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Audit-Focused Process Mining: The Evolution of Process Mining and Internal Control

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Dissertation Committee:

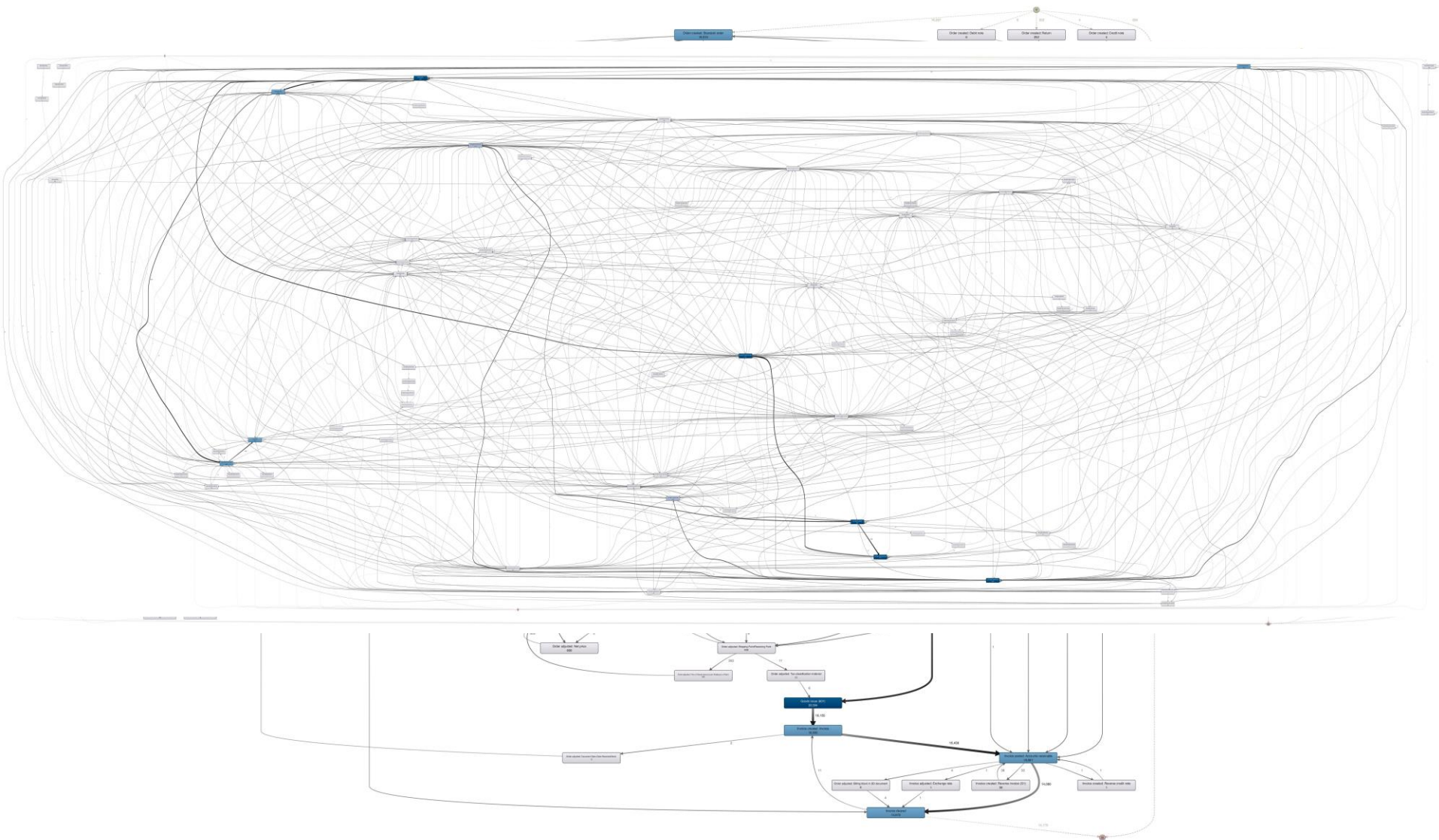
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What is Process Mining?



Why Process Mining?

- Digitization of business processes adds **complexity**, due to the **amount** of processes that occur **simultaneously** or with various lags (Kogan et al. 2010)
- This **increases** the **inability** of conducting business in the **ideal** process design (van der Aalst 2010)
- The **difficulty** in **understanding** and **evaluating** the **internal control** environment in today's business processes can be **facilitated** by the utilization of **process mining** techniques (Jans et al. 2014)
- Process mining can **address** the **problem** that most internal control experts face, which is having very limited information about what is **actually happening** in the business processes (Caron and Vantheinen 2012).

Motivation

- Auditors need to obtain an understanding of internal controls over financial reporting and performing analytical procedures (AS 12)
- Auditors conduct “walkthroughs”
 - inquiry of appropriate personnel
 - observation of the company's operations
 - inspection of relevant documentation
- Technology allows for different tools to validate information about companies and their business processes.

