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Rutgers Business School
Newark and New Brunswick

Expert Systems in Fraud Detection: Expert Knowledge Elicitations in a Procurement Card Context

12th Fraud Seminar

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Knowledge Based Expert Systems

- **Knowledge Based Expert Systems (KES):** “to construct computer software that performs/replicates tasks that are normally performed by human experts”
- Best suited for processes where the task is unstructured in design alternatives and where judgement and insight are required. The problem may be well defined, but the methodology is not.
- Requires transfer of knowledge from the human experts to the software – expensive and time consuming!
- Usually exists as a layer within a larger system
- Can be continually updated
- **Limitation:** Humans are not perfect experts!
- **Artificial Intelligence (AI):** software that tries to simulate humans decision making processes (ex: self driving cars), possibly can see patterns that are not easily detected by humans

Ultimate AI – Self Driving Cars!



Knowledge Based Expert Systems

- Expertise is difficult to acquire. Human Experts are expensive and in short supply!
- Accounting/Auditing problems tend to be rule intensive and can be solved with “if-then” rules
- The experts system must produce clearly identified solutions that most experts would agree with

Examples of Audit Expert Systems:

- Materiality judgements in audit planning
- Internal Control evaluations
- Going Concern Judgments
- Fraud detection on credit card transactions

INTRODUCTION: Procurement Cards

- P-Cards help **reduce** purchasing department costs and increase individual department purchasing decision-making (Daly and Buehner, 2003)
- Now given the large volumes of data and the advent of automated audit tools, internal auditors can **mine 100%** of the transactional data to **detect anomalies** (Murthy, 2010; Coderre, 2009 & 1999; Nigrini, 2006)
- However, this is **not always** the case, hence the increased likelihood of employee **misuse occurring**

INTRODUCTION: P-Card Fraud Risk

- Why do P-cards create higher fraud risk than employee credit cards?
 - P-card owners have a higher volume of transactions on a normal basis, while employee credit card usage is typically limited to a periodic event or business trip.
 - For P-card transactions, no pre-approval is required, while employee credit card transactions may require formal manager approval before the credit card provider is reimbursed.
 - Transaction amounts are higher due to type of goods/services purchased, which may increase the rationalization to commit fraud, even in small amounts.
 - Difficulty to detect misuse increases opportunity, which, together with rationalization, constitute two out of three fraud triangle components.

INTRODUCTION: Project Story

- Large multinational consumer goods manufacturer with many different divisions
 - 5600 active p-cards
 - 55,000 p-card transactions per month
 - 15.5 million dollars on average per month
 - a complex scenario!!
- Previous software audit tools were found not effective, and the firm's procurement card fraud expert, Lisa, is manually reviewing transactional data every month

2 Phases of the project:

- Build an expert system (an "electronic Lisa")
- Improve anomaly detection rate in p-card data

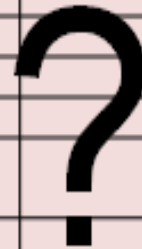
METHODOLOGY: Data Preprocessing and Exploration

- Monthly training data for the periods of 3/1/13 through 6/1/13
- 55,000 transactions per month with 55 data attributes
 - 2 years of data initially, 2011 & 2012
- Some of the data fields have **missing values**. For example, vendors choose the level of information that they will provide and some opt out of supplying purchase item description information.
- **Even a 95 cent cup of coffee is material!**

METHODOLOGY: Data Preprocessing and Exploration

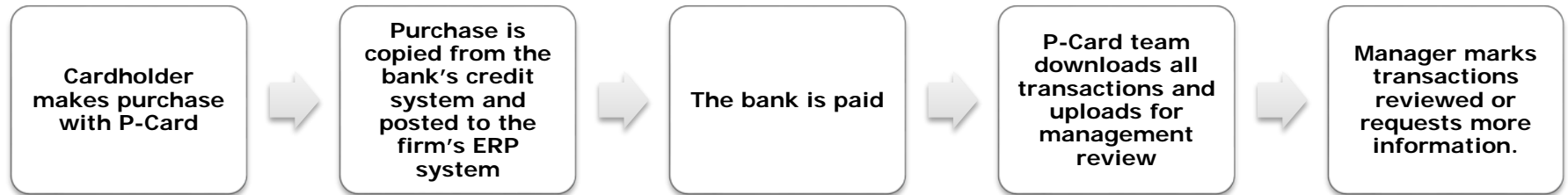
- One of the main **challenges** of this project is designing an expert system and profiling where key data fields are **missing**:

ID	City	Original Currency Amount	Merchant Name	Item Description	Product Code	Purchase Date
ID0484	ORLANDO	2,367.68	WM SUPERCENTER			
ID2934	CINCINNATI	2,472.93	WM SUPERCENTER			
ID0918	CINCINNATI	2,231.71	WM SUPERCENTER			
ID0918	CINCINNATI	2,393.84	WM SUPERCENTER			
ID0918	CINCINNATI	2,450.16	WM SUPERCENTER			
ID0918	CINCINNATI	2,454.88	WM SUPERCENTER			
ID0918	CINCINNATI	2,499.41	WM SUPERCENTER			
ID3264	WEST CHESTER	2,417.45	WM SUPERCENTER#3502			
ID0918	CINCINNATI	2,320.69	WM SUPERCENTER			
ID4347	JACKSON	2,459.78	WALMART.COM			
ID4347	JACKSON	2,384.48	WALMART.COM			
ID1547	RUSSELLVILLE	2,200	WAL-MART			
ID1547	RUSSELLVILLE	2,500	WM SUPERCENTER			
	TOTAL	31,153.01				

