21st World Continuous Auditing & Reporting Symposium

An introduction to the Jacquard research project

"Next Generation Auditing: Data-Assurance as a Service"

Building a Domain-Specific Language to capture concepts and methods of the Owner-Ordered Audit Tradition
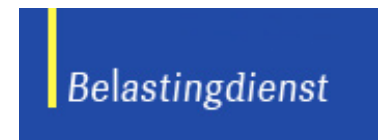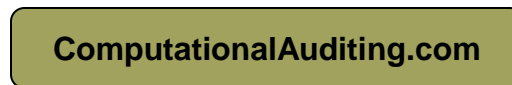
Philip Elsas

ComputationalAuditing.com

Rutgers, Newark, USA   **November 5-6, 2010**

Introduction

- **Since 2003: Company - Canada, Netherlands**

  Offering software and consultancy services to innovate audit practices and audit software firms

- **1988-2003: Deloitte.**

  with '97-'99 intermezzo at Bakkenist Management Consultants, sold to Deloitte.

  - **Principal, chief architect & inventor of Smart Audit Support**
  - **Smart Audit Support: since 1994 key in Deloitte's worldwide audit practice. Currently integrated in 'The Deloitte Audit'**
  - **System blueprint in chapter 5 of …**

- **1990-1996: PhD Computational Auditing**

  - **PhD in Mathematics & Computing Science on Financial Auditing**
  - **In parallel to Smart Audit project, 30% part-time, *Vrije Universiteit***
  - **Directly after appearance awarded with the biennial Alfred Coini Prize for the best publication in Auditing**

The Dutch Tax Office used Computational Auditing in 2001-2003 as frame of reference to compare Big 4 planning and decision-support models & systems to investigate how to improve audit productivity (57 page report); considers Smart Audit Support 'leader of the pack'

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Agenda

**Building a Domain-Specific Language (DSL)
to capture concepts and methods
of the Owner-Ordered Audit Tradition**

- **Audit Domain Challenge**

- **Owner-Ordered Audit Approach**

- **Jacquard project
  "Next Generation Auditing:
  Data-Assurance as a Service"**

Netherlands ranks in population as US state no. 5, between Florida & Illinois

Netherlands ranks in GDP as US state no. 4, between New York & Florida

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Today's audit challenge No.1

**International Federation of Accountants (IFAC),
"Financial Reporting Supply Chain"**

*"Shareholders should more actively pursue their ownership responsibilities" &
"Align managerial behavior with the interests of the owners",
Jane Diplock, 2010*

"Shareholders have little to say in the USA" &

*"Push legislators for statutory duty of care to investors, and get over the Caparo ruling (UK)",
David Webb, 2010*

European Commission, "Corporate governance in financial institutions and remuneration policies", green paper, June 2010, § 3.5 "The role of shareholders"

" ... lead to the abstraction, or even disappearance, of the concept of ownership normally associated with holding shares" & footnote 18

*General questions 3 & 5:
"How to practically improve shareholder control of financial institutions, if still realistic?" &
Necessary reinforcements for the external auditor*

Gaspar et al. "Shareholder Investment Horizon and the Market for Corporate Control"

diagnosis   ComputationalAuditing.com   *remediation*

Today's audit challenge No.2

*International Federation of Accountants (IFAC),
"Financial Reporting Supply Chain"*

*"Moving forward, national accountancy organizations should be charged with inventorying, bottom up, systemic disconnects that are difficult to voice for individual audit firms fearful of offending clients, and synthesizing them in an anonymous fashion.",
Jules Muis, Washington, DC, 2010*

Connecting 'micro' to 'macro'

See Royal NIVRA project "Sharing Knowledge" ("Kennis Delen"), NIVRA.nl

*See: "Preparing for an Audit Mandate to Contribute to Systemic Risk Anticipation",
'de Accountant' & accountant.nl, 2009, with follow-up in 2010*

*"My concern is that they are making themselves irrelevant."
Steven Thomas about auditors, based on the E&Y - Lehman case, 2010*

*Rick Bookstaber's
Congressional testimonies on:
- Hedge Funds, 2009
- Derivatives, 2009
- Systemic Risk, 2008 & 2007*

with requested comment on financial reform, June 2010

diagnosis   ComputationalAuditing.com   *remediation*

Today's challenge
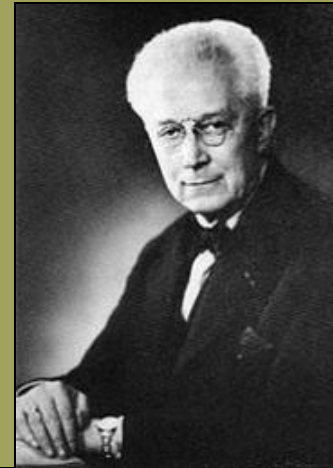
Th. Limperg Jr.

"Thus, the most important factor is society's needs, and the related factor that interacts with it is the ability of auditing methods to meet society's needs.

However, society's needs are not fixed and change over time.

Also, auditing methods can change and improve over time."

Douglas Carmichael, First and Founding Chief Auditor of the Public Company Accounting Oversight Board (PCAOB), with reference to the Theory of Rational Expectations by Th. Limperg Jr. (1879-1961) in "The PCAOB and the Social Responsibility of the Independent Auditor", 2004

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1840-1930: Two Main Directions of Audit

Money inflow for owners:
long-term ROI

Money inflow for management:
maximize equity

Owners

Management

NETH&UK

USA

Potential Owners

Owner-ordered audit, to check management:
to increase credibility that profits aren't UNDERstated, or unstated: that no revenues are missing& expenses (e.g. bonuses) aren't too high

