish comprehensive, solid and fundamental knowledge framework of the monitoring and detecting process. This paper proposed an agent-oriented ontology for monitoring and detecting money laundering process (MDMLP). It provides explicit formal presentation of fundamental components of certain knowledge and relationships among them. Agent-oriented methodology is applied to deal with the dynamic, complex, and distributed MDMLP.

## Keywords

intelligent agent; money laundering; Anti- money laundering; agent-oriented ontology

## 1. INTRODUCTION

Since the mid-1980s, money laundering (ML) has been increasingly recognized as a significant global problem, with serious economic and social ramifications [4]. Today, ML has become a key funding mechanism for international religious extremism and drug trafficking, and curtailing these

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illegal activities has become an important focus of governments as part of their ongoing wars on terrorism and drug abuse.

Increasingly, considerable efforts from different aspects have been dedicated into the war of anti-money laundering. Diversified regulations, guidelines, and laws issued by governments, organizations, and etc. Many anti-money laundering systems have been implemented. However, without a comprehensive and solid theoretical support, each effort combats ML in its own way. As ML is a kind of complex, dynamic, and distributed process, to combating ML requires a high degree of cooperative problem-solving capability. Thus, it is very important to start from a solid conceptual framework. In order to provide an explicit formal presentation of the conceptual knowledge of monitoring and detecting ML process, this research is conducted.

## 2. BACKGROUND

### 2.1 Money Laundering and Anti-money Laundering

Money Laundering (ML) is a term usually used to describe the ways in which criminals process illegal or "dirty" money derived from the proceeds of any illegal activity (e.g. the proceeds of drug-dealing, human trafficking, fraud, theft or tax evasion) through a succession of transfers and deals until the source of illegally acquired funds is obscured and the money takes on the appearance of legitimate or "clean" finds or assets [8]. The International Monetary Fund estimates that the aggregate size of ML worldwide could be somewhere between 2% and 5% of global gross domestic product (GDP), equivalent to approximately US\$590 billion to US\$1.5

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trillion annually. According to Celent Communications, the amount of illicit funds traveling through ML channels is estimated to reach over US\$926 billion worldwide by the end of 2005, and grow at an annual rate of 2.7%. However, those are just estimates. The full magnitude of the problem is still not known with any certainty.

Facing such severe problems, in 1989, the famous G-7 created a global ML watchdog organization called the Financial Action Task Force (FATF) in Paris. In 1990, the FATF issued its first annual report, containing its now-famous FATF 40 Recommendations. An important element and theme of the 40 Recommendations is the KnowYourCustomer (KYC) principles. KYC guidelines require developing a keen understanding, through appropriate due diligence, of who the true beneficial owners and parties to transactions are [10]. In addition, FATF also recommended implementing Suspicious Activity Reporting (SAR) models, record keeping, and AML controls as part of overall AML regimes. This emphasizes the importance to increase the level of vigilance against the ML process.

However, there are as many methods to launder money as the imagination allows, and the ML schemes being used are becoming increasingly sophisticated and complex as technology advances [6, 12]. Although KYC and SAR are spreading across the globe in forms ranging from best practice, “soft law” and even hard law, the money launders are forced to change their methods to some degree. ML is becoming increasingly difficult to deter and detect.

## 2.2 Ontology and Agent-oriented Ontology

Ontology is the branch of philosophy that deals with theories about the structure and behavior of the worlds that humans perceive [16]. Ontologies seek to articulate the fundamental types of phenomena and relationships among them, thus they can help human being to understand the phenomena more easily and clearly [14]. The ontology model for Monitoring and Detecting ML Process (MDMLP) could provide a simplified and explicit specification of the anti-money laundering process, and illuminates the components defining the process, thus facilitate human’s understanding on certain process.

Agent oriented methodologies have been researched by lots of researchers. Generally it is regarded as a systematic method to guide the development of agent-oriented systems [19]. In recent years, there has been considerable growth of interest in the design of a distributed, intelligent society of agents capable of dealing with complex problems and vast amounts of information collaboratively. Since agent technology provides flexible, distributed, and intelligent solutions for business applications, researchers have proposed to design and develop numerous intelligent-agents based business systems [7,15,17]. The main benefits of an agent-based approach come from its flexibility, adaptability, and decentralization. Guided by ontology, agent-oriented systems will benefit from a solid theoretical support. Since the ontology explicitly define the fundamental types of the phenomenon and relationships between them, it will be helpful to come up with a systematic modeling process.