PROCESS MINING

Dissertation Focus & Overall Contribution

- This dissertation is an attempt to demonstrate the application of process mining in internal controls and its evolution
- Demonstrate how process mining can address issues auditors face in today's business environment, and how the future of process mining is envisioned

Three essays:

1. *The Application of Process Mining in Internal Control Risk Assessment*
2. *Process Instances Risk Prioritization*
3. *Continuous Process Monitoring*



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The Application of Process Mining in Internal Control Risk Assessment

Essay 1

The Issue

- SOX section 404 requires companies to establish internal controls for financial reporting and assess them via auditors to ensure their effectiveness
- Auditors routinely fail to detect material weaknesses prior to a restatement

Reason:

- Auditors inaccurately assess control risk by misclassifying the severity of identified internal control deficiencies due to complexity in judging the materiality and likelihood of potential related errors (Aobdia et al. 2016)

Motivation

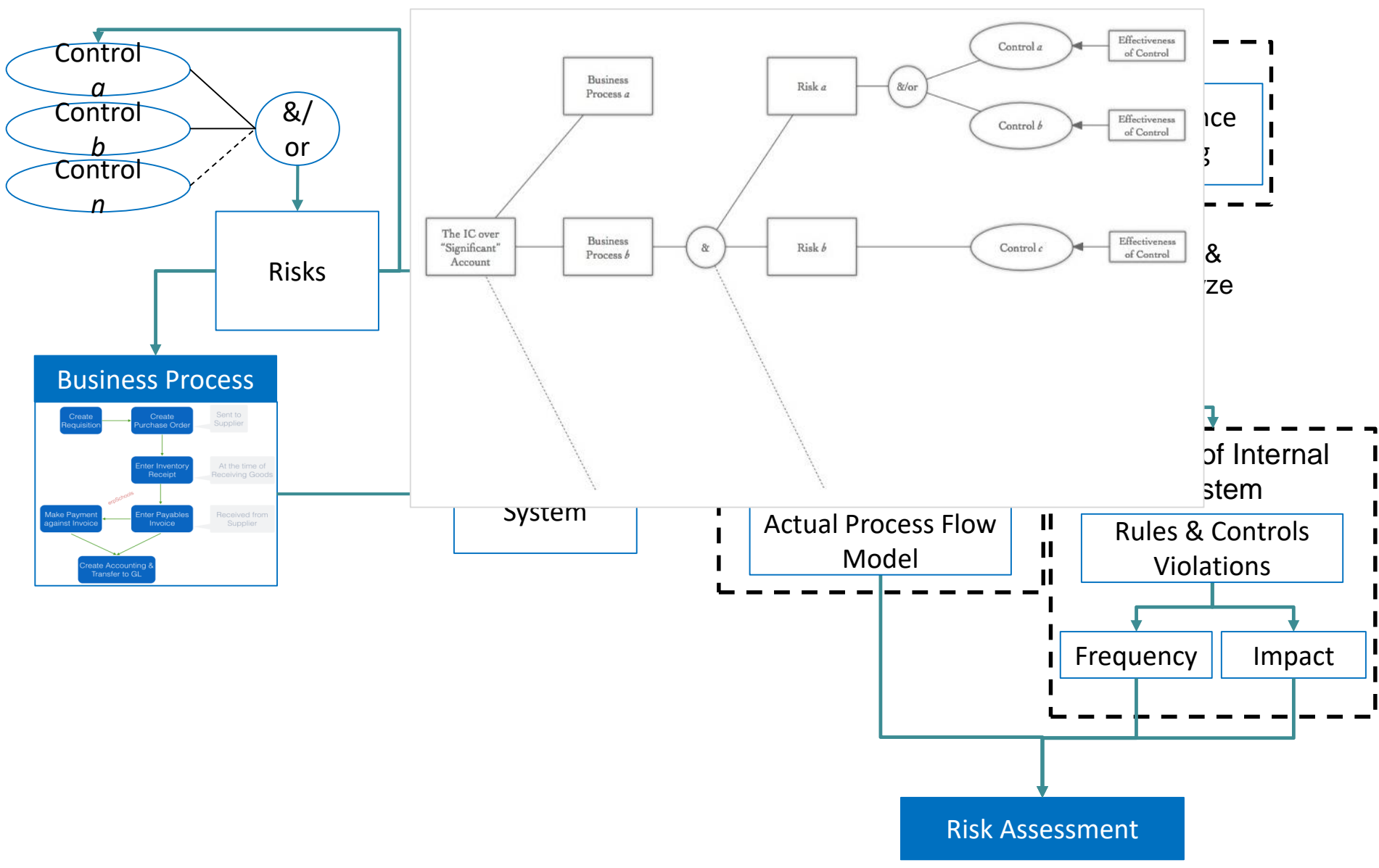
- Large number of transactions being executed on a daily basis
- To get any real comfort over the operating effectiveness of an internal control procedure is to test every instance of it running
- Most controls are now evidenced somewhere in an organization's computer systems
- Process mining can be used to detect violations of controls
- Exceptions can be used not only for investigative purposes, but also to assess control risk

Contribution

- Develop a framework to assist auditors in assessing and issuing an opinion on the effectiveness of the internal controls system for an organization
- Use process mining to formalize the measurement of controls by analyzing business workflows and identifying exceptions of transactions
- Showcase how process mining can be used as a tool to identify deficiencies in the internal control system and proposes a framework that auditors can use to quantify and objectively assess control risk

Methodology

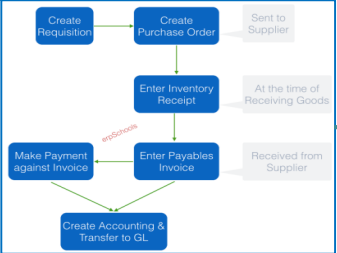
- Any business process consists of many different controls implemented to mitigate the risk of fraudulent activities and unintentional errors, to insure that the financial statements are represented fairly
- Auditors need to apply a two-part procedure when evaluating a business process:
 - check if controls are already implemented
 - evaluate and test if those controls are operating effectively