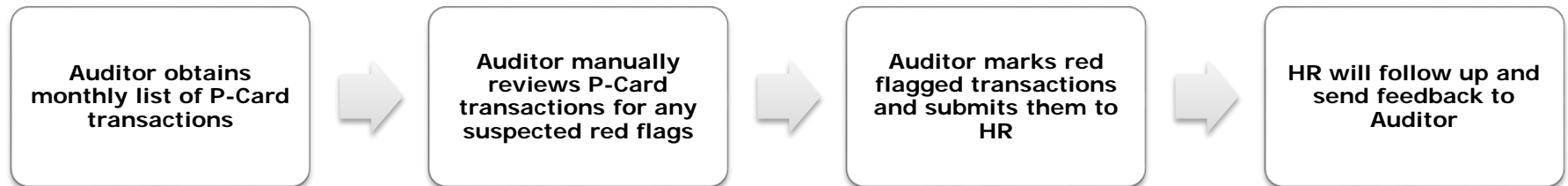


PROCESS FLOW UNDERSTANDING

Firm's Procurement Process



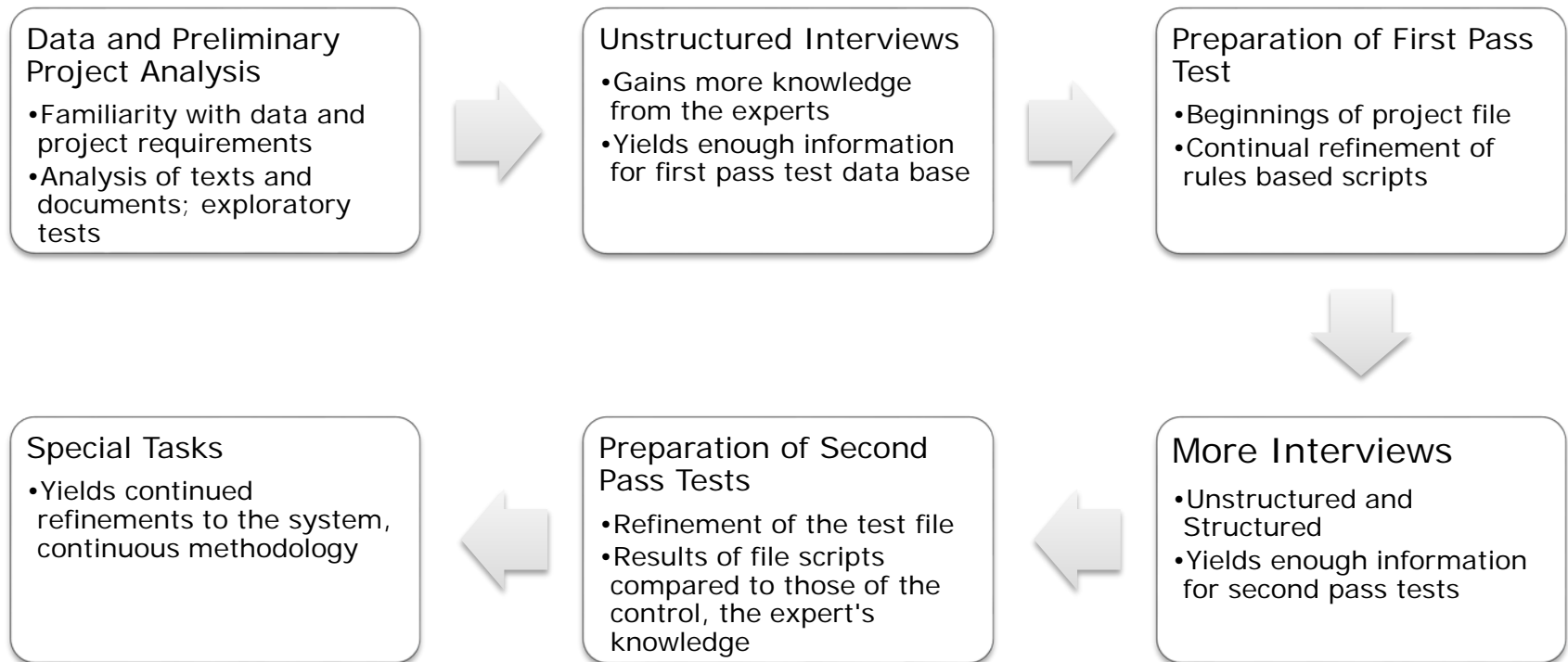
Auditor's Monitoring Process



KNOWLEDGE ACQUISITION

- The project requires elicitation of an **expert's knowledge**
- The **unstructured interview** is the most popular method of attaining expert knowledge to date (Weiss and Kulikowski, 1984) for the first pass test
- The **second pass** tests result from further unstructured interviews, structured interviews, limited information tasks, constrained processing tasks, and methods of tough cases

KNOWLEDGE ACQUISITION PROCESS



KNOWLEDGE ACQUISITION

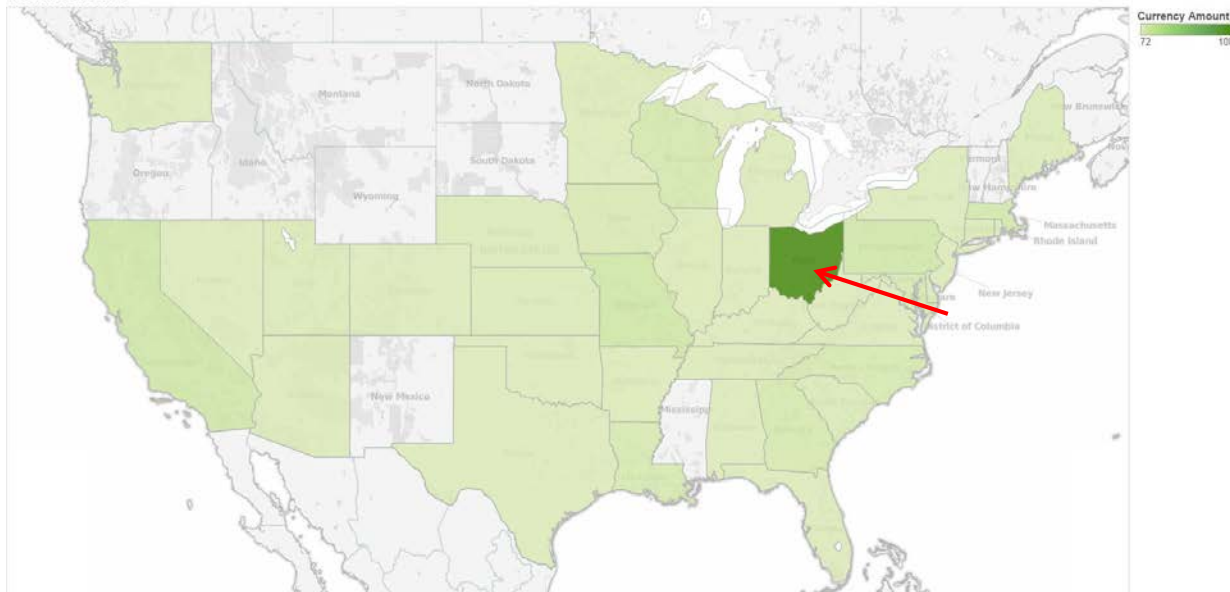
- The first preliminary analysis test was that of Limits

ID	Purchase Date	Total dollar amount spent per day	Monthly Credit Limit	Single Transaction Limit	Transactions per day	Difference - Single limit	Difference - Monthly limit
ID2974	11/29/2012	267,087.61	75,000	2,500	141	264,587.6	192,087.6
ID1929	9/10/2012	136,551.81	60,000	10,000	574	126,551.8	76,551.8
ID5209	5/17/2012	99,599.03	75,000	2500	3	97,099.0	24,599.0
ID1967	12/19/2012	96,250.89	75,000	2,500	3	93,750.9	21,250.9
ID1929	11/12/2012	99,821.08	60,000	10,000	193	89,821.1	39,821.1
ID3723	5/15/2012	89,625.26	75,000	10,000	421	79,625.3	14,625.3

- ID1929 has 574 transactions per day, which accounts for about 71 transactions per hour (assuming an 8 hour work schedule) and 1.2 transactions per minute
 - There is a need to review such cases to see if such behavior is normal or not.

KNOWLEDGE ACQUISITION

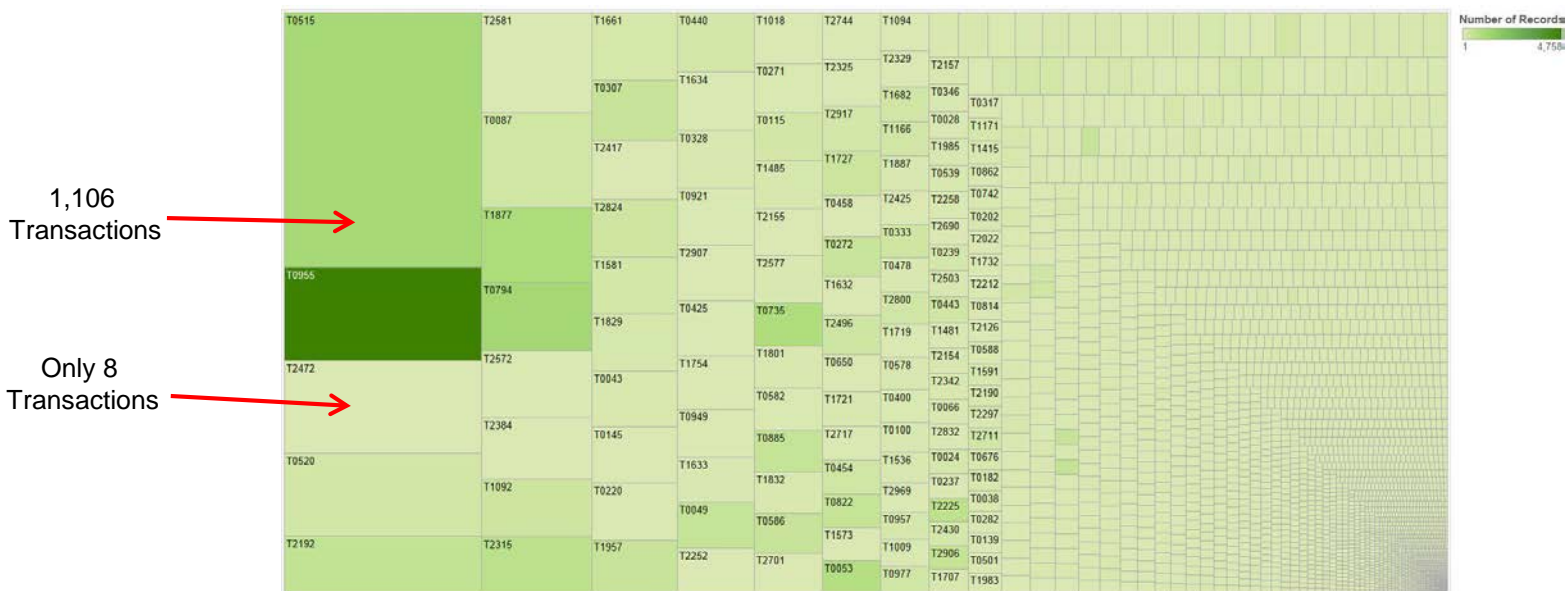
- In addition to the preliminary analysis, we conducted **Exploratory Visual Analysis** (EVA) to further understand the data and build a **basis for user purchase behavior**.