Management-ordered audit, to attract new investors:
to increase credibility that profits aren't OVERstated: that stated profits are real, and not (partly) fake
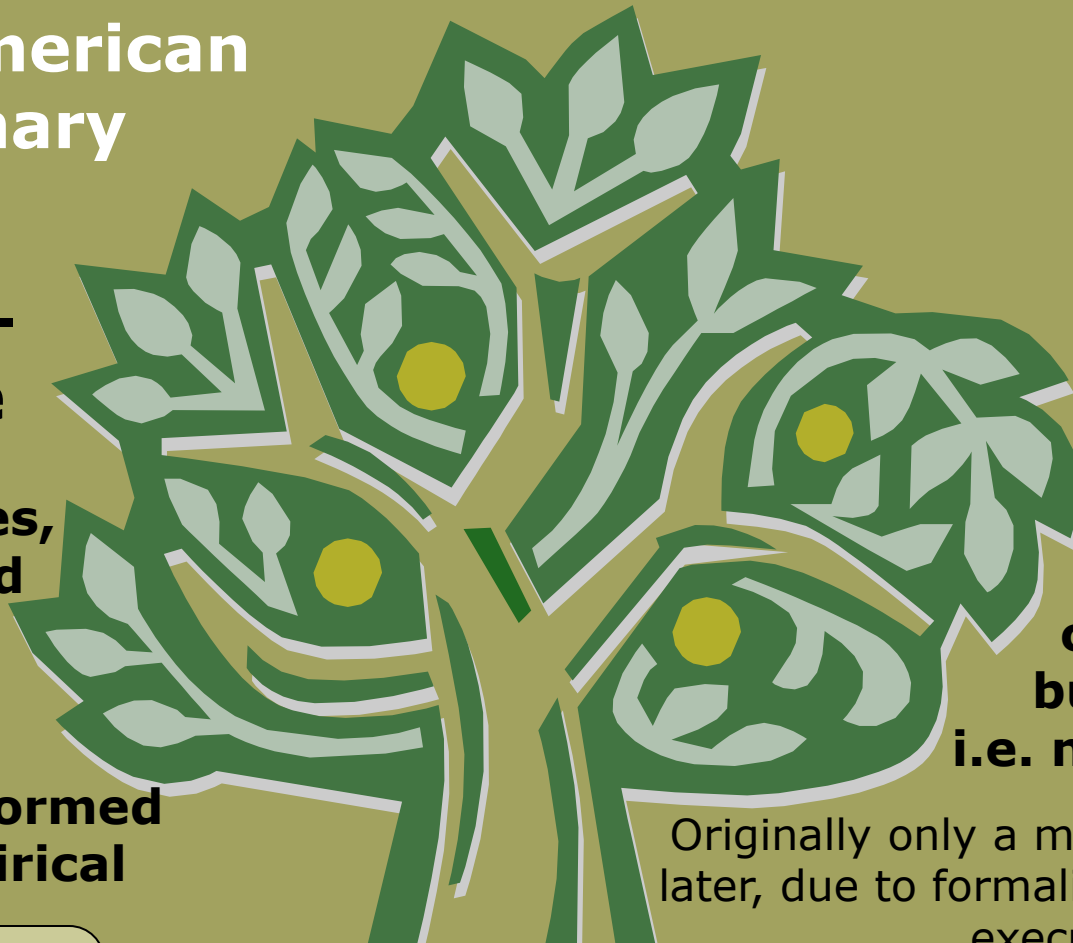
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1930-1990: Branching scientific approaches

Anglo-American evolutionary branch

practical-inductive

Audit policies, methods and standards follow from considering a lot of performed audits; empirical

1840-1930 foundation **management-ordered audit: overstated profits**

Dutch evolutionary branch

theoretical-deductive

Audit methods evolve from client's top-level business process, i.e. normative model

Originally only a mental process model; later, due to formalization, supported by executable process model
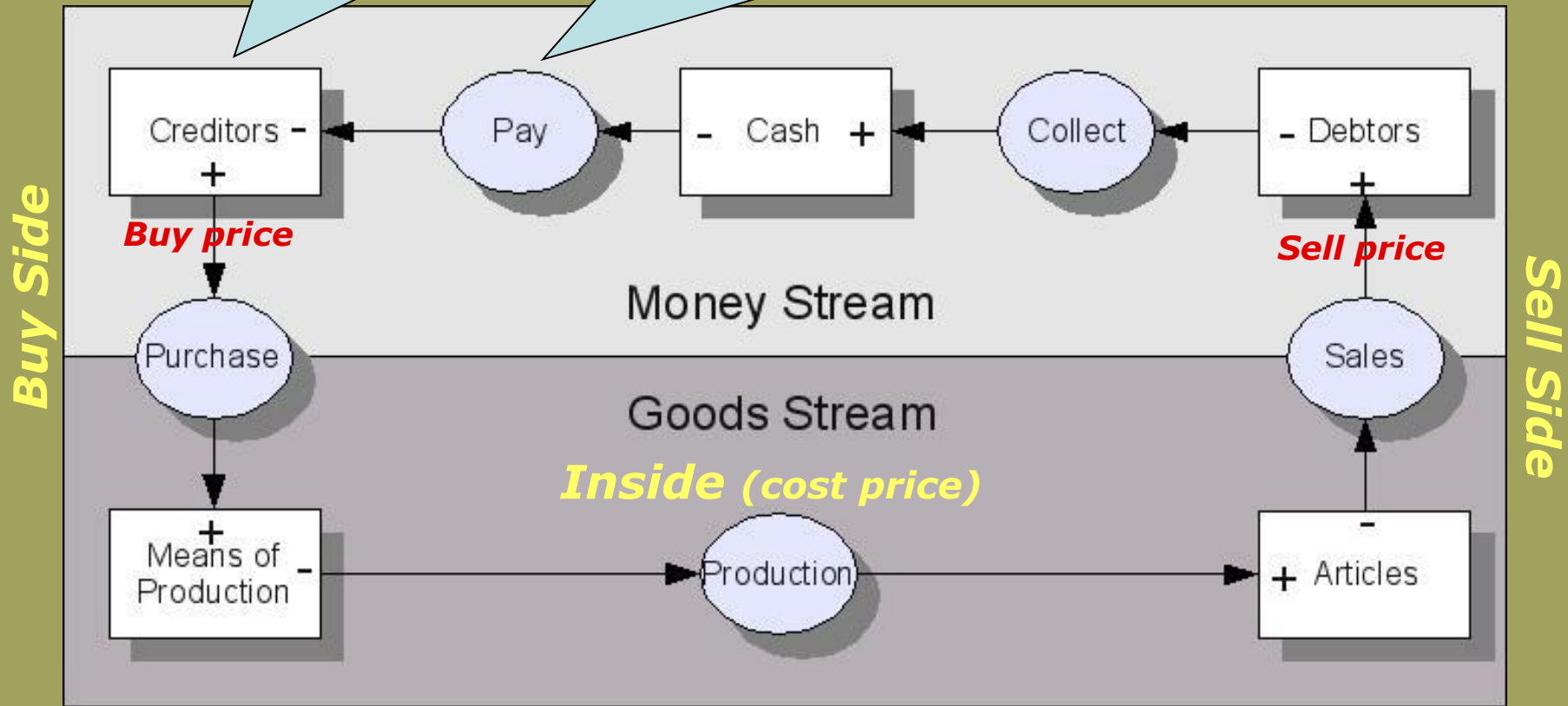
1840-1930 foundation **owner-ordered audit: understated profits**

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Supercycle: top-level business process

A rectangle represents a state, a balance sheet item

A circle represents a (trans)action, an activity, a mutation to connected states

'Soll' (To Be) & 'Ist' (As Is) modalities

Buy Side

Sell Side

Creditors −
+

Pay

− Cash +

Collect

− Debtors
+

Buy price

Sell price

Money Stream

Purchase

Sales

Goods Stream

Inside (cost price)

Means of Production
+
−

Production

+ Articles
−

Schmalenbach (1929), Limperg (1926, 1930's), Abr. Mey (1936), Burgert (1957), Starreveld (1962, 1980's), Frielink (1980's), Blokdijk (1975), Veenstra (1972, p.41)

Supercycle is key concept in Owner-Ordered Audit Tradition

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Addressing today's challenge no.1

Today we worldwide only use a management-ordered audit method. Ignoring the proven method of the owner-ordered audit.