Utilizing the advantages of both, agent-oriented ontology is more powerful and suitable for dealing with the complicated and diverse MDMLP.

## 3. AGENT-ORIENTED ONTOLOGY FOR MDMLP

Since the technologies and mechanisms used by money launderers is getting more and more sophisticated and complex. The ontology is able to facilitate monitoring and detection of such activity by providing simplified and explicit specification for the phenomenon. The agent-oriented ontology for monitoring and detecting the money laundering process (See Figure 2) is described based on the modeling method, *Tropos* [3,5].

*Tropos* proposes a conceptual framework, which is founded on concepts used to model early requirements by utilizing the notions of actor, goal and (actor) dependency [3,5,11,18]. The Tropos approach is a requirement- and goal-oriented conceptual modeling method. Using the *Tropos* methodology, we are able to model the world from the following very important perspectives: (1) Agent entities their obligations and capabilities; (2) Agent intentions; (3) Communications and dialogs among agents; (4) Monitoring and detecting processes and their relationships. The stereotypes of the Tropos figures are shown in Figure 1 [11].

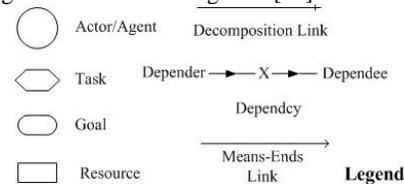


Figure 1. The Stereotypes

In the ontology of the Monitoring and Detecting Money Laundering Process (MDMLP) (see in Figure 2), there are seven conceptual agent entities collaboratively working together with their certain tasks and knowledge.

Referring to Hong Kong Monetary Authority [9], the risk-based approach is adopted in the MDMLP. As risk-based approach is commonly used in global AML practice, the detection result can be understandable and recognized. In the following sub-sections, each agent’s knowledge and actions are described in detail.

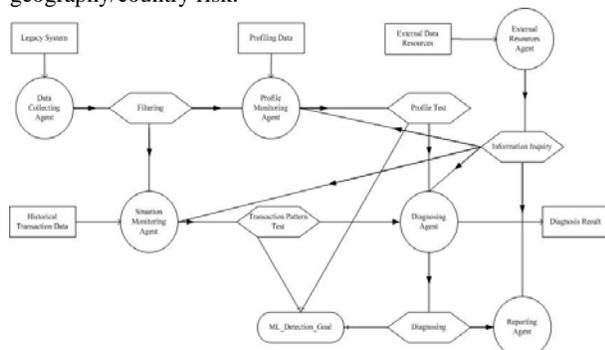
### 3.1 Data Collecting Agent

Data Collecting Agent provides the interface to existing financial system and is continuously collecting relevant client and transaction data in real time. It filters riskless transactions before initializing the whole monitoring and detecting process so that efficiency of the process can be improved. For instance, transactions like a university professor receives his/her monthly salary or a business man pays a restaurant 20 USD for his dinner by credit card, are risk free, and will not be monitored and assessed by the MDMLP.

### 3.2 Profile Monitoring Agent

Profile Monitoring Agent is mainly responsible for monitoring three risk factors, which are Geography/Country Risk, Entity/Business Risk, and Product/Transaction Risk [13]. Based on the totality of risk factors, Composite Risk is determined.

Some countries and territories are regarded as high risk countries, such as Colombia, which is one of the major drug source and transit country. If the customer's residence, the place where the customer's business is established, or the location of the counterparties with which the customer conducts transaction and does business with is Colombia, the transactions should be more carefully handled. Referring to the scoring method provided by Rick Small and John Byrne [13], the agent determines the geography/country risk of the transaction by considering several high-risk country list<sup>1</sup> provided by the global anti-money laundering regimes. The agent assesses the risks of both side involved in one transaction, and select higher one as the transaction geography/country risk.