Control *a*
Control *b*
Control *n*

Risks

Business Process



The IC over "Significant" Account

Business Process *a*

Business Process *b*

Risk *a*

Risk *b*

Control *a*

Control *b*

Control *c*

Effectiveness of Control

Effectiveness of Control

Effectiveness of Control

system

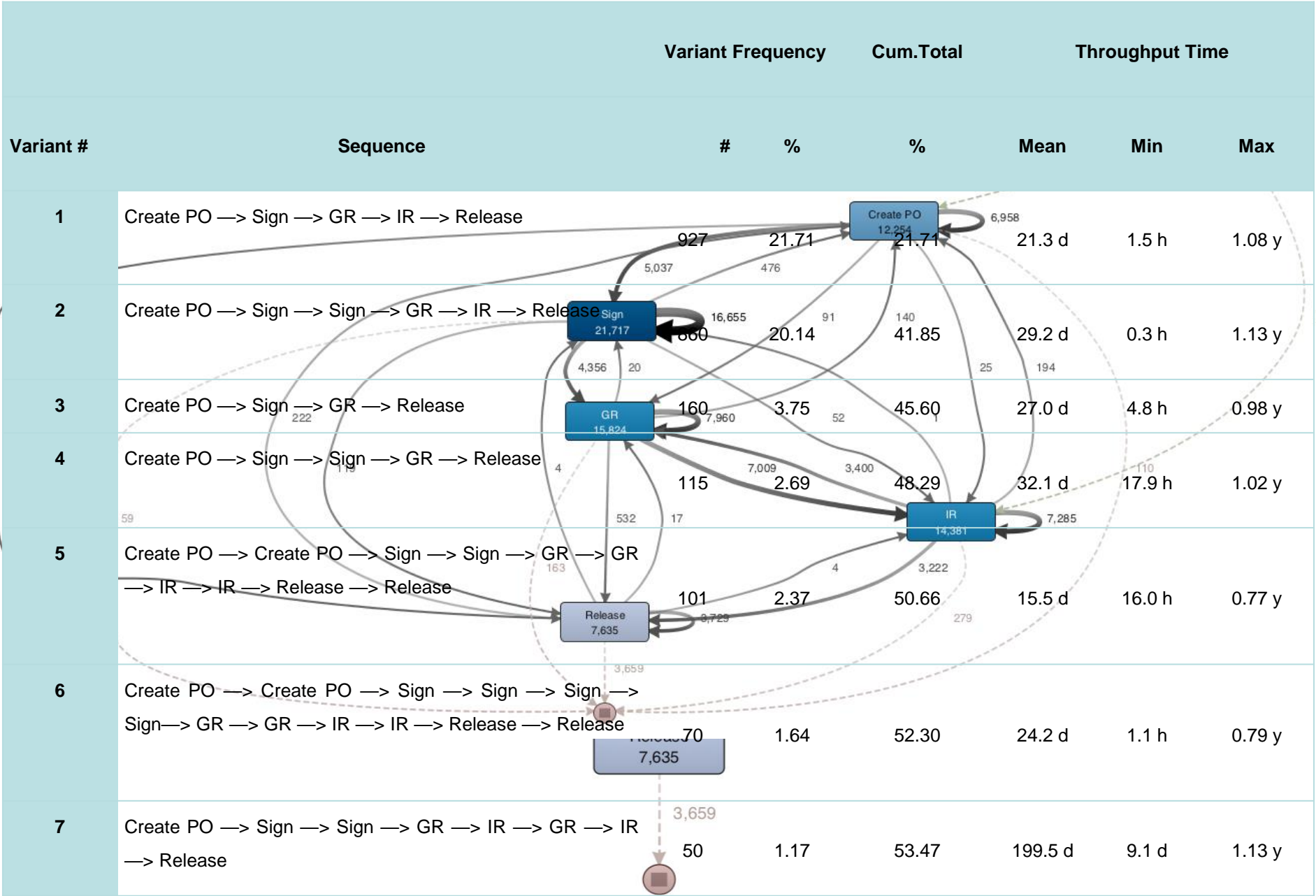
Actual Process Flow Model

Rules & Controls Violations

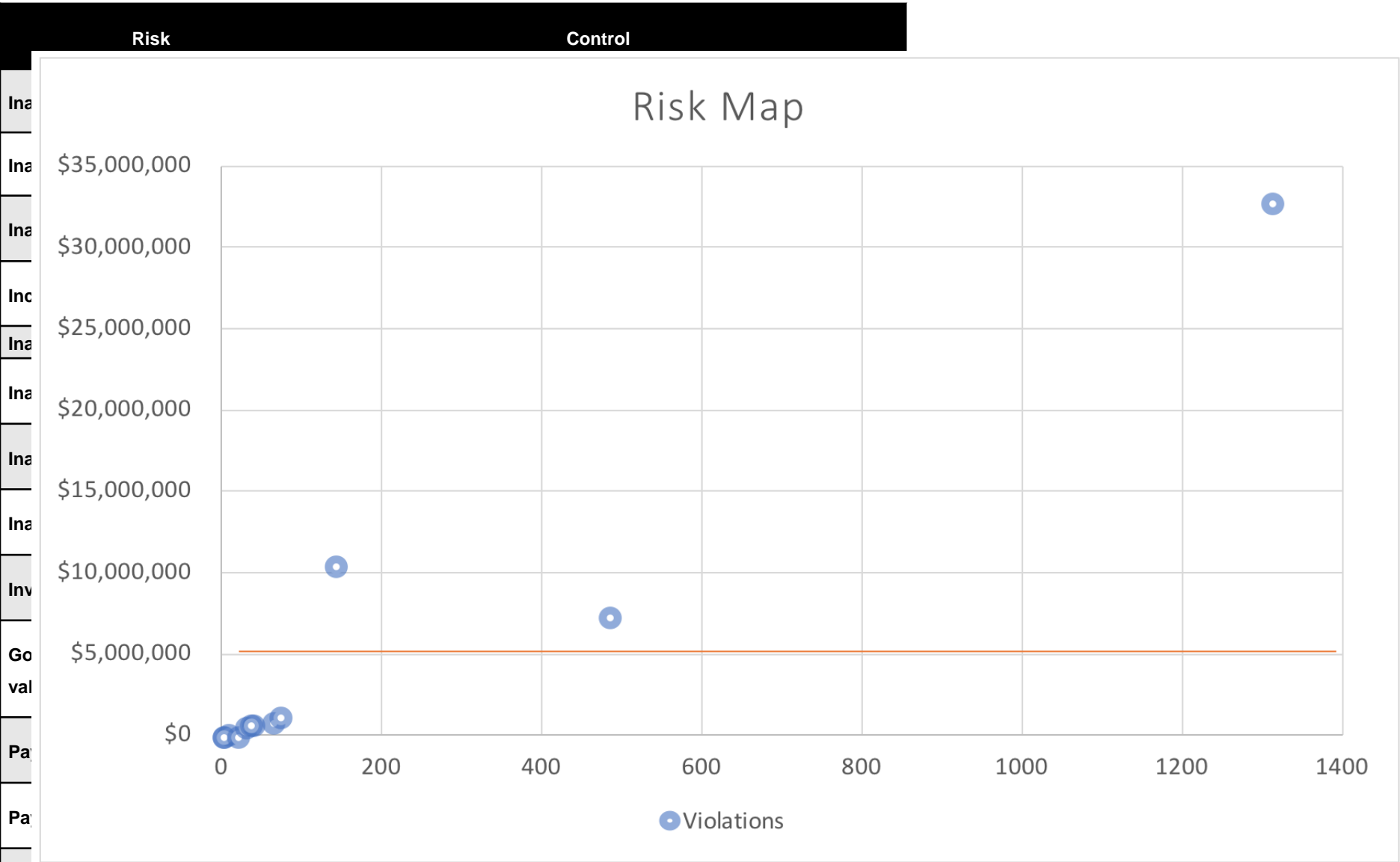
Frequency

Impact

Risk Assessment



Evaluation Of The Procurement Process Risks & Controls Model



Suboptimal task allocation

A good receipt activity must not be performed by a member of senior staff

Conclusion

- Demonstrate the use process mining to test internal controls to provide an overall risk assessment of the internal control system for a business process
- Provide auditors with a way to embrace a more formal internal control risk assessment process with quantitative outcomes
- **Limitation:** Not all types of controls were tested



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Process Instances Risk Prioritization

Essay 2

Introduction

- Complex ERP systems capture thousands if not millions of transactions on a daily basis
- It is impractical to analyze this huge amount of data using traditional and periodic techniques
- The use of advanced techniques result in generating an overwhelming amount of exceptions (Alles et al. 2006; Debreceeny et al. 2003)
- Process-aware information systems allow for dynamic process and service changes → leads to large number of process model variants (Li et al. 2008)
- Process mining analysis results into a large number of anomalies or exceptions that can be overwhelming

Contribution

- Proposing a methodology that provides auditors with guidance as to which notable transactions need further investigation based on a risk score
- The identification and prioritization of such risky process instances helps with the information overload problem that entails population testing
- Provide a solution to one of the challenges auditors face when applying process mining in their audit engagement
 - The large number of false positive variants