- The most **heat (color) intensity** among the states goes to Ohio, i.e. it has 64% of the total dollar amounts spent alone.

KNOWLEDGE ACQUISITION

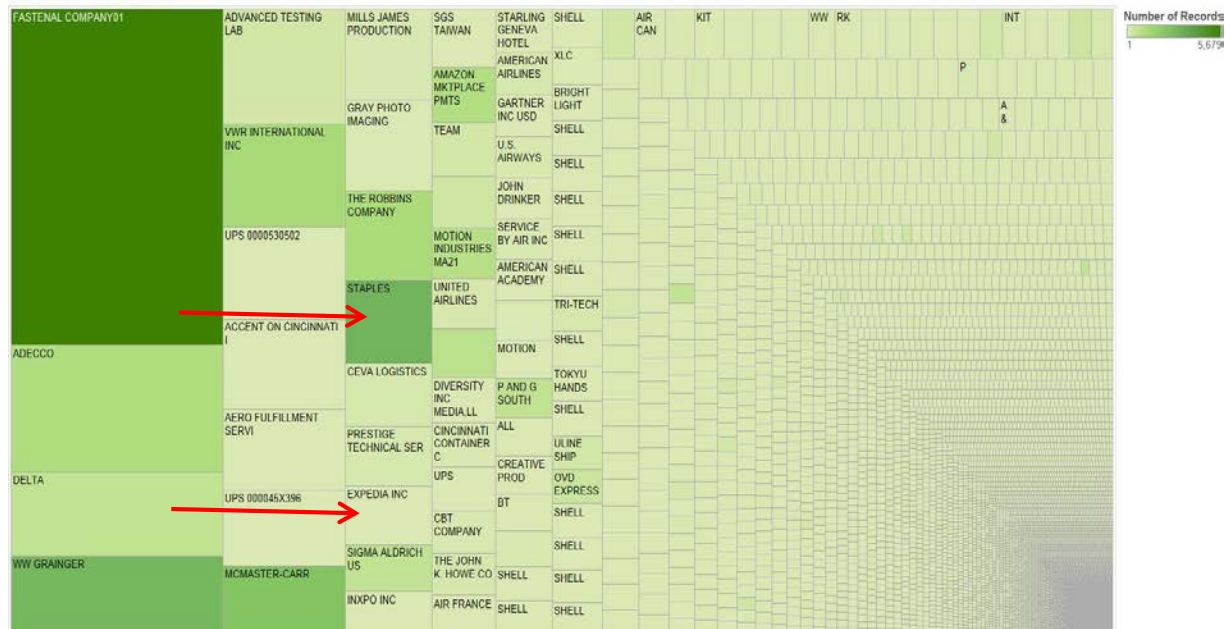
- By aggregating dollar amounts per transaction for both merchants and employees and looking at the overall visual display, we can further **understand the data** and be able to **build better purchase patterns**



- One example here is employee T2472, were despite being third place in terms of total dollar spending (\$424,879), has **only 8** records in total, **compared** to employee T0515 in first place with **1,106 records**

KNOWLEDGE ACQUISITION

- As for merchants, we can look at those that stand out in terms of number of records and dollar amounts. For example **Staples is third place in terms of transactions and also has a high dollar amount.** (being a store that sells diverse products, one should put in more consideration)
- Another is Expedia, with only 6 records, it is just behind Staples in dollar amount



KNOWLEDGE ACQUISITION

- Textual analysis was then conducted with the data

ID	Purchase Date	Original Currency Amount	Extended Item Amount	Merchant Name	Item Description
ID1637	2/17/2011	0	50	STAPLES 00101907	\$ 50 APPLES ITUNES
ID1917	2/22/2012	0	7.59	TARGET 00014472	POKER CHIPS 11.5G GAME ESSEN
ID0925	3/25/2011	84.95	75	AMAZON MKTPLACE PMTS	ITUNES GIFT CARD
ID4720	7/22/2011	0	10	BOLDEN INSTRUMENT	FUEL CHARGE \$10
ID2503	10/6/2011	31.95	31.95	AMAZON MKTPLACE PMTS	PROACTIV SOLUTION ORIGINAL REPAIRIN
ID0305	10/11/2011	16.28	12.99	AMAZON.COM	CONAIR TOUCH AND TONE MASSAGER WITH
ID2315	10/11/2012	49.69	41.66	STAPLES	STRESS BUSTER MASSAGE FOOT
ID5477	11/14/2012	24.5	22	AMAZON MKTPLACE PMTS	BRIDAL WEDDING JEWELRY HAIR HEADBAN

- One case (highlighted in red) identified immediately **as fraudulent** by the company
- Other items were determined legitimate after follow up.

KNOWLEDGE ACQUISITION

- Association Rules and Decision Trees:

MCH code 7542 (car washes):

IF (MCH_MCC_Description = "Car Washes")

AND (Department_Cost_Center CONTAINS "Facilities Management" OR "Executive" OR
"Buildings and Grounds")

THEN → PASS.

IF (MCH_MCC_Description = "Car Washes")

AND (ACC_Master_Accounting_Code = EQUAL "GAS" OR "INCIDGAS")