**Figure 2. Agent-oriented ontology of MDMLP**

In addition, some individuals are already blacklisted in the Publicly Exposed Persons (PEP) lists, for example, Oussama Ben Laden. If the client name is Oussama Ben Laden, his transaction will always been inspected closely. While some businesses are regarded as high risk businesses, for instance, if the customer is running a Casino or the customer conducts the transaction with a Casino, the transactions should be closely monitored. The entity/business risk is assessed by monitoring two aspects of the client. For an individual client, name and occupation are assessed. For a business client, the business nature and owner's name are assessed. The agent matches the name with reliable PEP lists<sup>2</sup>, and tests the name risk. For business risk, Rick Small and John Byrne [13] also provided scoring method to measure the risk level of different industries and businesses by weighing on different business risk factors<sup>3</sup>. Besides, in Bank Secrecy Act Comptroller's Handbook, the U.S. Office of the Comptroller of the Currency lists several "high risk" businesses that "could

potentially be a source of money laundering." [2]. The entity risk of internal client is decided by considering both factors, while the counter party risk monitoring depends on the availability of required information. If all the data is available, after measuring the entity/business risk of both sides of the transaction, the agent should select the higher one to be the overall entity/business risk.

Besides, products of transaction are regarded as high risk, such as cash deposit, cross country wire transfer, etc [13]. These high risk products are often used by money launderers since they are difficult to trace back.

Having three factors' risk levels decided, the composite risk is determined by looking into a 3-risk-dimension-cube [13].

### 3.3 Situation Monitoring Agent

Situation Monitoring Agent is responsible for monitoring the transaction patterns of the account. Abnormal transaction patterns, which are different from the usual account activities, could indicate the suspicious money laundering activities.

To identify and report suspicious transactions requires the agent to have a good understanding of what is normal and reasonable activity for particular types of customer, taking into account the nature of the customer's business. The agent is able to identifying transactions that are unusual either in terms of amount (for example, by reference to comparative figures for similar customer, or to the regular fund movement in the same client account in the history) or type of transaction [9].

There are several possible methods to measure if the account activities are abnormal by comparing with the historical data. One of them is the acceleration of the differences of short term and long term moving average of accumulated fund movement including both inflow and outflow.

Moving average (MVA) is one of the oldest and most popular technical analysis tools in the stock market [1]. MVA of the stock price represents the consensus of investor expectations over a certain time period, thus it describes a moving trend of the stock price. Generally, short term MVA is more fluctuated than a long term MVA. The difference between short term and long term MVA can be used to measure the short term price fluctuation degree comparing with the long term trend. The MVA of accumulated fund flow of the account under monitoring represents the increasing trend of accumulate transaction amount, which works similarly to the stock price MVA. A sudden and significant acceleration in the difference between short term trend and long term trend suggests the abnormal transaction activity. Since laundering dirty money always requires performing fund inflow or outflow, both flows should be monitored. When the historical data is unavailable, which means it is a recently created account, effective monitoring and detecting way is focusing on the client profile.

### 3.4 Diagnosing agent

Diagnosing Agent receives the results of different risk-based measurement and other external information (e.g. the updated information of regulations, newly detected ML cases and scenarios, which can help it justify and improve the predefined decision making rules) from External Resources Agent, and starts the diagnosis process. And the diagnose

<sup>1</sup> The high-risk country lists include Financial Action Task Force (FATF) Non-Cooperative Countries and Territories, Countries designated under USA Patriot Act Section 311, Countries with no money laundering laws or regulation, Drug Source or Transit Country, Organization for Economic Cooperation and Development (OECD) Tax Problem Country, Transparency international Corruption Index, etc.

<sup>2</sup> For example: "Specially Designated Nationals and Blocked Persons" issued by Office of Foreign Assets Control, U.S. Department of Treasury, September 19, 2005

<sup>3</sup> The business risk factors include specifically on US Regulator List, Recent Authoritative Advisories, Derived from Items Listed by Regulators, Cash Intensive Placement Risk, Layering Integration Risk

result is stored for future review. If a transaction is suspicious, the agent should be able to decide what transactions in history are correlated with the transaction and contribute to the ML activity by considering the related additional data from the External Resources Agent, since a single transaction usually cannot form the entire ML process.

### 3.5 Reporting Agent

Reporting Agent will present and communicate a potential ML alert to the appropriate compliance personnel. The agent is able to support the business process to assist with suspicious case investigation. It does this by providing evidence of client activity and information, ensuring the case officer has all of the relevant customer intelligence at hand. If necessary, additional information is requested from Diagnosing Agent. This allows them to make a fact based decision and it also demonstrates regulatory due diligence in the process. The agent also facilitates combining the automatically generated alerts with suspect manual reports.