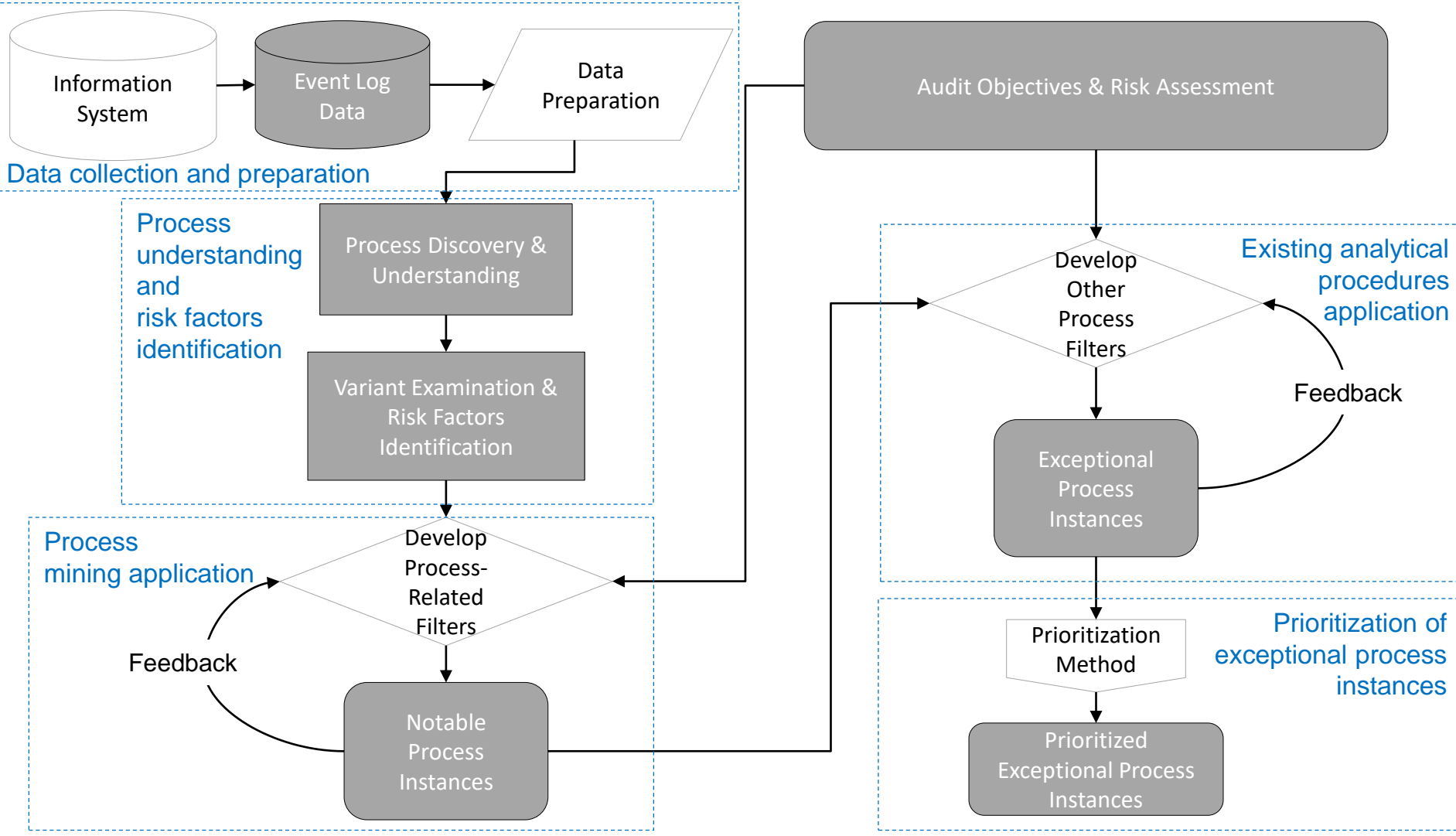
Contribution

- Provide guidance on the use of process mining in conjunction with existing analytical procedures to:
 - allow auditors to focus on process instances that are likely to be considered high-risk
 - reduce the risk of failing to detect material misstatement
 - enhance audit effectiveness

Methodology

The methodology that is used to objectively score the riskiness of transactions is based on:

- Process mining with filters
 - Filters mapped to the risks and controls for the targeted business process
 - Each filter is given a weight based on importance and relevance using auditor judgment
- Other analytical procedures to identify exceptional transactions from the notable subpopulation
- Exceptional transactions will be scored based on the number of violations for each transaction along with the transactional value.
- Transactions will be ranked based on their risk score



Risk Score Formula

$$\text{Risk Score } (X_i) = \sum W_{F_j} V_{F_j} M_{X_i},$$

Where

- *X* refers to the exceptional process instance
- *W* is the risk level of filter F_j
- *V* is the binary variable that equals 1 if process instance X_i violates filter F_j , and 0 otherwise
- *M* is the monetary value of process instance X_i

Data

- Data Preparation:
 - 128 process instances with 21 variants that lacked both GR and IR activities and had a PO value of \$0
 - Days of the week were added to the event log based on the timestamp in order to apply related filters

Events	71,203
Beginning Process Instances (P.I.)	4,270
Removed Incomplete P.I.	(128)
Final Number of P.I.	4,142
Variants	1,040

Application & Results (Process Mining)

Risk Factor Category	Sub-Category	Filter	Risk Level
Missing Key Activity	Missing GR activity	Any process instance missing GR	High
	Missing IR activity	Any process instance missing IR	High
	Missing Release activity	Any process instance missing Release	High
Problematic Order	Unusual start for a PO	Process instances starting with IR	Medium
	Payments before all goods are received	Payment before GR	High
	Ending with Create PO	Process instances ending with Create PO	Low
	Ending with GR	Process instances ending with GR	Low
Segregation of Duty	SOD violation	The employee who created the order also released the order	High
Weekend Activity	Unauthorized weekend activity	Process instances with activities happening on weekends	Medium

1,346 unique notable process instances

Application & Results (Analytical Procedures)

Risk Factor Category	Sub-Category	Filter	Risk Level
Missing Values	Missing PO value	Any process instance missing PO value or equals \$0	High
	Missing PO quantity	Any process instance missing quantity value for PO	High
	Missing Invoice	Any process instance missing invoice value	High
2-Way Match Violation	Unmatched PO and goods values	Any process instance with PO and GR values that do not match	High
	Unmatched PO and goods quantities	Any process instance with PO and GR quantities that do not match	High
	Unmatched goods and invoice values	Any process instance with GR and IR values that do not match	High

814 unique exceptional process instances (457 > \$5,000)

Application & Results (Prioritization)

Process	Missing IR	Missing Release	Unusual start	Pay before GR	Create PO ending	GR ending	SOD violation	Weekend	Missing PO value	Missing PO quantity	Missing invoice	Unmatched PO & GR	Unmatched	Unmatched GR & IR	Violation	Score	Monetary Value	Risk Score
Instance	3	3	2	3	1	1	3	2	3	3	3	3	3	3				
88702		X						X				X	X		11	\$11,579,094	127	
88814		X						X				X	X	X	14	\$7,882,137	110	
87646								X				X	X	X	11	\$3,137,867	35	
87639								X				X	X	X	11	\$2,659,998	29	
89106								X				X	X		8	\$3,120,400	25	
89465						X						X	X	X	10	\$1,507,415	15	
88749						X						X	X	X	10	\$1,179,759	12	
89503	X	X		X								X	X		13	\$877,638	11	
87640								X	X			X	X	X	14	\$729,189	10	
88816		X										X	X	X	12	\$686,957	8	

Framework Comparison

	Process Instances Risk Prioritization Framework		Chiu et al. (2018)	
	<u>Count</u>	<u>Percentage</u>	<u>Count</u>	<u>Percentage</u>
	Notable Process Instances	1,346	32.5%	3,918
Exceptional Process Instances	814	19.7%	--	--
Threshold	457	11.0%	1,227	13.4%

Conclusion

- The aim and contribution of this study is to provide auditors with guidance on the use of process mining in conjunction with existing analytical procedures to identify exceptional transactions that would require further investigation
 - Focus on process instances that are likely to be considered high-risk
 - Reduce the risk of failing to detect material misstatement
 - Enhance audit effectiveness.
 - Help with the information overload problem that entails population testing
- **Limitation:** Depends on the filters developed in the different stages of the framework and the weight given to each filter
- **Future Work:**
 - Switch the application of process mining and other analytical procedures.
 - Implement the risk score methodology found in this study to a continuous process mining solution to allow or block transactions based on their risk score