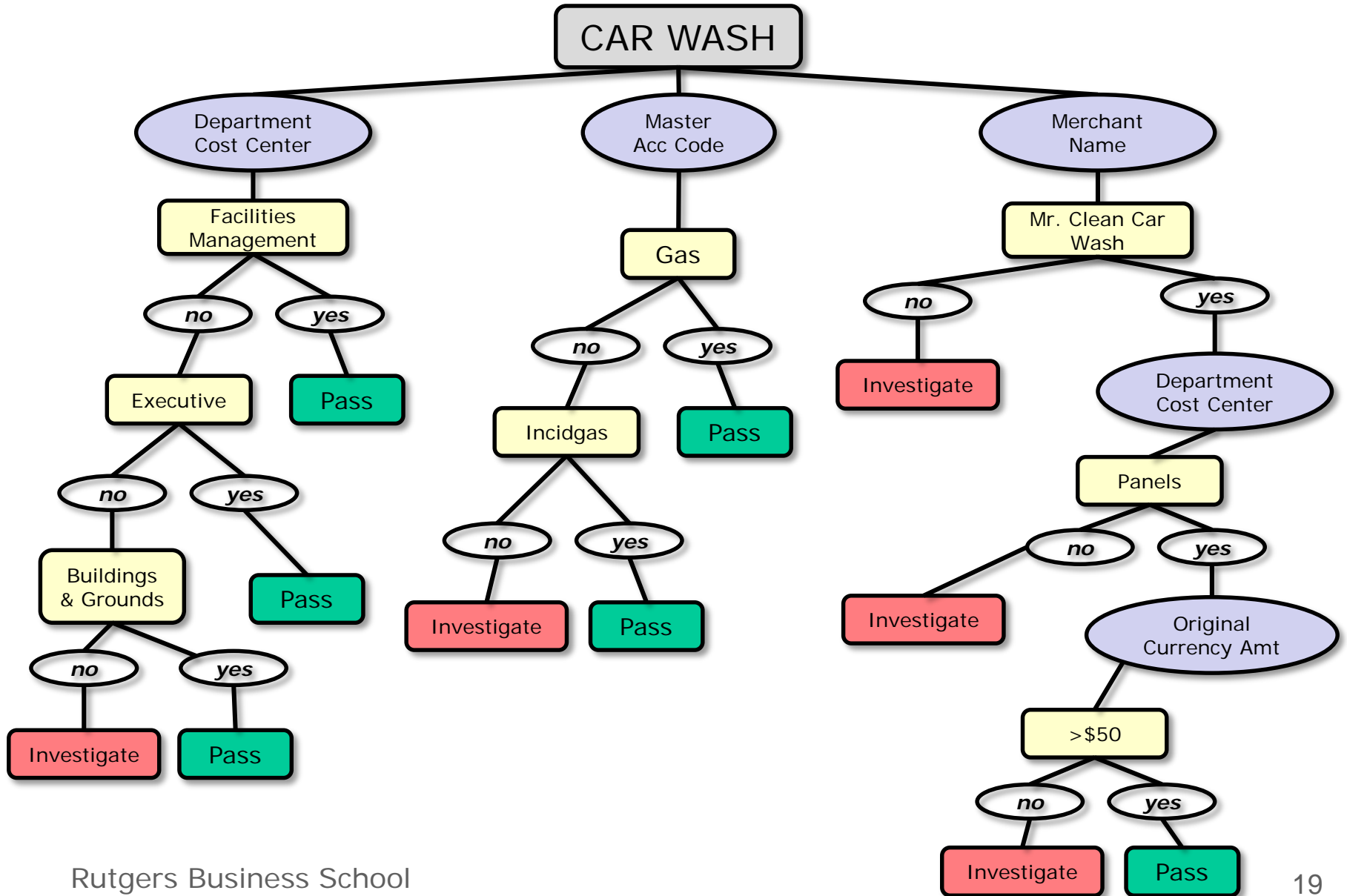
THEN → PASS.

IF (MCH_Merchant_Name = "MR CLEAN CAR WASH")

AND (Department_Cost_Center CONTAINS "PANELS")

AND (FIN_Original_Currency_Amount > \$50)

THEN → PASS.



EXPERT TOOL - PASS TESTS

- Our initial run of the expert system produced a total of **1408** exceptions (June - July 2013 test data)
- Another **100+ association rules were added to the tool** and after running the **SECOND PASS TEST** we achieved **95% ACCURACY**
- **Four** cases of personal use/fraud have been confirmed during the **first pass** test alone.

	Red Flags Produced	Red Flags Confirmed	Effectiveness
First Pass	1408	957	68%
Second Pass	1300	1235	95%

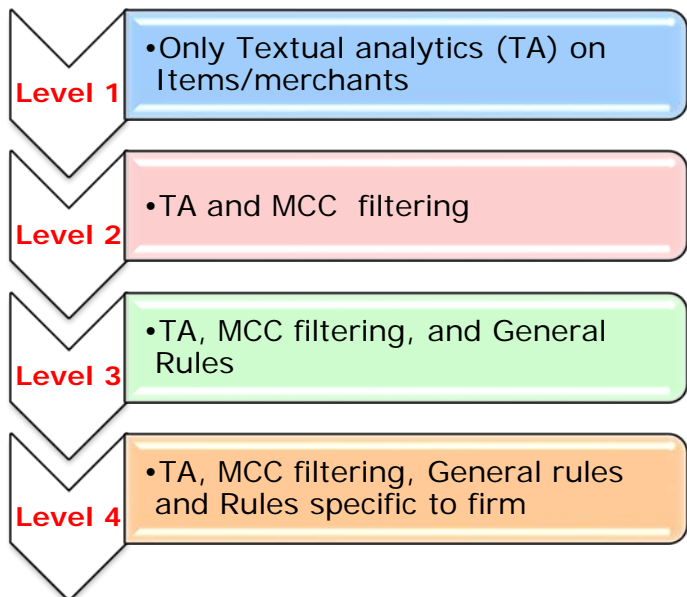
EXPERT TOOL - PASS TESTS

- The Tool was ran again on **October, November, and December** data of 2013
- The tool obtained a **98.5%** match to the auditor's flagged transactions

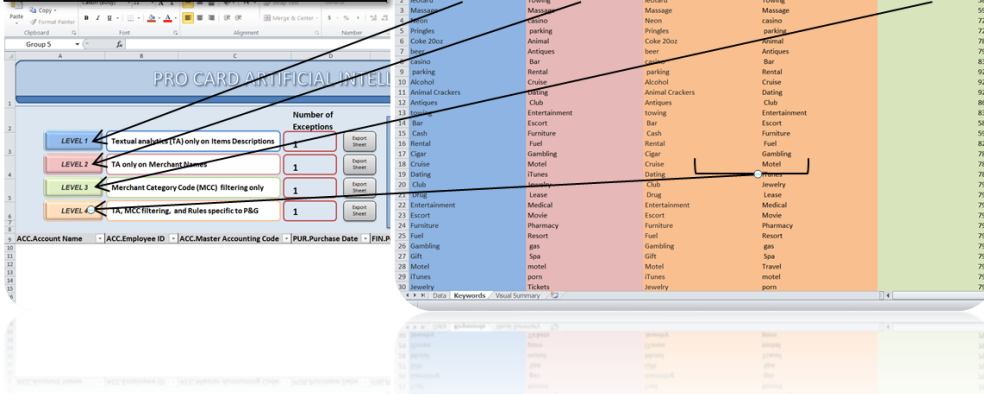
	Red Flags Produced by Expert Tool	Red Flags Produced by Auditor	Effectiveness
First Pass	2267	2236	98.5%

P-CARD TOOL - ILISA

- The tool was developed in **EXCEL** due to **the firm's request**.
- The tool will have **different levels** of exceptions, from high false positives to high false negatives
 - The expert will have the ability to decide which level to focus on