Why don't we allow shareholders to substantiate their ownership responsibilities? Why not have long-term incentive structures imposed upon management via the owner-ordered audit method?

The potential risk pertaining to management picking up the bill for an integral two-way audit (the 'paying, thus dominating' risk), can be mitigated by continuing high-quality documentation ('if it's not documented, it's not audited'), complemented by governmental reviewing

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Addressing today's challenge no.2

Financial institutions are exposed to more moral hazard than ever before. Why not measure systemic risk while it's building up? Why not introduce preventive measures to reduce built-up?

A newborn, powerful preventive measure is the Royal NIVRA's 'Sharing Knowledge' project, with supportive technology.

The auditor is positioned to attest whether internal controls and incentives are in place to provide data of adequate reliability.

A reliability emphasizing long-term ownership interests.

Anything better to neutralize management's exposure to moral hazard than the owner-ordered audit?

Individual financial institutions might each be free of an internal systemic risk, while, as a collection, they may induce an external systemic risk. This occurs when a lot of institutions take a similar position, while the other side is not sufficiently covered. Loosely speaking: too many are on the same side of the ship, without them being able to see one another. The auditor is a pre-eminent party to make such accumulated systemic risk visible. It's a party that is able to aggregate information into systemic risk indicators - or to certify the required reporting channel - while taking professional care of confidentiality issues.

See: 'de Accountant', April 2010

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Golden opportunity for audit profession

Pull side

- **Improve the audit profession's relevancy to society**
  - **Individual audit: ownership orientation (chall. 1)**
  - **Contribute to systemic risk mitigation (chall. 2)**

Push side

- **R&D of supportive concepts and technology**

Match-making between 'pull' & 'push'

Internationalize the owner-ordered audit method.
This requires deep computational support. Why?

To minimize international, educational burden (3-years post-Master)

To streamline train-the-trainer, roll-out & getting ROI fast

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"Next Generation Auditing:
Data-Assurance as a Service"**

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Jacquard project:
Next Generation Auditing: Data Assurance as a Service

- **Project lead: CWI, the Dutch national Center of Mathematics & Computing Science, Paul Klint, Tijs van der Storm, Paul Griffioen + …**
- **Project partners:**
  - **PricewaterhouseCoopers, Jacques de Swart & Mona Mashaie (13th WCAS)**
  - **The Dutch Tax Office, Marc van Hilvoorde (XBRL)**
  - **ComputationalAuditing.com, Philip Elsas**
- **Project result: Domain-Specific Language (DSL) in Software as a Service (SaaS) architecture, 2010-2014**
- **Project sketch: RascalMPL- & model-based audit support**

www.cwi.nl/en/2010/1064/Software-engineering-researchers-and-audit-experts

Rascal is DSL to make DSLs

CWI — Centrum Wiskunde & Informatica

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pwc

Belastingdienst

What's a DSL?

In software development and domain engineering, a domain-specific language (DSL) is a programming language or specification language dedicated to a particular problem domain, a particular problem representation technique, and/or a particular solution technique.

The concept isn't new—special-purpose programming languages and all kinds of modeling/specification languages have always existed, but the term has become more popular due to the rise of domain-specific modeling.

Domain-specific modeling (DSM) is a software engineering methodology for designing and developing systems, such as computer software. It involves systematic use of a graphical domain-specific language (DSL) to represent the various facets of a system. DSM languages tend to support higher-level abstractions than general-purpose modeling languages, so they require less effort and fewer low-level details to specify a given system.

Source: Wikipedia

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What's supported by the DSL?

**Owner-ordered auditing:
dominating and integrating with management-ordered auditing**

- **Quantitative: completeness of management's stated profits**

- **Qualitative: assess irreplaceable internal control to
  secure actions of agents**

  - **assess what? long-term incentive & authorization structure**
  - **how? segregation of duties serving long-term owner interest**

- **Supercycle: client's top-level business process**

  - **from mental model to supportive process model**
  - **unifying quantitative and qualitative**

**Why, and how, the present financial crisis is driving owner-ordered
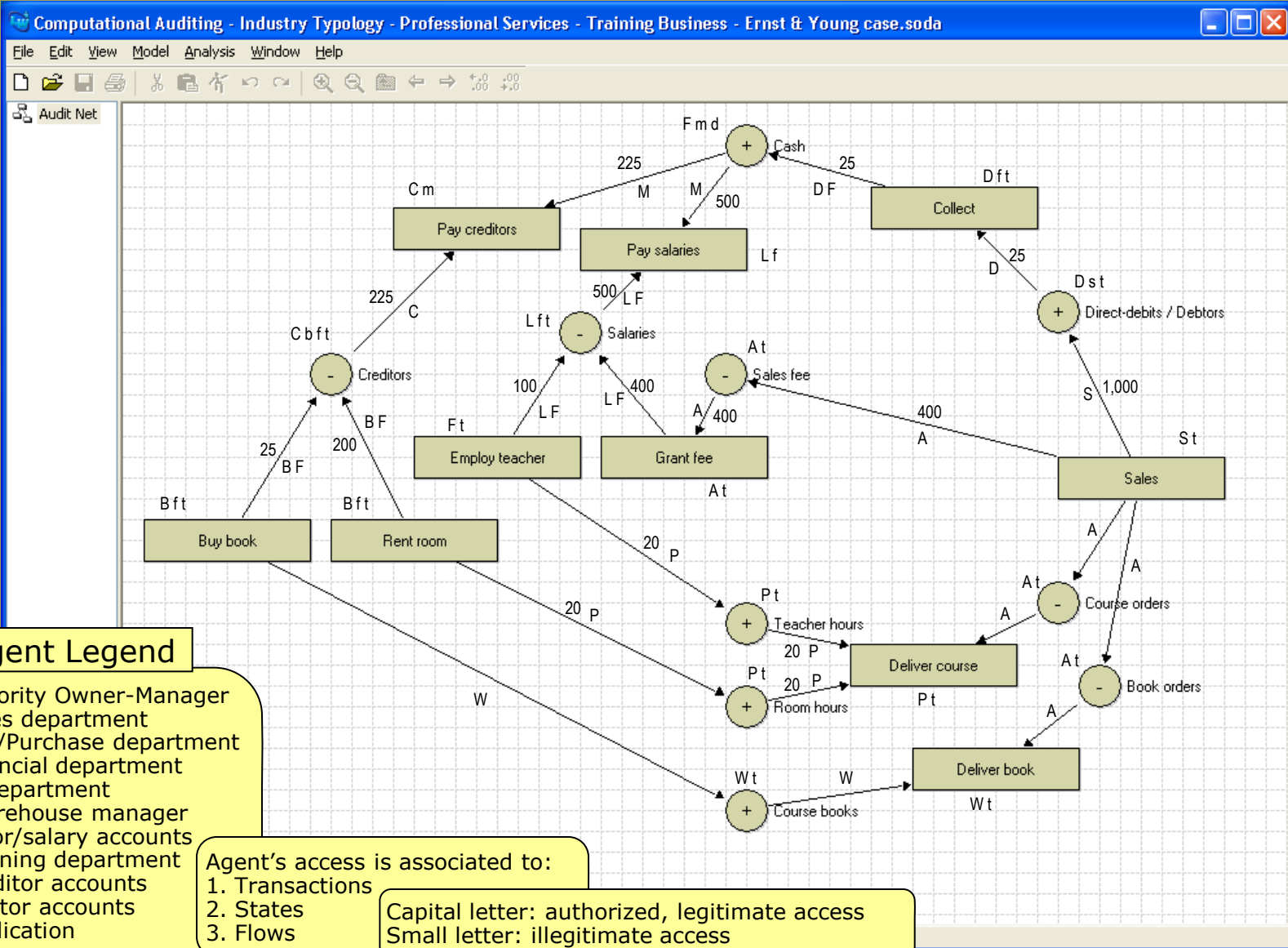auditing core concepts out of a local past and into a global future**