### 3.6 External Resources Agent

External Resources Agent mainly communicates with external world, searches and retrieves requested information from outside resources through internet, such as government AML departments, corresponding financial institutions and non-financial institutions, etc

## 4. CONCLUSION

This paper provides an agent-oriented ontology for monitoring and detecting money laundering process. In summary, the contributions of this study include:

- A formal representation for MDMLP, represented by a powerful modeling method, *Tropos*;
- The agent-oriented ontology of monitoring and detecting money laundering, where agents (or actors) in the ontology are able to carry out actions to achieve goals or perform tasks with intentions. The ontology provides the simplified and explicit theoretical guidance for the actually intelligent multi-agent system design and implementation, by comprehensively and innovatively presenting the knowledge of the scheme of MDMLP.

The application of our ontology can lead to unambiguous understanding of the concepts of monitoring and detecting money laundering schemes. Moreover, our ontology provides a framework with which various approaches can be integrated together to provide more sophisticated functions and facilities. Therefore, by creating a rich ontology, the study provides the basis for formal study and leads to analysis, design, and development of anti-money laundering systems.

Following the ontology, the intelligent multi-agent prototype system is under construction. The simulation based on the real transaction data will provide further evaluation and validation for the ontology.

## REFERENCE

- [1] Achelis, S. B. *Technical analysis from A to Z: cover every trading tool ... from the absolute breadth index to the zig zag*, McGraw Hill, NY, 2001, 27.

- [2] Bank Secrecy Act (BSA), *Anti-money laundering Examination Manual*, 2001, 42.
- [3] Bresciani, P., Anna perini, A., Giorgini, P., Giunchiglia, F., and Mylopoulos, J. Tropos: An Agent-Oriented Software Development Methodology. *Autonomous Agents and Multi-Agent Systems*, 8 (2004) 203–236.
- [4] Camdessus, M. *Money laundering: the importance of international countermeasures*. IMF to the Plenary Meeting of the Financial Action Task Force on Money Laundering, Paris, 1998.
- [5] Castro, J., Kolp, M., and Mylopoulos, J. Towards Requirements-Driven Information Systems Engineering: the Tropos Project. *Information Systems* 27, 6 (2002), 365-389.
- [6] The CICA (The Canada Institute of Chartered Accountants), *Canada's anti-money laundering & anti-terrorist financing requirements*, Feb. 2004.
- [7] Gao, S., Wang, H., Wang, Y., Shen, W., and Yeung, S., Web-service-agents-based Family Wealth Management System. *Expert Systems with Applications*, 29 (July 2005), 219-228.
- [8] HM Treasury, *Anti-money laundering strategy*, Oct. 2004.
- [9] Hong Kong Monetary Authority, *Supplement to the Guideline on Prevention of Money Laundering*, June 2004.
- [10] IFAC (International Federation of Accountants), *Anti-money laundering*, Jan. 2002.
- [11] Mylopoulos, J., Kolp, M., and Castro, J., UML for Agent-Oriented Software Development: the Tropos Proposal. In *Proceedings of the Fourth International Conference on the Unified Modeling Language*, Toronto, 2001
- [12] Reuter, P., and Truman, E. M. *Chasing dirty money: the fight against money laundering*. Institute for International Economics, Washington, DC, 2004.
- [13] Small, R. and Byrne, J. *Risk Based Approach to Customer Due Diligence*. August 22, 2005, [http://www.bankersonline.com/tools/kb\\_riskratingsystem.pdf](http://www.bankersonline.com/tools/kb_riskratingsystem.pdf)
- [14] Tamma, V. and Bench-capon, T. An ontology model to facilitate knowledge-sharing in multi-agent systems. *The Knowledge Engineering Review*, 17,1 (2002), 41-60.
- [15] Vahidov, R. and Fazlollahi, B. Pluralistic multi-agent decision support system: a framework and an empirical test. *Information & Management*, 41,7 (2004), 883-898.
- [16] Wand, Y. and Weber, R. Reflection: Ontology in Information Systems. *Journal of Database Management*, 15,2 (2004)
- [17] Wang, H., Mylopoulos, J., and Liao, S. Intelligent Agents and Financial Risk Monitoring Systems. *Communications of the ACM*, 45,3 (2002), 83-88,
- [18] Xu, D., Wang, H., and Wang, M. A conceptual model of personalized virtual learning environments. *Expert Systems with Applications*, 29 (2005), 525–534.
- [19] Yu, E. and Cysneiros, L. M. Agent-Oriented Methodologies - Towards A Challenge Exemplar. In *Proceedings of the 4th Intl. Workshop on Agent-Oriented Information Systems (AOIS'02)*, 2002