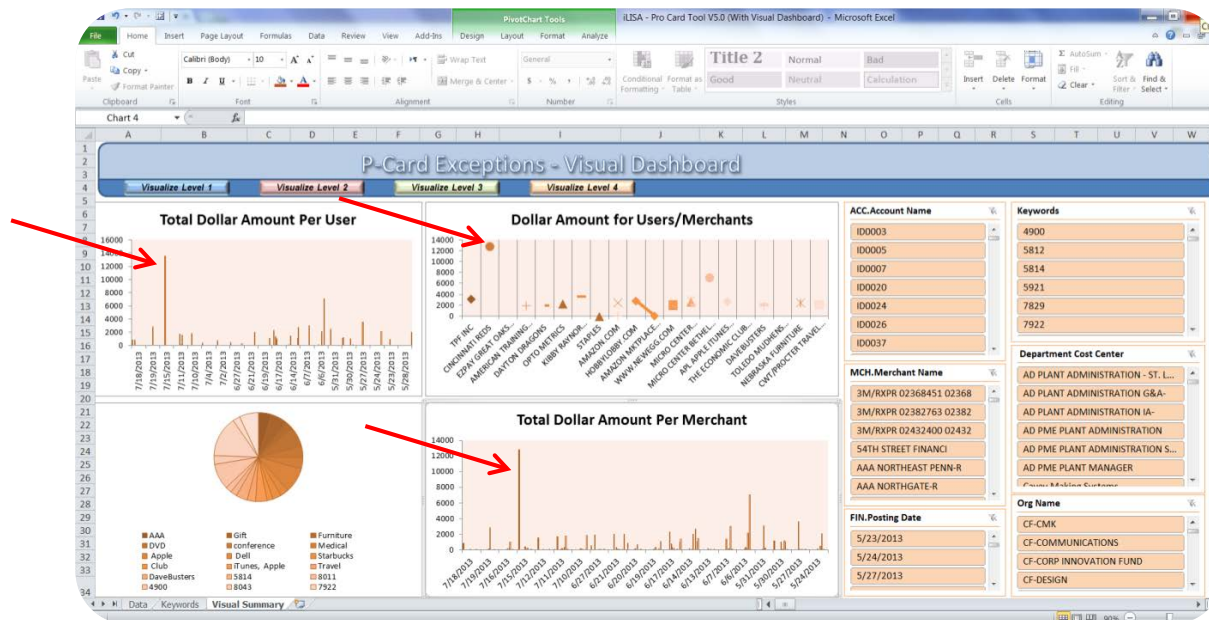


Each Keyword list corresponds to the level of analysis. The list is color coded for ease of use. Modifying each list will affect the corresponding analysis level.



P-CARD TOOL - ILISA

- We added a new feature which includes a **visual dashboard** of exceptions founds.
- The dashboard will provide a **quick** and **efficient** way of observing exceptions and noticing any spikes in the visuals.



MOVING FORWARD

- Global Internal Audit is very happy with this project to date...the human and real expert concurred on **172 instances of confirmed fraud**
- We will then develop this tool for the international divisions
- Management wants to move from a batch processing to real time data processing
- We will next be looking at their accounts payable
- We also will be working with other firms on expert systems development
- Working on 2nd phase of the project in dealing with transactions with missing information utilizing pattern recognition and employee/merchant profiling

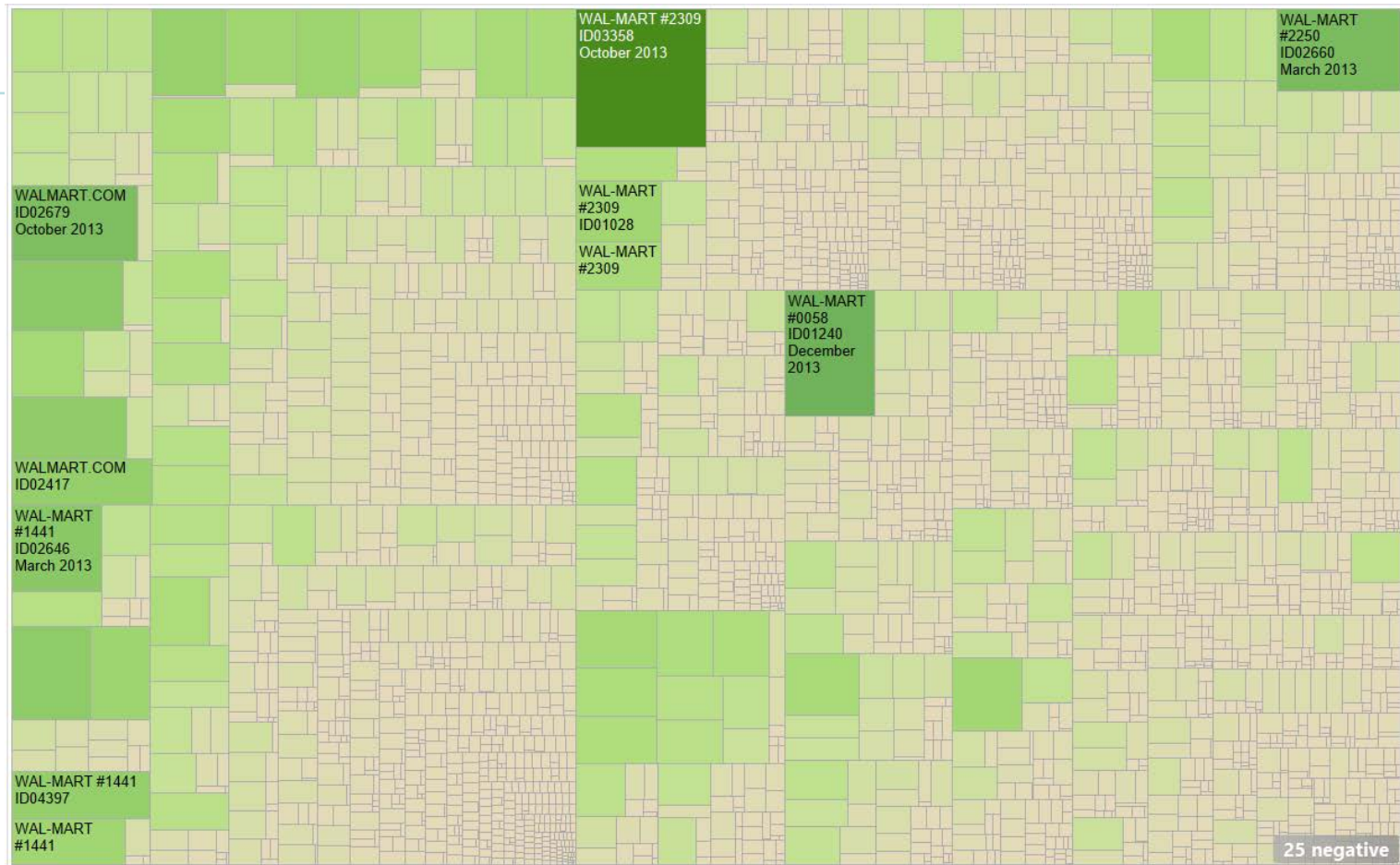
AI/Second Phase: Missing Values Knowledge Acquisition/Overview of Data

Measure for Jan 2013 to April 2014	Total Data Set	Missing Purchase Item Information Data Set
# of Transactions	741,710	194,528 (26% of total)
# of Employee IDs	4532 (cards are 5600)	4339
Total \$ Fin Original Currency	\$157,115,184	\$65,926,544 (42% of total)
Total # of vendors	101,900	41,258