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Continuous Process Monitoring

Essay 3

Motivation

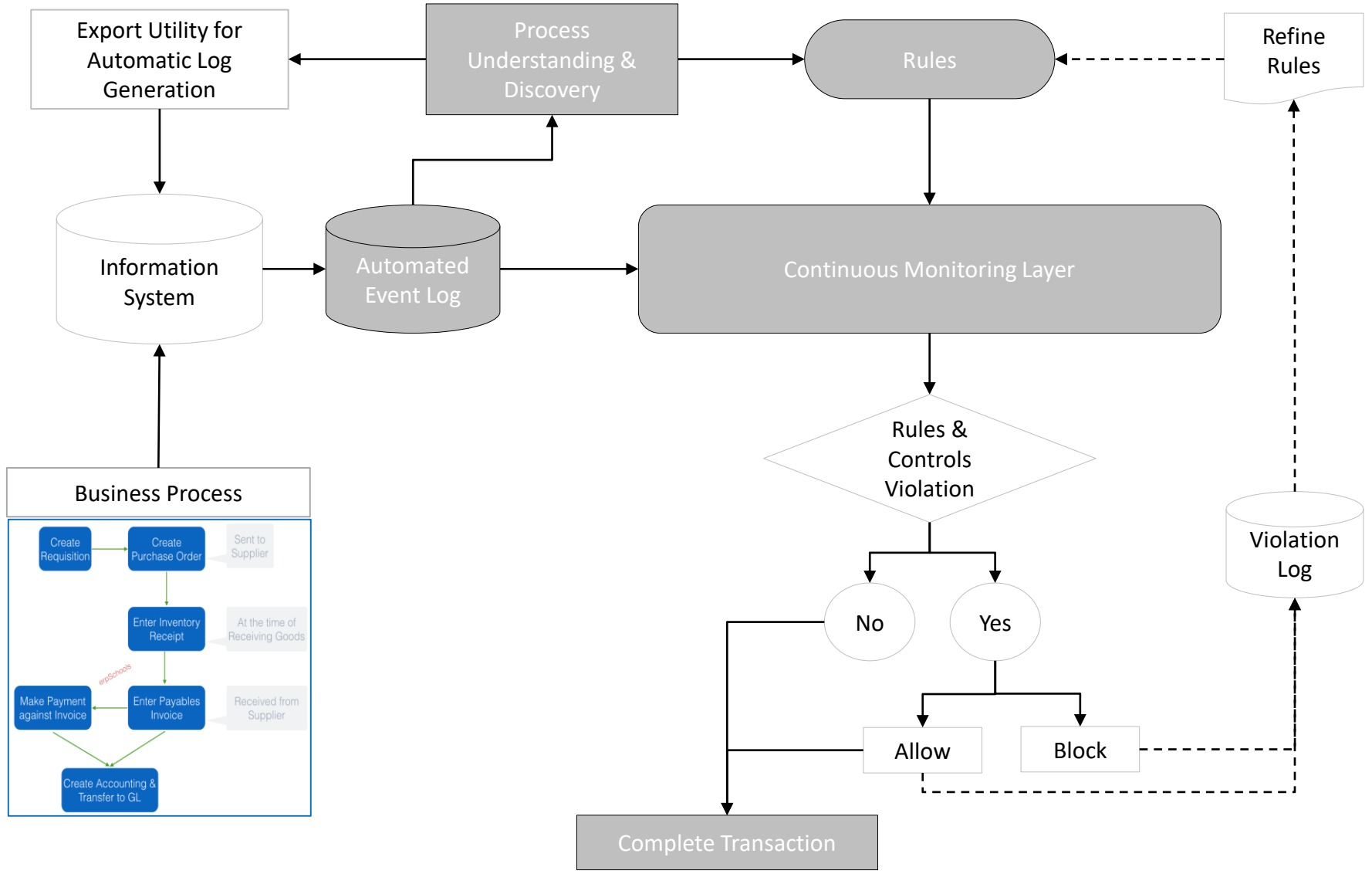
- Reduce the time delay between the **occurrence** and the **analysis** of business operations related events
 - increases the **information value**
- Do it automatically and continuously
- Today's business **environment** allows for the adoption of **continuous analytical monitoring-based** assurance because of the **electronization** of firms through the widespread use of ERP systems (Vasarhelyi et al. 2004)

Contribution

- Develop a **novel approach** for assurance that **combines** the advantages of **continuous monitoring** with those of **process mining**
- **Actively detect** and **investigate deviations** and exceptions **as they occur** along the transaction process
- The use of **process mining** on a **continuous** basis to **monitor** business processes and provide **assurance** hasn't been found in the auditing literature