SIKS

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KONINKLIJKE NEDERLANDSE
AKADEMIE VAN WETENSCHAPPEN

Key Audit Phases

1. **Ist supercycle mining**
   Extend process mining to client's top business process

2. **Soll supercycle identification**
   Identify Soll supercycle in Ist smart flowchart

3. **Continuous auditing**
   **Confront a stream of business events to Soll,
   close-to-real-time; quantitative & qualitative**

4. **Collect, collate & aggregate deviations automatically**
   Supported by Dempster-Shafer-Srivastava method

5. **Publish deviation top-10 on supercycle dashboard**
   Interactive interface to query the enterprise; iPhone app

Phase 1: Ist supercycle mining

Agent Legend

M: Majority Owner-Manager
S: Sales department
B: Buy/Purchase department
F: Financial department
T: IT department
W: Warehouse manager
L: Labor/salary accounts
P: Planning department
C: Creditor accounts
D: Debtor accounts
A: Application

Agent's access is associated to:
1. Transactions
2. States
3. Flows

Capital letter: authorized, legitimate access
Small letter: illegitimate access

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SoDA - Computational Auditing - Process Mining - Procurement Process Flowchart discovered from Business Event Log [SAS 70 Statement Type II & SAS 99]

File Edit View Tool Help

Audit net

Identify Soll supercycle by excluding Ist flows, based on automatically identified candidate Ist flows

Apply constraints to check if remaining model is a valid Soll

Last save .... none
Elements 17

Agents

Process flowchart nodes:

Start

3232

Prepare

3232

Procurement request

A   2537   →   Receive invoice

2541   4752

Handled orders

B

10   2960   Approve   Purchase order   261   1678

3221   2541   875   Received invoice   803

D

Approved request   3232   Prepare order   Finalize order

2566   803

Purchase order   C

Record

2566   803

Disapprove   Received product   1678

9   Receive & accept goods or services   4540

10   Rejected request   11   Record   11   End

Add   Delete   Properties...

Analyzing 3232 cases, classi-fying casualties (red arrows):
A. Invoice receipt without prior approval (2537x)
B. Approval acquired after pur-chase completion (261x)
C. Purchase order established for rejected request (9x)
D. Handled order status skip-ping receipt (875x), etc.

Design-time workflow vs. run-time workflow

Based on: "Towards a Computer-Assisted Audit Analysis of Business Processes: Process Mining as Tool for IT Auditors", Maria Bezverhaya, Emiel Caron & Piet Goeyenbier, 'de EDP-Auditor', NOREA, 2009

Pull signal from audit practitioners & IT audit educators, e.g. "Process Mining" by Mieke Jans & CARLAB, Rutgers, 2010

Push signal from Technical University of Eindhoven, ProM, Fluxicon & Anne Rozinat

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On-the-fly, close-to-real-time checking of spanning business equations

Confront a stream of business events to Soll

"Continuity Equations" Miklos Vasarhelyi et al. CARLAB, Rutgers, 2010

Reconcile with external evidence
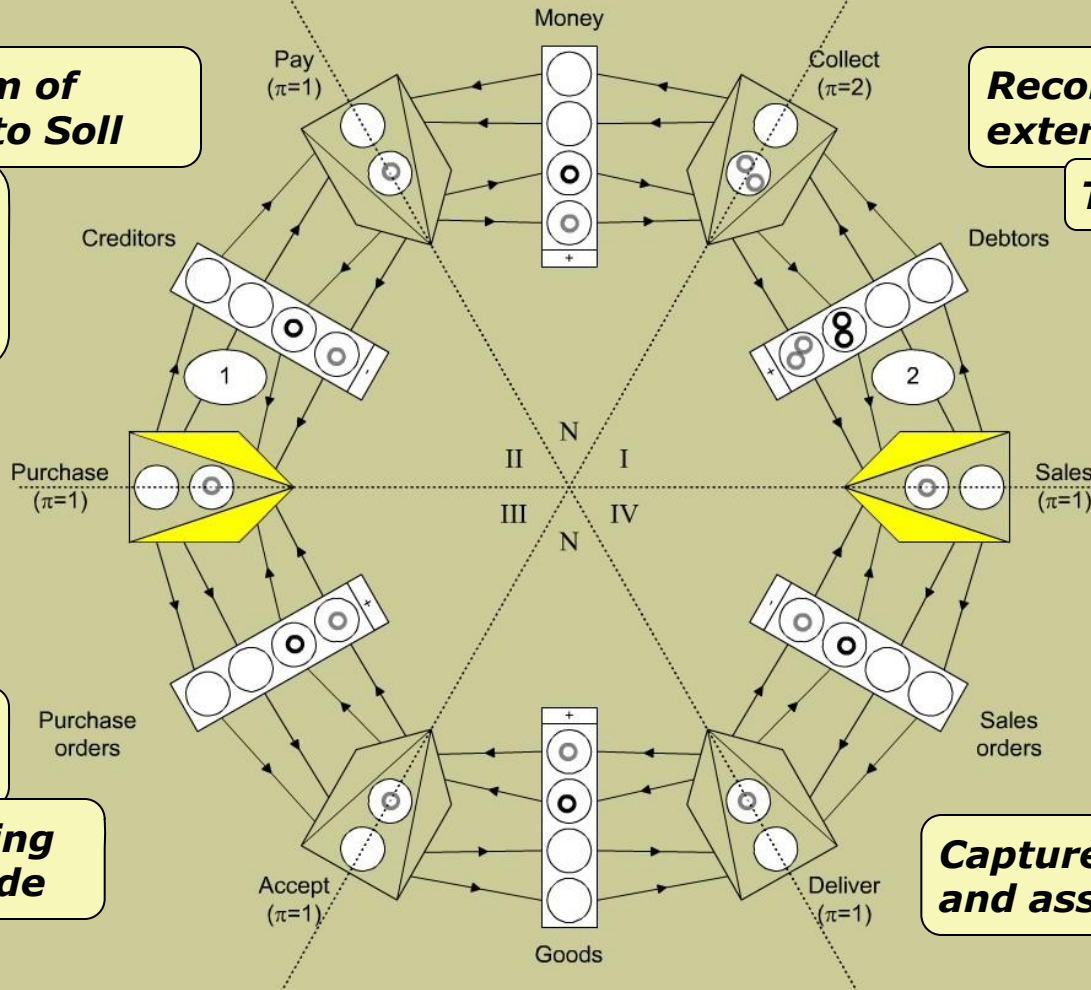
Triangulation