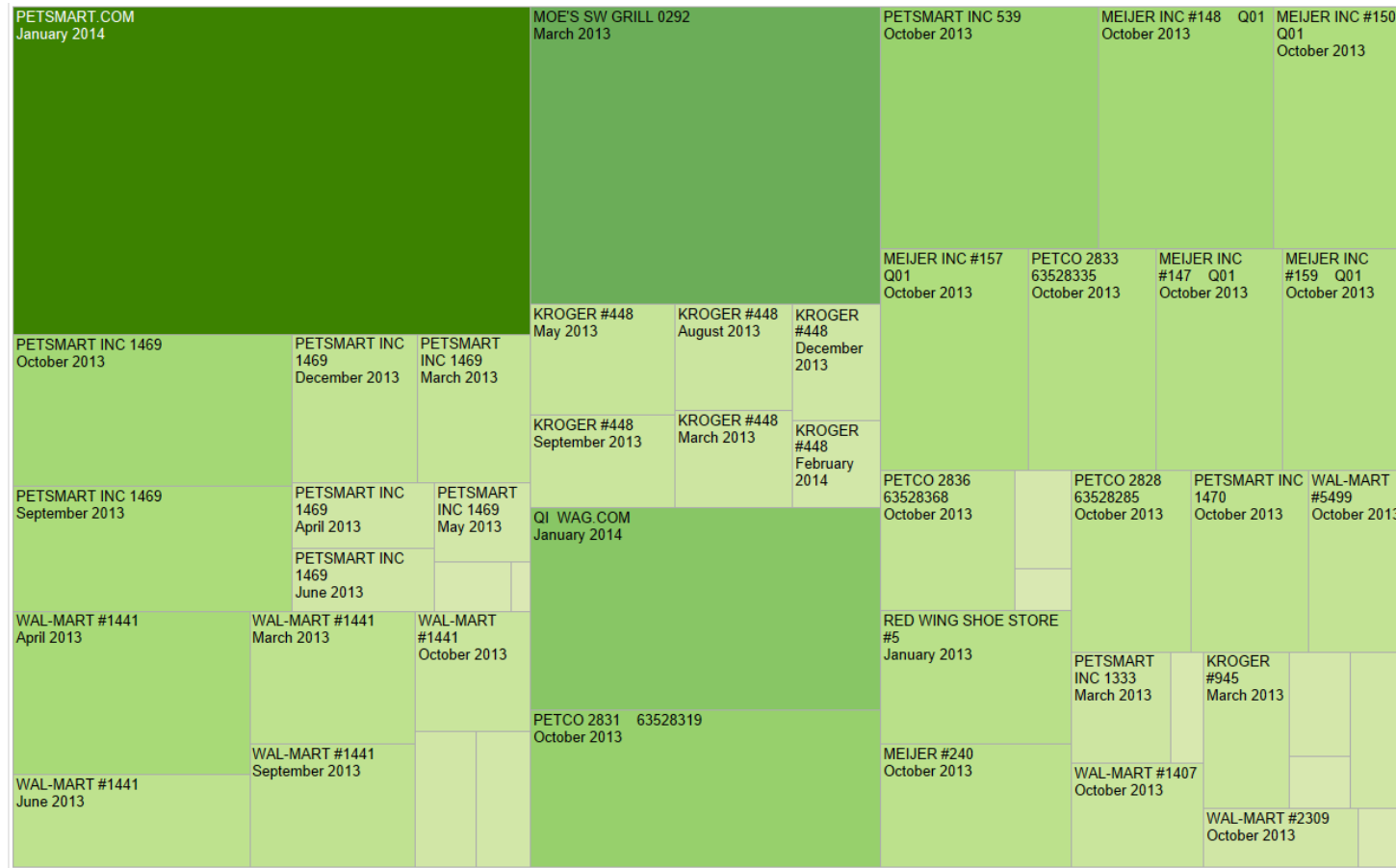
Second Phase: Missing Values Knowledge Acquisition/Merchant Types and Names

Merchant	# of Trans	# Emp ID	\$ Total	# of ??
Walmart	4171	1290	\$343,750	All
Sam's Club	819	259	\$126,612	All
Amazon	11,690	276	\$19,302	Non-credit
Target	224	115	\$37,170	All
Ulta/Sally B	51	21	\$6804	15 (29%)
Petsmart	174	43	\$12,328	25 (14%)
PetCo	116	9	\$60,764	none

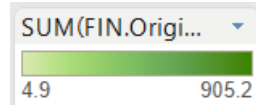
SECOND PHASE – Walmart transactions



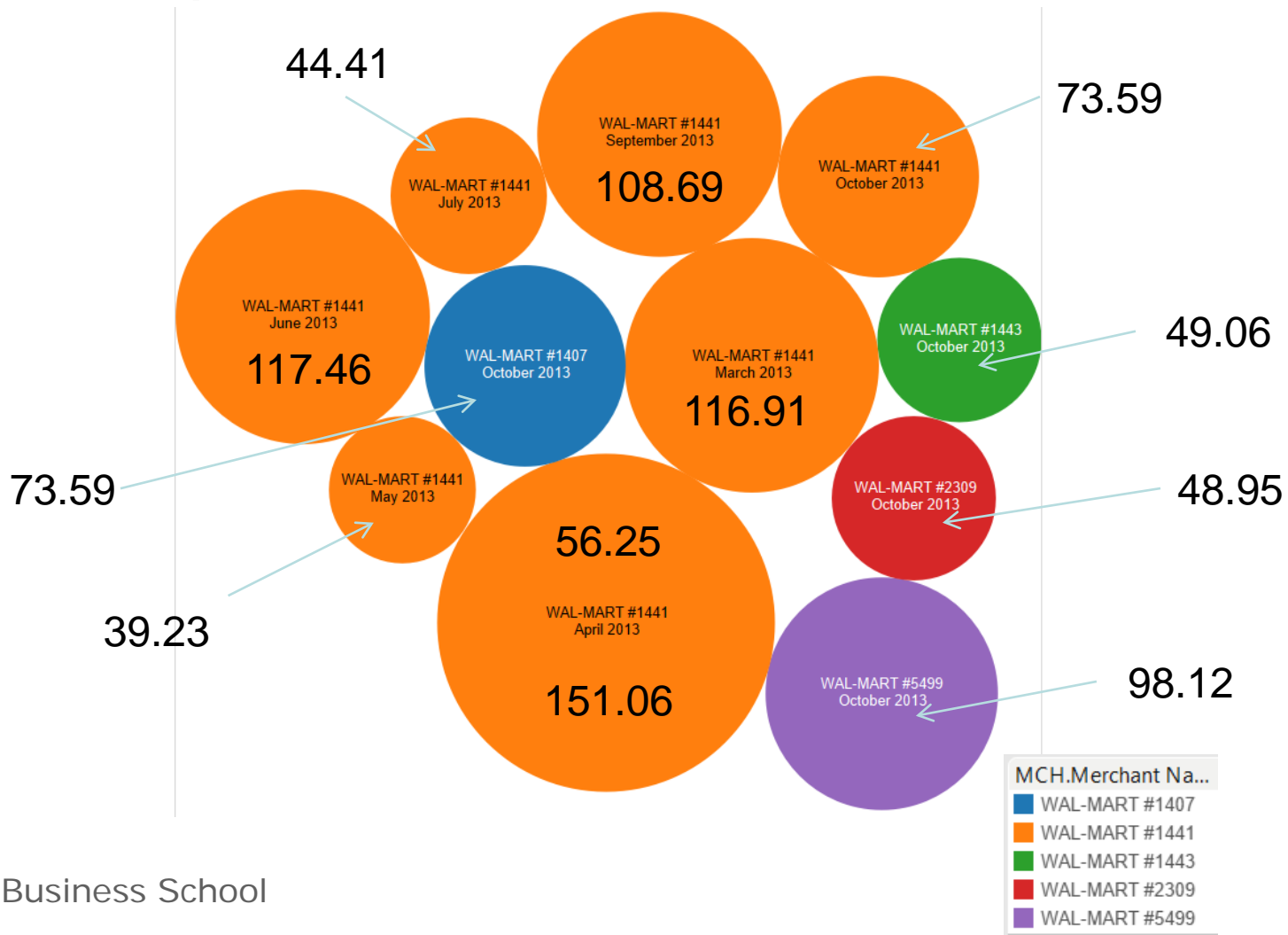
SECOND PHASE – EmpID #744 purchases



54 purchases for \$6421, 12 Walmart transactions for \$977



SECOND PHASE - EmpID#744: 12 Walmart purchases for \$977



SECOND PHASE – MISSING VALUES

- Another informative merchant: PETSMART
- 174 transactions by 43 cards for \$12,328