Methodology

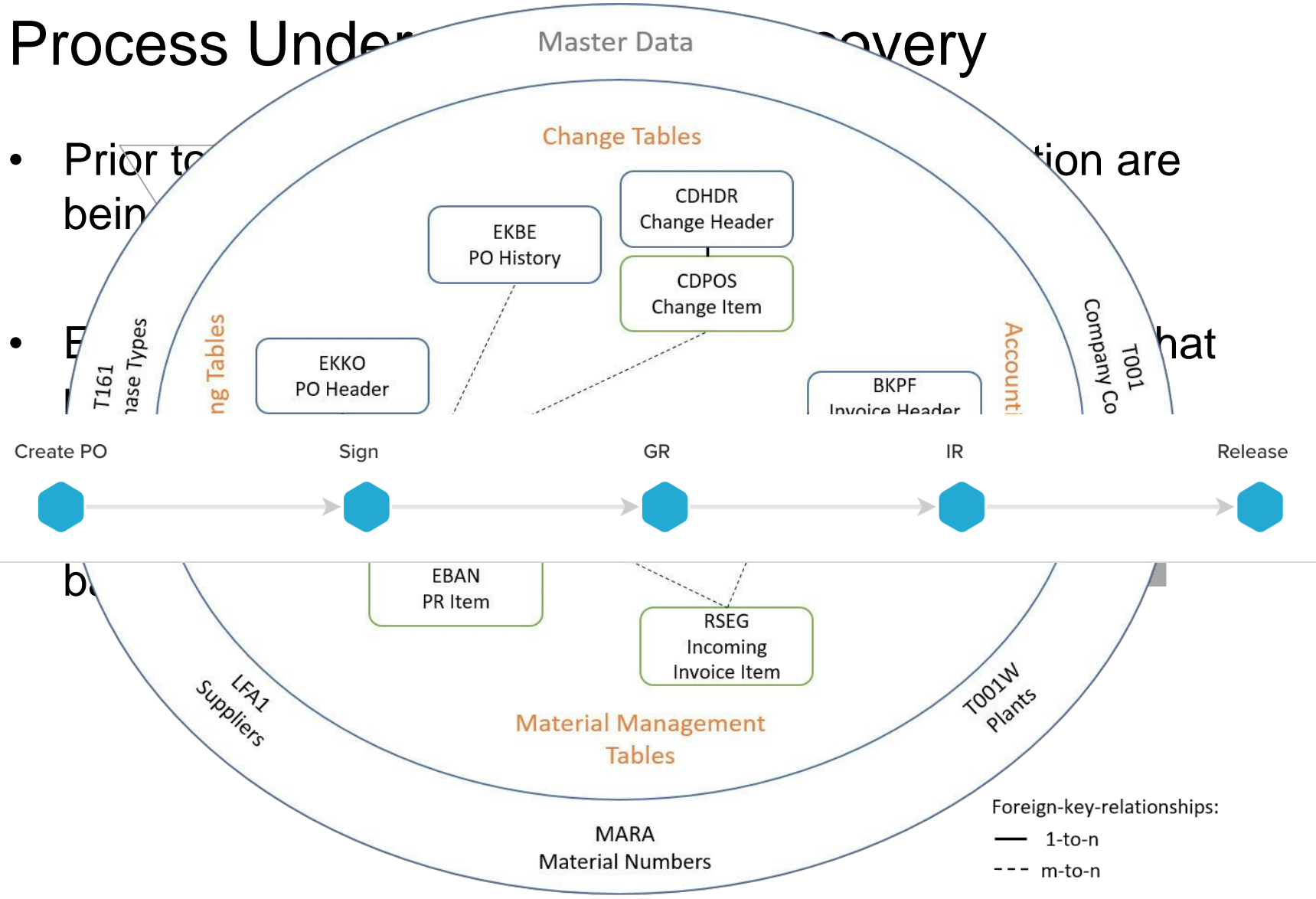
- Continuous Monitoring with Process Mining techniques
 - Based on a monitoring control layer
 - Rule-based process mining
- Implementing this methodology requires two key components:
 - IT structure that facilitates data gathering
 - Analytic monitoring methodology to support continuous monitoring (Vasarhelyi et al. 2004)



Process Under Recovery

- Prior to being
- E

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hat



Automatic Log Generation

- Automatically generate the event log and event streams to be used as an input for the continuous monitoring layer
- To automate log extraction, there needs to be an export utility on top of the system.
 - This can be an SAP Plug-in.
 - The plug-in has to be engineered for that system.
- The export utility **extracts** the required information as the activities are being performed for a transaction, and join them to **automatically** generate the log
- Ensures continuous flow of data

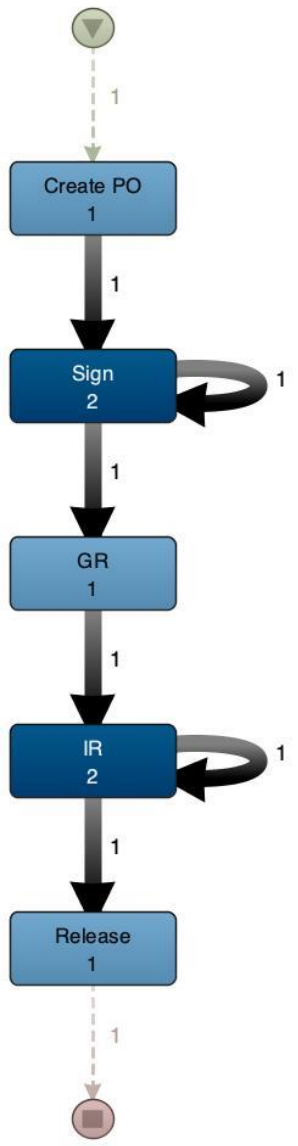
Rule Pattern	Example from the P2P process
An activity of type <i>a1</i> must be performed at least once	A <i>sign</i> activity must be performed at least once
If an activity of type <i>a1</i> is performed then an activity of type <i>a2</i> must be performed	If a <i>goods receipt</i> activity is performed then an <i>invoice receipt</i> activity must be performed
An activity of type <i>a1</i> must be started/ completed before/ after/on <i>t</i> time units	A <i>Sign</i> activity must be started before date of <i>goods receipt</i>
A person must not perform both activities for role <i>r1</i> and activities for role <i>r2</i>	A person must not <i>sign</i> and <i>release</i> the same <i>purchase order</i>
A person must not perform both an activity of type <i>a1</i> and an activity of type <i>a2</i>	A person must not <i>sign</i> and perform a <i>good receipt</i> activity for the same <i>purchase order</i>
A person must not perform all activities of the activity type set <i>sA</i>	A person must not perform all activities of the P2P process
An activity of type <i>a1</i> must be performed under μ	A <i>good receipt</i> activity must be performed during regular business hours
A person must perform an activity of type <i>a1</i> before/at/after time <i>T</i> (with <i>T</i> referring to time/activity/event)	A person must perform a <i>release</i> activity after time <i>T</i> = timestamp of <i>goods receipt</i> event
An activity of type <i>a1</i> must be performed by a member of role <i>r1</i>	A <i>release</i> activity must be performed by a member of <i>senior staff</i>
An activity of type <i>a1</i> must not be performed by a member of role <i>r1</i>	A <i>good receipt</i> activity must not be performed by a member of <i>senior staff</i>
The value for event data type <i>a1</i> must be specified	The value of a <i>purchase order</i> must be specified
The value of event data type <i>a1</i> is equal to the value of event data type <i>a2</i> and <i>a3</i>	The values of <i>Purchase order</i> , <i>goods receipt</i> , and <i>invoice receipt</i> must match before the corresponding invoice can be paid
The value of data type <i>a1</i> may not change before/at/ after a completion of activity <i>a2</i>	The value of a <i>purchase order</i> may not change after a <i>sign</i> activity has been performed