3rd party evidence processing

Interrelate all buffer contents

Especially spanning buy side & sell side

Capture deviations and associated risks

Money

Pay ($\pi=1$)

Collect ($\pi=2$)

Creditors

Debtors

Purchase ($\pi=1$)

N

II   I

III   IV

N

Sales ($\pi=1$)

Purchase orders

Sales orders

Accept ($\pi=1$)

Deliver ($\pi=1$)

Goods

http://www.ComputationalAuditing.com/images/Kring.swf

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Phase 3, Continuous Auditing, Quantitative: Continuous Checking of Spanning Equations

7) $(A/R)_B + \underline{\textbf{Sales}} + \textbf{TS} - (A/R)_E \rightarrow \textbf{C/R}$

6) $\underline{\textbf{COGS}} + \textbf{Gross Profit} \rightarrow \textbf{Sales}$

3) $(\textbf{Inv})_B + \underline{\textbf{P}} - (Inv)_E \rightarrow \textbf{COGS}$

2) $\underline{\textbf{C/D}} - (A/P)_B + (\textbf{A/P})_E - TP \rightarrow \textbf{P}$

1) $(\textbf{Cash})_B + \underline{\textbf{C/R}} - TO - (Cash)_E \rightarrow \textbf{C/D}$

8) $(\textbf{VAT})_B + \textbf{TS} - TP - TO \rightarrow (\textbf{VAT})_E$

Integrating owner-ordered audit method (quantities in boldface font on understatement & quantities in regular font on overstatement) **& management-ordered audit method** *(just the reverse audit direction)* **into two-way audit approach**

- Equation numbers relate to classical audit literature (Frielink et al.)
- The whole equation system is automatically generated from supercycle diagram. Sub-scripts 'B' and 'E' stand for Begin and End; C/R: Cash Receipts; A/R: Accounts Receivable; TS: value added Taxes received on Sales; COGS: Cost of Goods Sold; Inv: Inventory; P: Purchases during the period; A/P: Accounts Payable; TP: value added Taxes Paid on purchases during the period; C/D: Cash Disbursements; VAT: Value Added Taxes; TO: Taxes payment Outflow *(with thanks to Raj Srivastava)*

Phase 3, Continuous Auditing, Qualitative: Continuous Checking of Segregation of Duties

Continuous auditing web service intercepts Authorization Change Request & signals:

refuse

human intervention required

OK

X-Raying Segregation of Duties: Support to Illuminate an Enterprise's Immunity to Solo-Fraud, Int. Journal of Accounting Info. Systems, June 2008, pp.82-103

"Audit Automation as the Foundation of Continuous Auditing" Michael Alles, Alexander Kogan, Miklos Vasarhelyi & Donald Warren, 16th WCAS, 2008

**Answers the question:
"Free of opportunities for traceless embezzlement, without need to collude?"
Design, Implementation & Operation**

Segregation of Duties is key in irreplaceable internal control: irreplaceable in the sense that there is no way for an external auditor to compensate its lacking or failing, while it is indispensable for a rationally justifiable approval

Segregation of Duties is substantiated very strongly in Owner-Ordered Audit Tradition

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2 Receivables **+** **3 Inventories** **=** {

At least one non-current inventory

5 Assets *or*

5 Current Assets

All three inventories are current

Type Polymorphism: Least Upper Bound in the Taxonomy

XBRL US GAAP Taxonomy

- Statement of Financial Position [Abstract]
  - Statement [Table]
    - Statement, Scenario [Axis]
    - Class of Stock [Axis]
    - Statement [Line Items]
      - Assets [Abstract]
        - Assets, Current [Abstract]
          - Cash, Cash Equivalents, and Short-term Investments [Abstract]
          - Receivables, Net, Current [Abstract]
          - Inventory, Net [Abstract]
          - Prepaid Expense, Current [Abstract]
          - Deferred Costs, Current [Abstract]
          - Derivative Instruments and Hedges, Assets [Abstract]
          - Assets Held-for-sale, Current [Abstract]
        - Assets, Noncurrent [Abstract]
          - Inventory, Noncurrent [Abstract]
          - Property, Plant and Equipment, Net [Abstract]
          - Long-term Investments and Receivables, Net [Abstract]
          - Goodwill
          - Intangible Assets, Net (Excluding Goodwill) [Abstract]
        - Assets, Total
      - Liabilities and Stockholders' Equity [Abstract]

Aggregation in XBRL:
- **Calculation linkbase**
- **XBRL Formula**

Articulate XBRL Assurance functionality using a dedicated website builder (plug-ins) instead of handcrafting XBRL Formula's

See: "On Positioning XBRL Assurance Business Rules in a Computational Infrastructure for Modern Auditing", 2009, University of Kansas, Annual International Conference on XBRL

Plug-in: transferable 'type polymorphism' mechanism for XBRL Assurance Builder & Player

Domain-Specific Language (DSL) for auditing: Pacioli, developed by Dutch software partner in cooperation with national research center for mathematics and computer science in the Netherlands (CWI) & University of Amsterdam

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Phase 4, Aggregate deviations, don't stop at individual audit: Nexus micro-macro

"Preparing for an audit mandate to contribute to systemic risk anticipation", accountant.nl

"Automatic aggregation in auditing, with an application to systemic risk anticipation", 19th World Continuous Auditing & Reporting Symposium, Rutgers, New Jersey, 2009

Royal NIVRA's 'Sharing Knowledge' project & "Risk control and technology", Royal NIVRA Dutch Auditing Day, Amsterdam, 2009

With supporting technology to:

1. **Receive input data streams via auditor-certified channels:** *to assure data is reliable from a long-term ownership perspective*

2. **Aggregate data anonymously**

3. **Present a Rosling-style big picture of Bookstaber's systemic risk indicators, with built-in triggers for timely alerts:** *to pro-actively inform financial institutions, why not via their auditors?*

See: challenge no. 2

"Hans Rosling shows the best stats you've ever seen"

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Phase 4, Nexus micro-macro: sustainability