FIN.Posting D	FIN.Origin	PUR.Item Description	MCH.Merchant Nam	PUR.Line Item	Total Amount	PUR.Product Code	PUR.Purchase Date
3/21/2013	-2.98		PETSMART INC 1469		0		
3/21/2013	103.22		PETSMART INC 1469		0		
3/21/2013	29.26		PETSMART INC 1469		0		
3/15/2013	89.43		PETSMART INC 1469		0		
3/14/2013	59.48		PETSMART INC 1333		0		
3/14/2013	48.43		PETSMART INC 1469		0		
3/12/2013	10.6		PETSMART INC 1469		0		
3/11/2013	22.34		PETSMART INC 1469		0		
3/11/2013	52.49		PETSMART INC 1469		0		
3/5/2013	10.64		PETSMART INC 1237		0		
3/4/2013	606.87		PETSMART INC 2038		0		
3/4/2013	559.44		PETSMART INC 248		0		
2/27/2013	53.58		PETSMART INC 1469		0		
2/26/2013	24.1		PETSMART INC 1469		0		
2/25/2013	84.92		PETSMART INC 1333		0		
2/25/2013	63.84		PETSMART INC 1469		0		
2/25/2013	15.29		PETSMART INC 1237		0		
2/21/2013	44.36		PETSMART INC 1469		0		
2/21/2013	171.37		PETSMART INC 1469		0		
2/21/2013	75.19		PETSMART INC 1237		0		
2/15/2013	10.95		PETSMART INC 1469		0		
2/14/2013	1.07		PETSMART INC 1469		0		
2/12/2013	32.08		PETSMART INC 1469		0		
2/7/2013	17.03		PETSMART INC 1469		0		
2/6/2013	34.93		PETSMART INC 1469		0		



SECOND PHASE – MISSING VALUES

Association Rules, first pass:

- If COMPANY = "IAMS" then **PASS**
- If COMPANY = "NATURA" then **PASS**
- All others **FAIL**

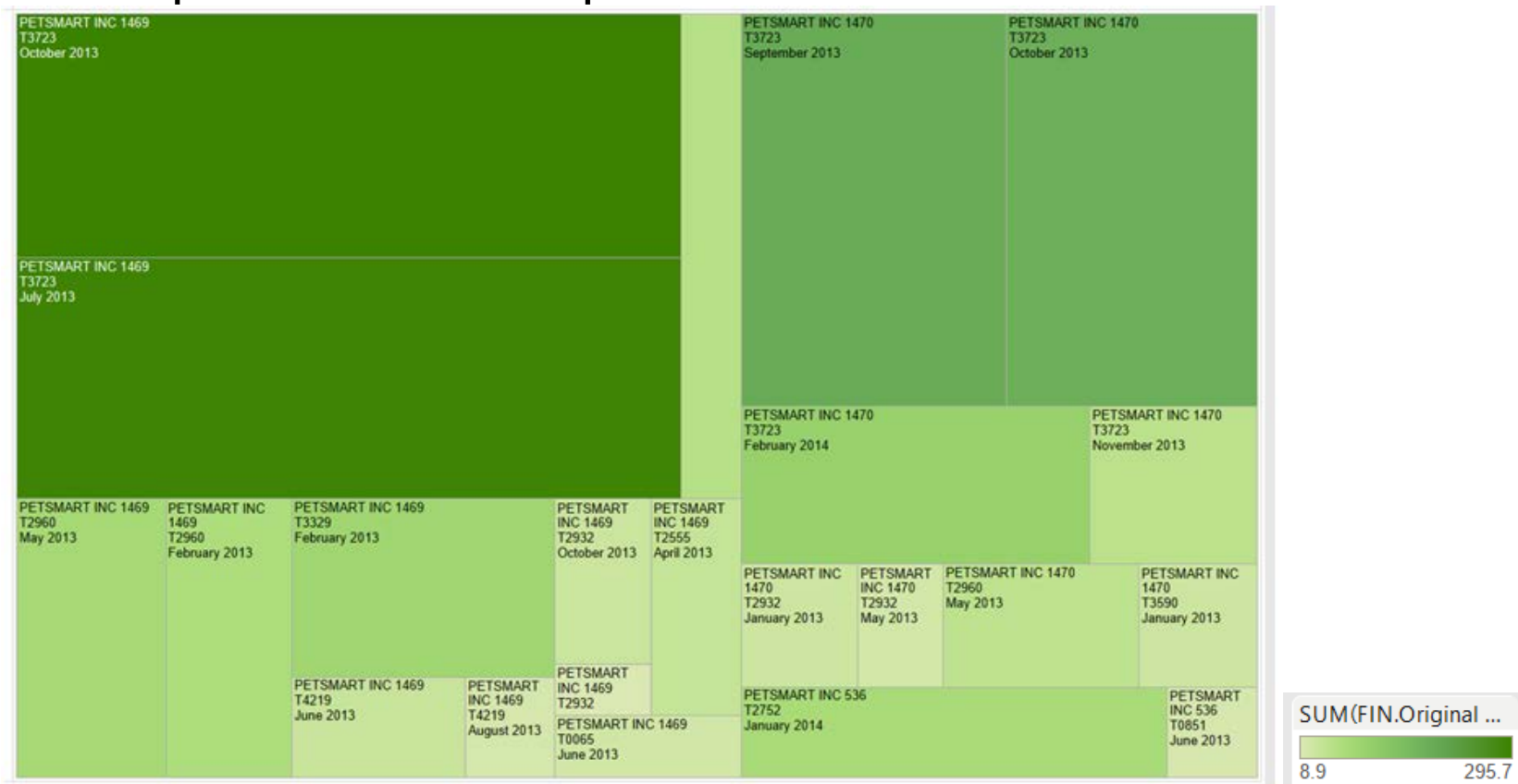
Association Rules, second pass:

- If ORG_NAME = "pet" then **PASS**
- If ORG_NAME = "Product Safety and Regulatory Affairs" then **PASS**
- All others **FAIL**

25 TRANSACTIONS ARE FLAGGED AS FAIL

SECOND PHASE – MISSING VALUES

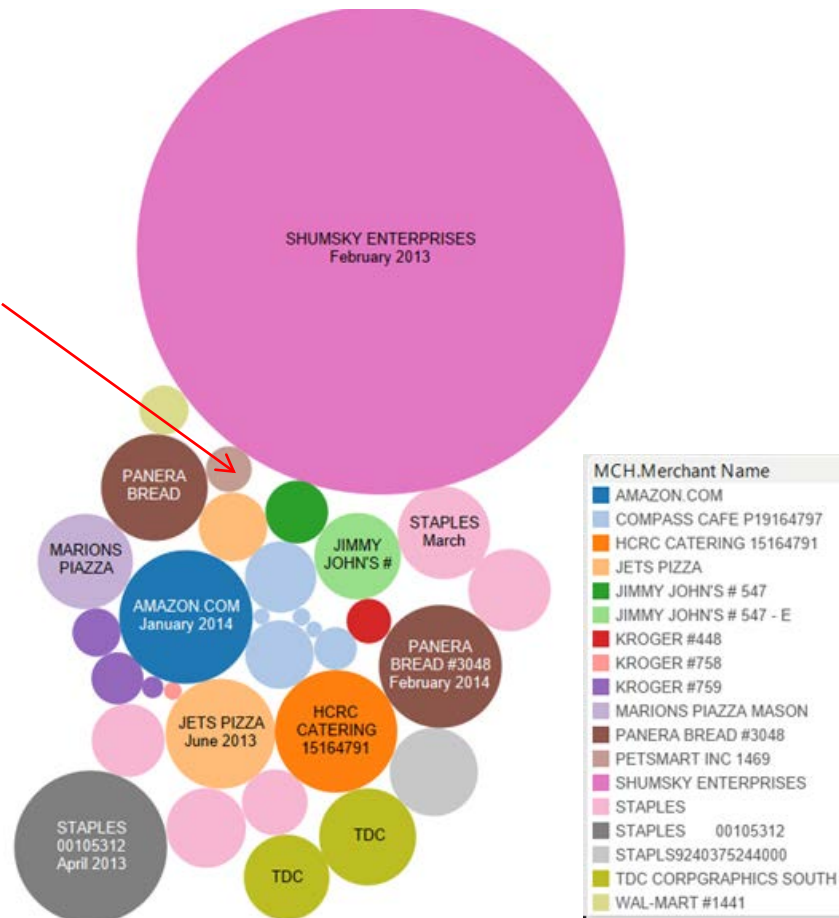
- Heat Map of the 25 suspicious Petsmart transactions:



SECOND PHASE – ID # 3937 @ Petsmart

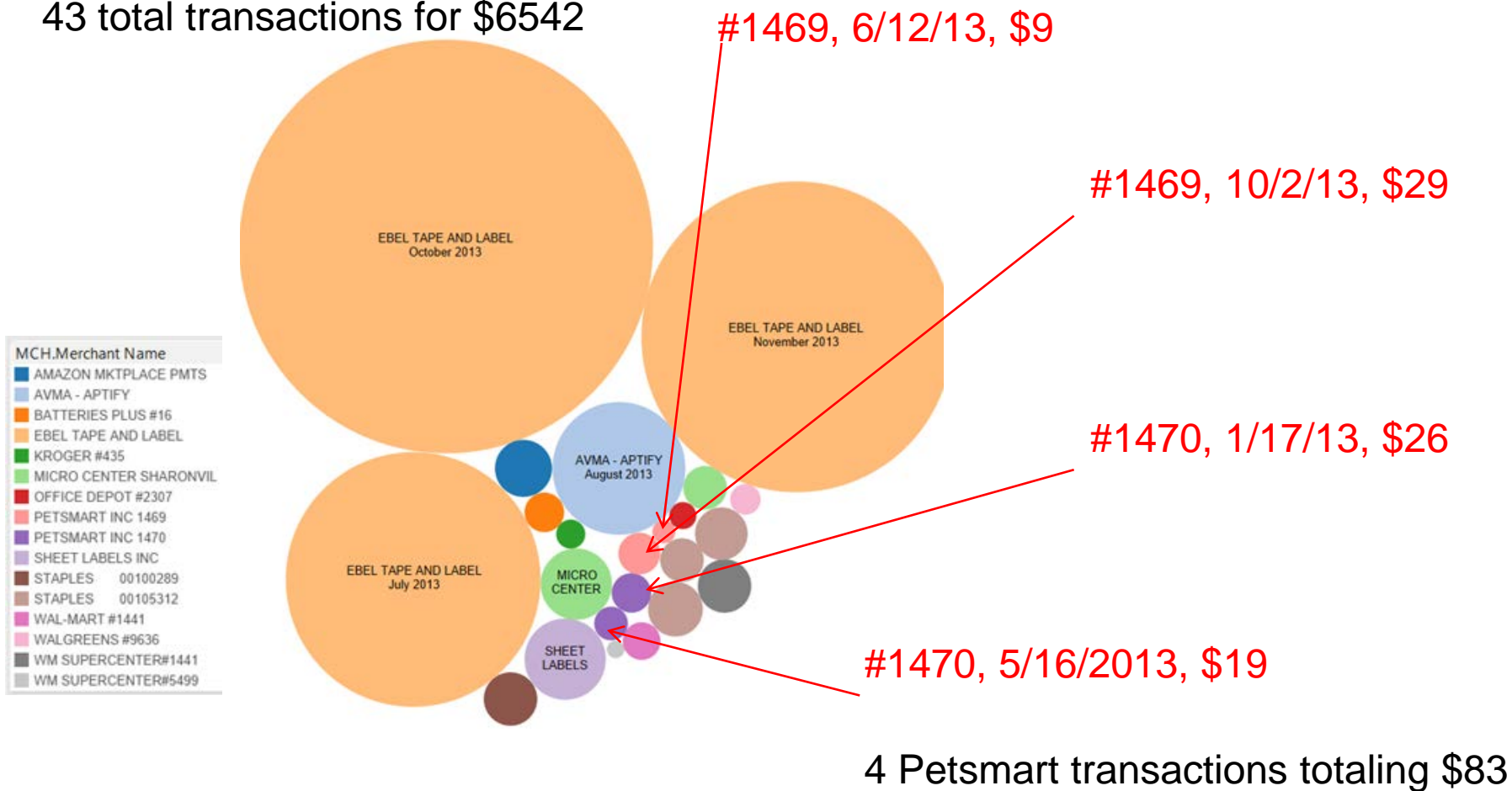
#1469, 6/21/2013, \$21

63 total transactions for \$4436



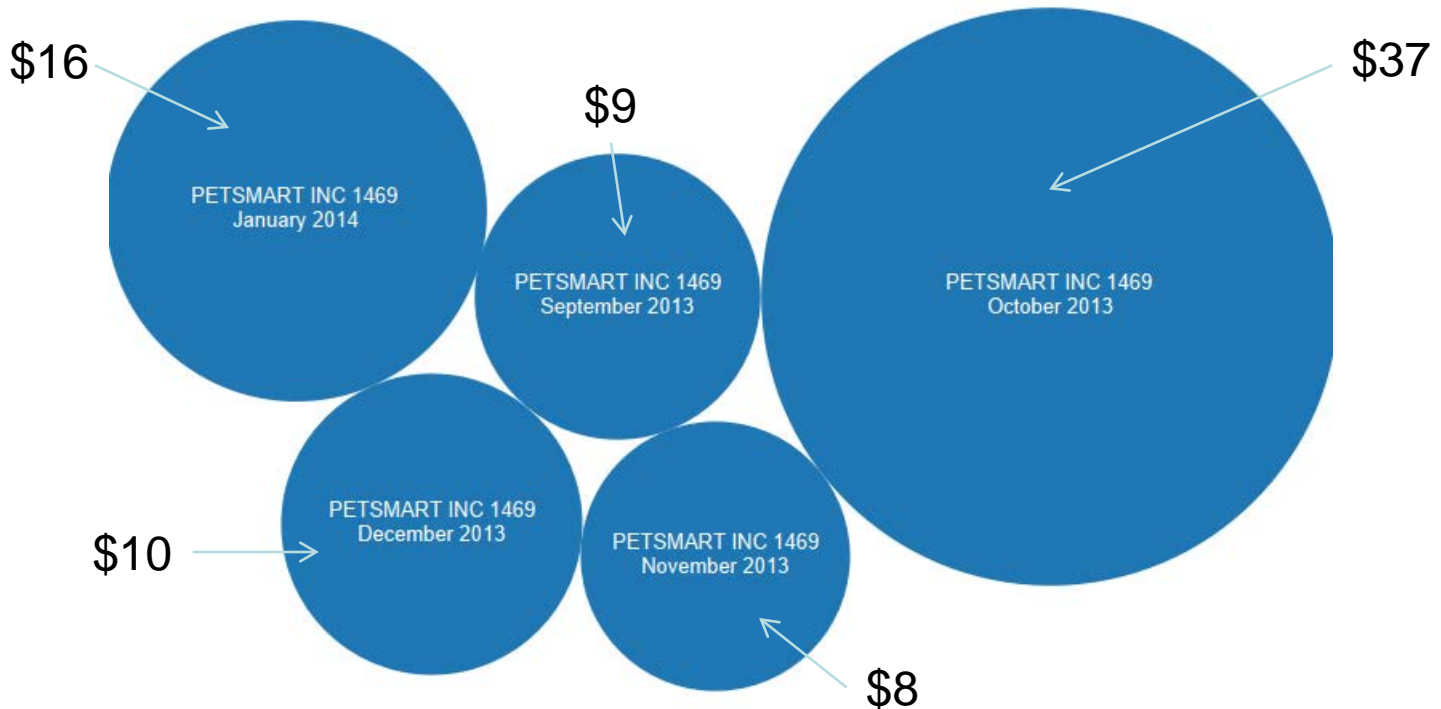
SECOND PHASE – ID # 4360 @ Petsmart

43 total transactions for \$6542



SECOND PHASE – ID#1878 @ Petsmart

Department: IAMS (legitimate)



KEY TAKEAWAYS:

- P-Card use has a high inherent fraud risk
- The “real expert” is not an absolute expert
- The tool will be needing constant updates
- Behavior profiling and clustering work is just starting as a second phase and will be added to the tool to improve its expertise. Hidden Markov Models and a hybrid Belief Networks/Dempster - Shafer approach will be applied in an AI approach
- iLisa will be a better expert than the human one!!!

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