Continuous Monitoring Layer

- Abstracted layer placed on top of the business process
- The CM layer is based on an independent system called the monitoring and control layer (Vasarhelyi et al. 2004)
- The layer **stores** the “**ideal**” **model** for the business process and the **rules** already defined
- Test each transaction against prescribed model and defined rules to catch violations

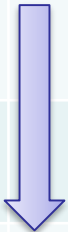
Case # 89501

Activity	Originator	
Create PO	P1	0
Sign	P1	0
Sign	P2	0
GR	P3	0
IR	P3	0
IR	P3	0
Release	P4	0



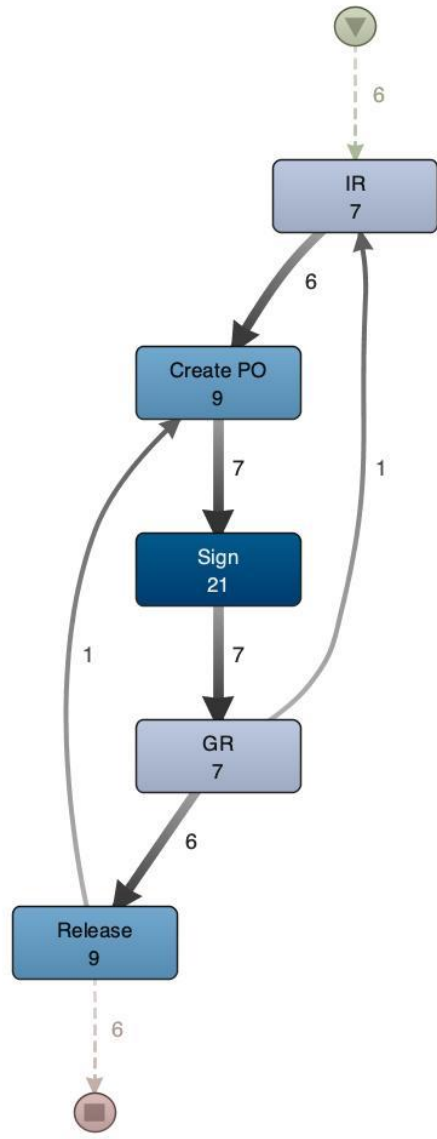
Value PO	Value GR	Value Pay
0.00		
0.00		
0.00		
0.00	600	
0.00	600	600.00
0.00	600	600.00
0.00		

Duplicate payment suspicion



Case # 90027

Activity	Originator
IR	P1
Create PO	P2
Sign	P2
Sign	P3
GR	P1
Release	P4



	Value GR	Value Pay
5	17,784	17,783.75
5		
5		
5		
5	17,784	
5		

6 cases where the first activity is an IR not a PO creation

Case # 89554

Activity	Originator	Timestamp	Value PO	Value GR	Value Pay
Create PO	P1	02/19/2016 12:19:01	15.71	Segregation of duty violation	
Create PO	P1	02/19/2016 12:19:01	49.00		
Sign	P1	02/19/2016 12:19:02	15.71		
Sign	P1	02/19/2016 12:19:02	49.00		
GR	P1	02/19/2016 12:20:27	15.71	15.71	3 way match violation
GR	P1	02/19/2016 12:20:27	49.00	49.00	
IR	P1	02/24/2016 11:51:45	15.71	15.71	21,783.05
IR	P1	02/24/2016 11:51:45	49.00	49.00	21,783.05
Release	P2	02/24/2016 14:26:28	15.71		
Release	P2	02/24/2016 14:26:28	49.00		

Conclusion

- Instead of reacting after the violations have long occurred, this solution allows auditors to actively detect and investigate deviations and exceptions as they occur along the transaction process by continuously monitoring business process controls and testing transactions
- Demonstrate the use of process mining as a preventative approach rather than detective (rarely found in the auditing literature)



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Conclusion

Conclusion

- **Essay 1**

- Contributed by providing auditors with a way to objectively measure the effectiveness of internal controls and risk assessment
- Are controls are implemented, to what degree, and what's the impact?

- **Essay 2**

- Contributed by providing auditors with guidance on the use of process mining in conjunction with existing analytical procedures to identify exceptional transactions that would require further investigation
- The identification and prioritization of high-risk process instances help with the information overload problem that entails process mining

- **Essay 3**

- Contributed by providing a methodology to actively detect and investigate deviations and exceptions as they occur along the transaction process
- Demonstrate the use of process mining as a preventative approach rather than detective (rarely found in the auditing literature)

Thank You