The owner-ordered audit method of assessing the completeness assertion is superbly transferable from 'completeness of revenues' to 'completeness of pollution'
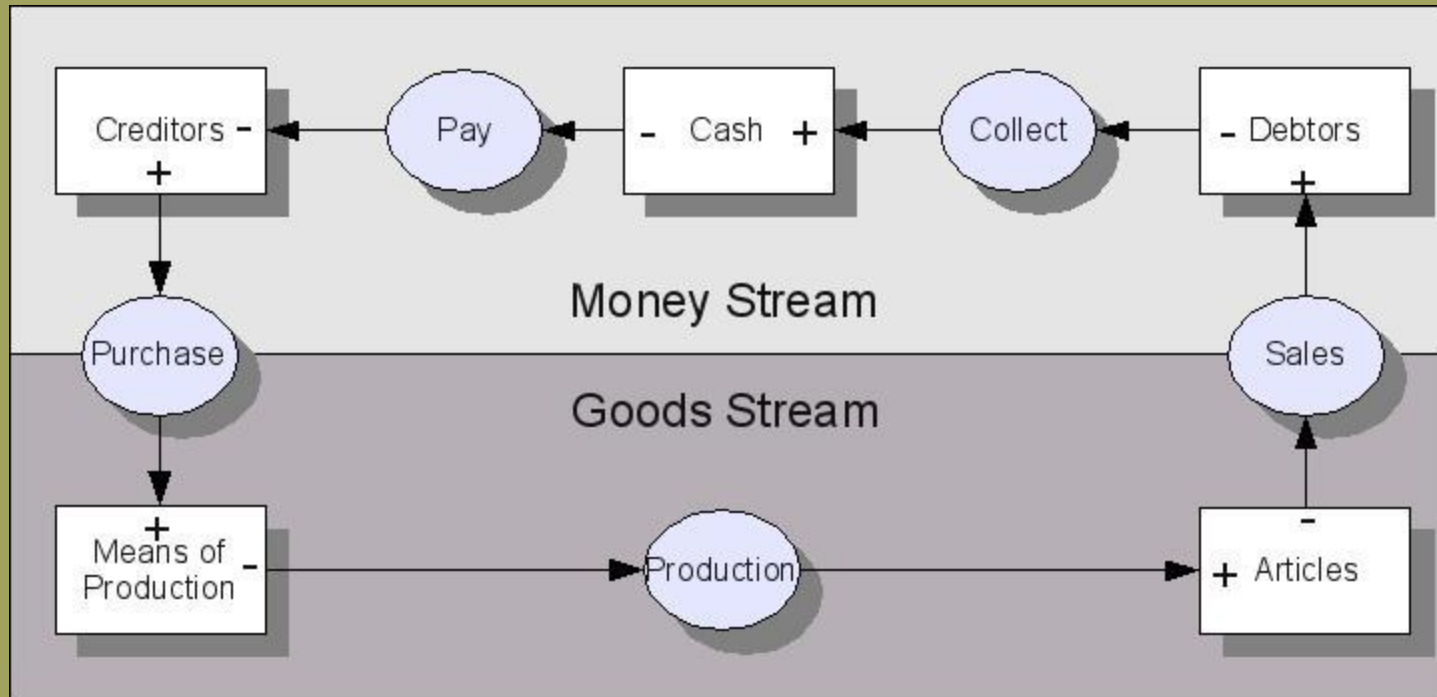
Publish on interactive dashboard
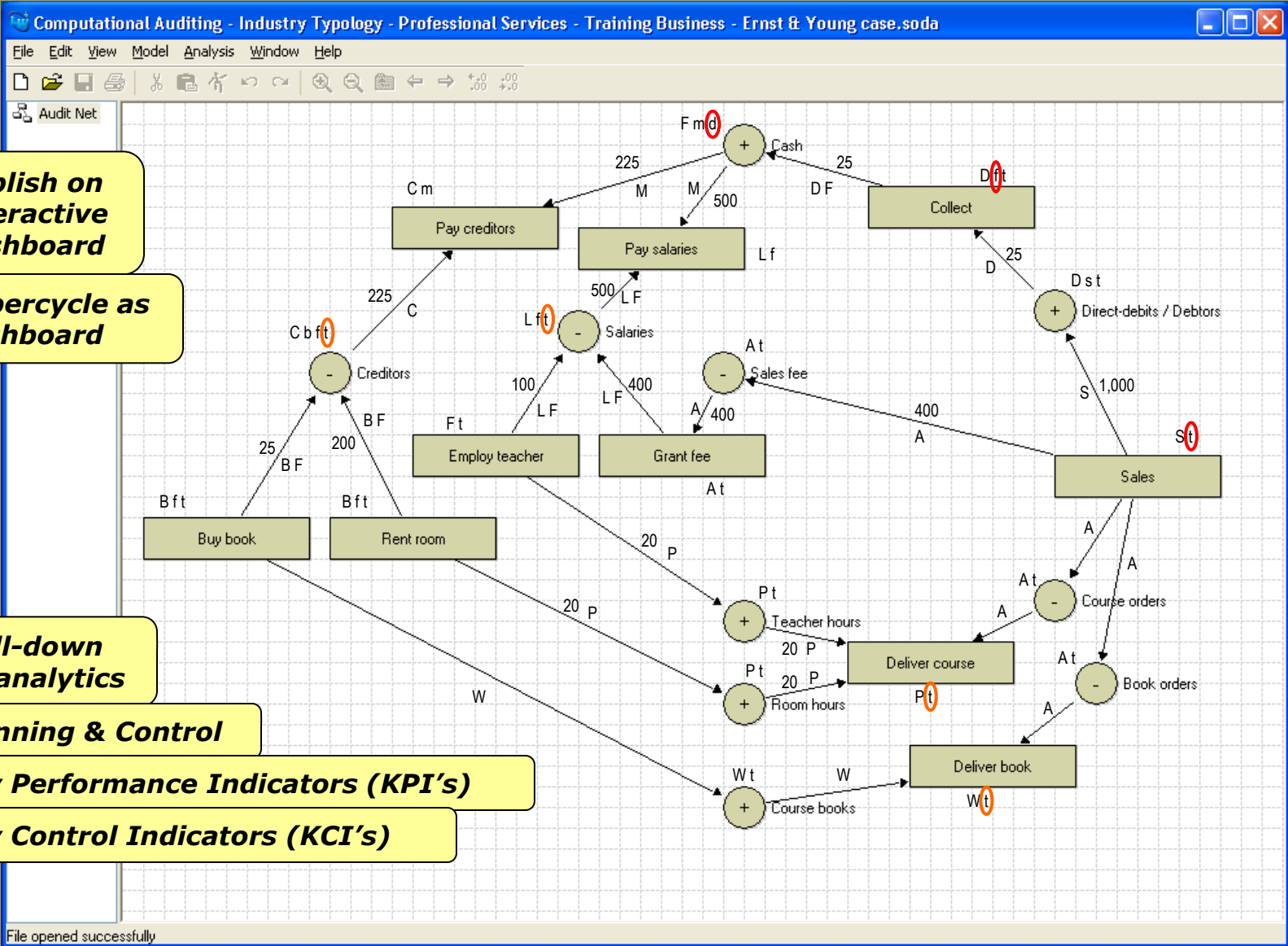
Supercycle as dashboard

Drill-down on analytics

Planning & Control

Key Performance Indicators (KPI's)

Key Control Indicators (KCI's)

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Example Key DSL operators

1. **SoD operator (Segregation of Duties) + case by PwC**
   Support to map & analyze a body of authorizations

2. **BoM operator (Bill of Material)**
   Using product spec to generate production process spec

3. **PFDF expressions (Process Flow Determining Factors)**
   Proven method to integrate product-specific supercycles

4. **Continuous Spanning Equations & Reconciliation Checks**
   Extending proven equational method to continuous app

5. **XBRL operators**
   Polymorphism mechanisms for type & tag coercions

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NWO.nl: The Netherlands Organisation for Scientific Research

Jacquard.nl: Joint Academic and Commercial Quality Research & Development, the Netherlands premier funding programme for software and service research

Using data to prevent fraud that data won't reveal

Illustration based on a case study

Jacques de Swart - PwC

Paul Griffioen - CWI

Philip Elsas - ComputationalAuditing.com

October 2010

ComputationalAuditing.com

CWI.nl: Dutch National Center for Mathematics & Computing Science

Belastingdienst.nl: Dutch Tax Office

Contents

1. Case description

2. Starreveld's supercycle

   • General Ledger representation

   • Authorisation representation

3. Illegitimate actions

4. Petri nets and Fourier-Motzkin algorithm

5. 12 canonical scenarios for potential fraud that data won't reveal

6. Follow-up

7. Data request from multi-national PwC client

8. Conclusion

Case description

Based on a case by Harold Kinds, Director Audit Technique of the Dutch member firm of the International Network of Accountants and Auditors (INAA), and ComputationalAuditing.com and published in "X-Raying Segregation of Duties", Int. Journal of Account. Info. Systems, June 2008, Vol. 9, pp. 82-103

A heating system maintenance company runs six processes:
1. Sales
2. Procurement (including subcontracting)
3. Labour allocation
4. Maintenance visits
5. Accounts Receivable to Cash cycle
6. Accounts Payable to Cash cycle

A $600 sale involves five annual maintenance contracts and requires 10 units of supplies, 5 units of tools and transport, 5 units of subcontractors and 15 units of labour, having fixed unit costs of $6, $10, $8 and $20, respectively, thus yielding $600 - $60 - $50 - $40 - $300 = $150

Starreveld's supercycle – General Ledger (GL) representation

Circles denote balance sheet items

Squares denote income statement items

The lower half represents goods/services flows

The upper half represents financial flows

The left half represents internal buy side flows

The right half represents internal sell side flows

Value is generated at Sales & cashed in Bank
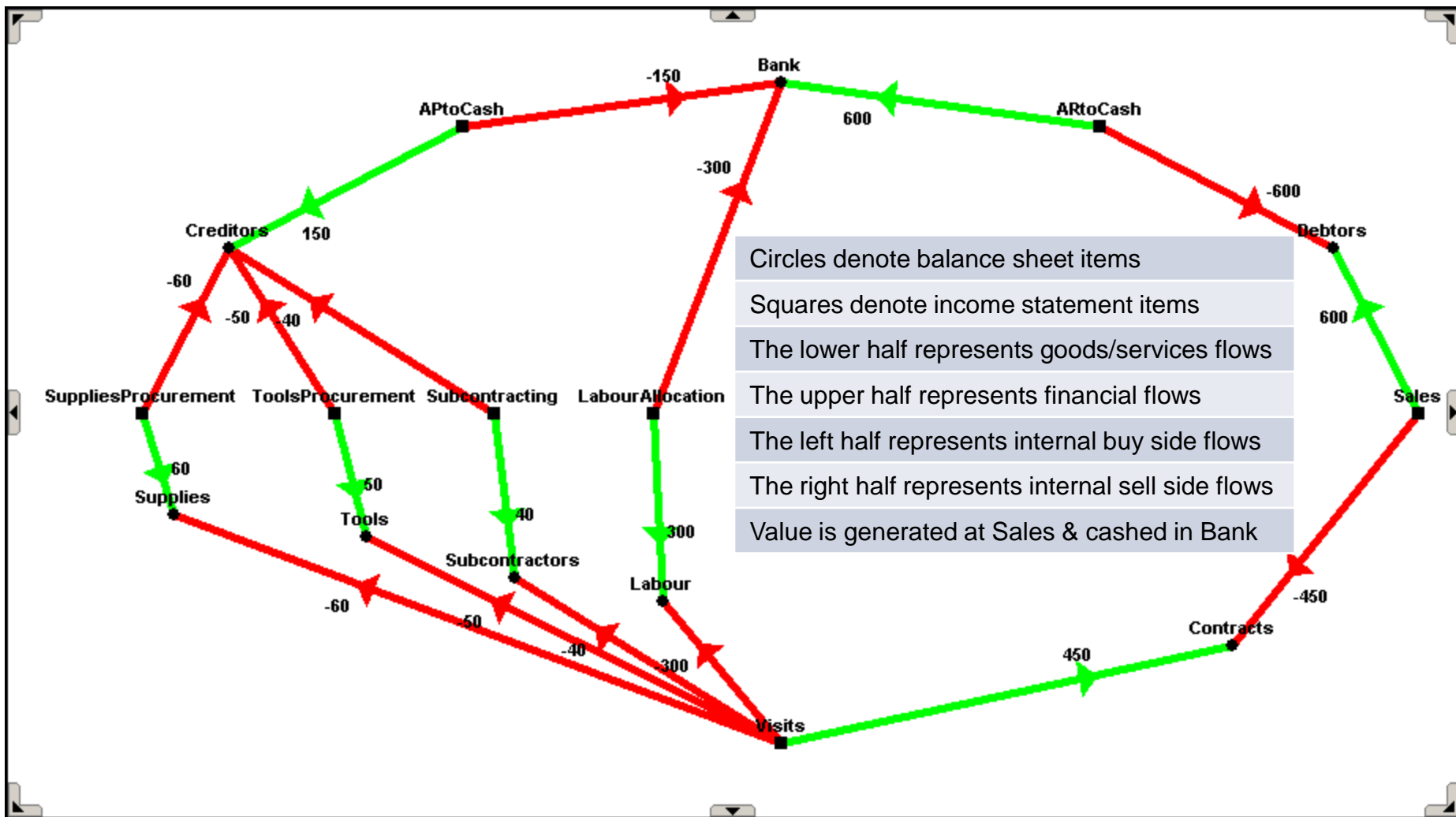
Starreveld's supercycle – Authorisation representation

f	Finance
t	Technician
h	HR
o	Majority owner
b	Buyer
s	Sales
w	Warehouse
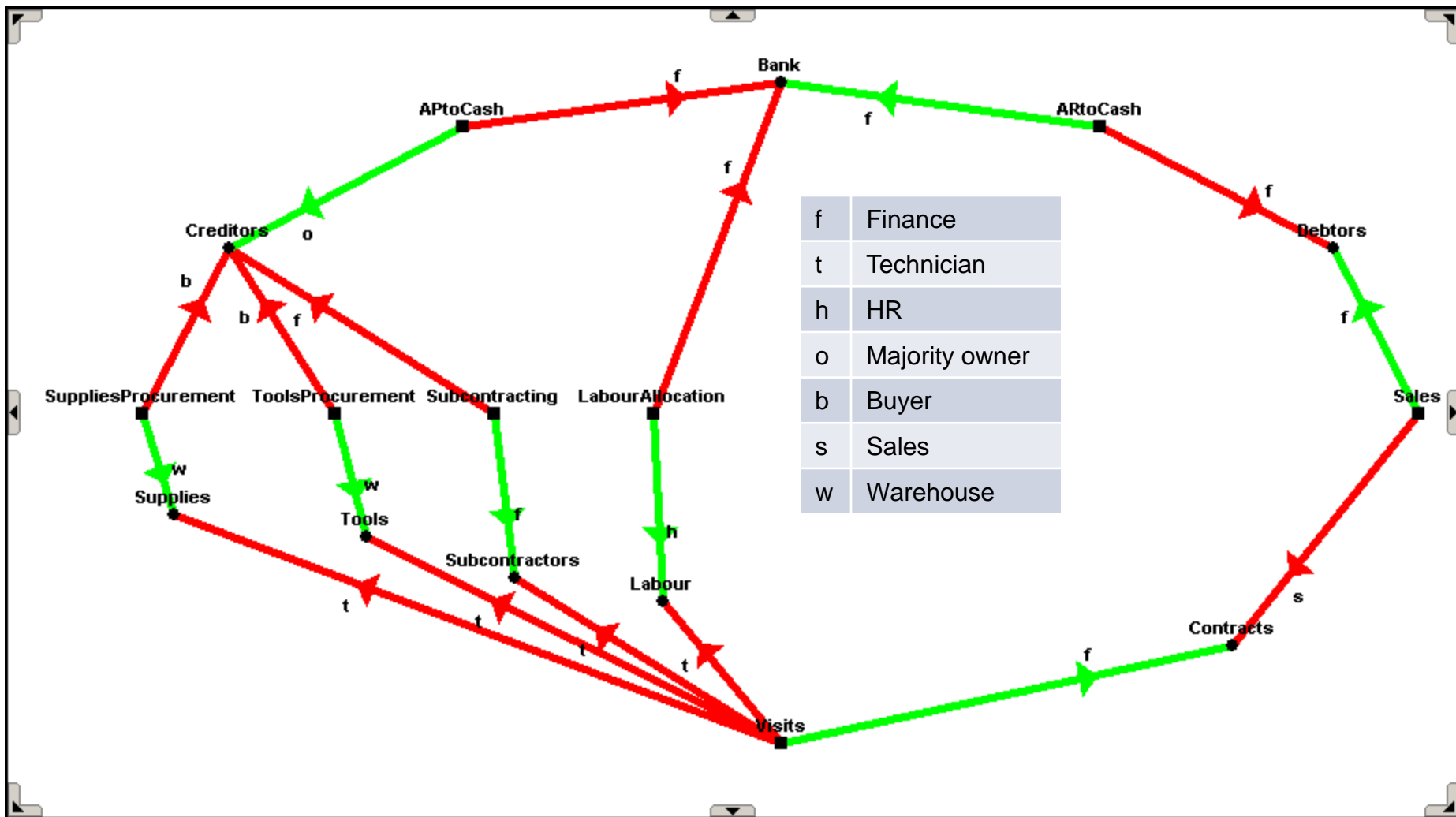
Illegitimate actions

We call an action illegitimate if it does not belong to the Soll supercycle.
From the previous slide we derive officials who can act illegitimately, and how:

balance sheet item

official bsi	f	b	s	w	h	o	t
Bank	1						
Debtors	1						
Supplies				1			1
Tools				1			1
Subcontractors	1						1
Labour					1		1
Creditors	1	1				1	
Contracts	1		1				

income statement item

official isi	f	b	s	w	h	o	t
Sales	1		1				
ARtoCash	1						
Visits	1						1
SuppliesProcurement		1		1			
ToolsProcurement		1		1			
LabourAllocation	1				1		
Subcontracting	1						
APtoCash	1					1	

Petri nets and Fourier-Motzkin

The supercycle can be interpreted as a Petri net.

The Fourier-Motzkin algorithm computes:

- the space spanned
- by all canonical forms
- of sequences of bookings
- both legitimate and illegitimate
- by only one official (or colluding group)
- extracting value from the company
- without leaving traces behind in the GL

For our case, the algorithm returns 12 canonical forms of potential fraud by f that extract a multiple of $150 from the company without leaving traces in GL

4 out the 12 scenarios for potential fraud that data won't reveal:

pwc

		Potential fraud scenarios			
		1	2	3	4
Legitimate Income Statement bookings	Sales	1	1	1	1
	ARtoCash	600	450	600	600
	Visits	5	5	5	10
	SuppliesProcurement	10	10	10	20
	ToolsProcurement	5	5	5	10
	LabourAllocation	15	15	15	30
	Subcontracting	5	5	5	10
	APtoCash	150	150	300	300
Illegitimate Income Statement bookings	Sales	-1	-1	-1	-1
	ARtoCash	-600	-450	-600	-600
	Visits	-5	-5	-5	-10
	SuppliesProcurement	-10	-10	-10	-20
	ToolsProcurement	-5	-5	-5	-10
	LabourAllocation	-15	-15	-15	-30
	Subcontracting	-5	-5	-5	-10
	APtoCash	-150	-150	-150	-300
Illegitimate Balance Sheet bookings	Bank	-150			
	Debtors		-150		
	Creditors			150	
	Contracts				5

Interpretations

1. f keeps the profit of the last sale for himself

2. f sells against cost price to friend

3. f pays his friendly supplier twice

4. f gives his friend an additional free ride

Follow-up

The algorithm also yields the minimal authorisation decrease for f to exclude this potential: f should not be permitted to record sales of contracts.

Next steps in our research:

- Extend Domain Specific Language in audit context
- Collect (far) more complex cases (e.g. multi-national PwC clients)
- Establish XBRL interface to GL and authorisation data
- Refine the Fourier-Motzkin algorithm
- Integrate with other types of data analysis

Data request by multi-national PwC client:

- ISA 240 (SAS 99) tables from SAP
  - BKPF
  - BSEG
- Defining the right scope
  - Not too much, or too little data
  - Not too many users, zoom in via departments
  - Having a good balance between financial and goods/services flows

Conclusion:

Strange but true:

Data allows us to prevent fraud
that data won't reveal

Early publicity is courtesy of
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Your questions, or advisory comments

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