Latencies

- **Business Process 1**: Time it takes to perform a process.
- **Business Process 2**: Time it takes to pass information between processes.
- **Outcomes**: Time it takes for a decision to lead to an outcome.

Latency Types:
- **Intra-process latency**: Time it takes to perform a process.
- **Inter-process latency**: Time it takes to pass information between processes.

Decision latency is the time it takes for a decision to lead to an outcome.
Elements of progressive automation

Economic events → Sensing → Data Processing Organization And storage process 1 → Data Processing Organization And storage Process 2 → Integration Across Systems → Delivery → Automated decision making → Execution
Continuous Assurance Model
An evolving continuous audit framework

- Automation
- Sensoring
- ERP
- E-Commerce

Continuous Audit

Continuous Risk Monitoring and Assessment

Continuous Data Audit

Continuous Control Monitoring

Continuous Audit
Audit Methodologies

- Multidimensional Clustering
- Process Mining
- Continuity Equations
- Predictive Auditing
- Visualization
- Analytic Playpen

Audit Automation

P&G: Order to Cash
Auditor Judgment
Siemens- AAS Automation
AICPA – ADS / APS
CCM

Deterministic exceptions

Automatable actions

Residuals
Process risks

Environmental risks

Black Swans

Variable selection algorithms (heuristics expert based)

Risk minimization / audit return maximization algorithms

Audit Procs. Re-arranged
1. Continuous Assurance – The strategy behind auditing in the real time economy
2013
The Acceptance and Adoption of Continuous Auditing by Internal Auditors: A Micro Analysis

Miklos A. Vasarhelyi
Micheal Alles
Siripan Kuenkaikaew
James Littley
Measuring the Degree of CA Adoption

• We have developed an “Audit Maturity Model” that corresponds to the Technology Adoption Lifecycle model of Bohlen et al (1957) and Rogers (1962).

• Our model emphasizes on how products and markets change as the technology becomes more refined and widely adopted.

The Rogers’ Product Life Cycle Curve
The Audit Maturity Model

- Objectives
- Approach
- IT/Data access
- Audit automation
- Audit &MGT sharing
- MGT of audit fnc.
- Analytical methods

Traditional   Emerging   Maturing   Continuous

- Insurance
- Bank1
- Bank2
- Hi-tech1
- Hi-tech2
- Consumer1
- Consumer2
- Consumer3
- Consumer4
The CarLab

Continuous Audit and Reporting Laboratory
Graduate School of Management
Rutgers University
AAA impact of research taskforce 2009

• Perhaps the most important contribution of accounting information systems research to practice in the auditing and assurance domain is in continuous assurance. The work of Vasarhelyi and his colleagues on continuous assurance demonstrates the application of strong theoretical foundations to the practical problems of the auditor; in this case the internal auditor.
<table>
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<th>University</th>
<th>AIS</th>
<th>Audit</th>
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<tbody>
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<td>12 Yrs</td>
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<td>1 (4)</td>
</tr>
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<td>5 (3)</td>
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<td>Cen Fla</td>
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<td>3 (3)</td>
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<td>3 (3)</td>
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<tr>
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<td>4 (6)</td>
<td>5 (4)</td>
</tr>
<tr>
<td>So Florida</td>
<td>7 (4)</td>
<td>8 (4)</td>
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<tr>
<td>Florida St</td>
<td>8 (4)</td>
<td>5 (4)</td>
</tr>
<tr>
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<td>9 (3)</td>
<td>9 (2)</td>
</tr>
<tr>
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<td>9 (3)</td>
<td>9 (3)</td>
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<tr>
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<td>28 (1)</td>
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<tr>
<td>Michigan St</td>
<td>9 (3)</td>
<td>9 (2)</td>
</tr>
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<td>Portland St</td>
<td>9 (4)</td>
<td>9 (3)</td>
</tr>
<tr>
<td>Brigham Young U</td>
<td>14 (4)</td>
<td>28 (2)</td>
</tr>
<tr>
<td>Georgia St</td>
<td>14 (3)</td>
<td>14 (3)</td>
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<td>20 (1)</td>
<td>14 (1)</td>
</tr>
<tr>
<td>Auburn</td>
<td>20 (3)</td>
<td>20 (2)</td>
</tr>
<tr>
<td>Cal St Long Beach</td>
<td>20 (2)</td>
<td>14 (2)</td>
</tr>
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</table>
Audit Innovation at the CarLab

- Continuous Audit at AT&T
- Continuity Equations
- Multidimensional clustering
- Process mining
- Predictive auditing
- Rule based outlier detection
- Audit Data Standard (with AICPA/ASEC)
Continuous Process Auditing at AT&T (1986-1991)
CPAS definition

• The Continuous Process Audit System (CPAS) approach can be defined as a philosophy of auditing that aims to monitor key corporate processes on a continuous basis, in order to achieve audit by exception.
CPAS effort

This methodology will change the nature, timing, procedures and effort involved in audit work.

Follow the life-cycle of the application, different timing for different cycles

Advanced analytics linked to processes, data rich, new methods

Alerts, Causal linkage, Confirmatory extranets, CRMA

Audit by exception
Billing System - Customer Billing Module

Customer Database

Extract Customer Accounts

Calculate Amount Due

Update Billing Info

Journal Files

Format Bill

Print Bill

Errors

Billing

Pay

Inquiry

Overview

Trans

Bill Upda

AmtDue

Accounts Missing: 10

Table

Process Errors

Missing:

10

1000

1000

998

988

2

0

1000

998

988
CPAS Changed Role of Auditor

- The auditor will place an increased level of reliance on the evaluation of flow data (while accounting operations are being performed) instead of evidence from related activities (e.g. preparedness audits).
- Audit work would be focused on audit by exception with the system gathering knowledge exceptions on a continuous basis.
Continuity equations
Ordering Process → Receiving Process → Voucher Payment Process
CA System
Data Segments for Analytical Modeling:
1,2,3,4,5,6,....,100

updated

CA System
Data Segments for Analytical Modeling:
1,2,3,4,5,6,...,100, 101

updated

CA System
Data Segments for Analytical Modeling:
1,2,3,4,5,6,...,100, 101, 102

AP Model 1
101 Predicted Value

AP Model 2
102 Predicted Value

AP Model 3
103 Predicted Value
Multidimensional Clustering for audit fault detection

Sutapat Thiprungsri
Miklos A. Vasarhelyi
Visualizing combination of attributes, we will be able to see similarity and differences among claims.
Analyzing individual variables, we will be able to see clearly that some claims have rare values.
Process mining

Mieke Jens (Hasselt University)
Michael Alles (Rutgers Univ.)
What is Process Mining of Event Logs?

- The basic idea of process mining is to extract knowledge from event logs recorded by an information system. Until recently, the information in these event logs was rarely used to analyze the underlying processes. Process mining aims at improving this by providing techniques and tools for discovering process, control, data, organizational, and social structures from event logs. Fuelled by the omnipresence of event logs in transactional information systems... process mining has become a vivid research area.

- [http://is.tm.tue.nl/staff/wvdaalst/BPMcenter/process%20mining.htm](http://is.tm.tue.nl/staff/wvdaalst/BPMcenter/process%20mining.htm)
An Example of An Event Log of an Invoice

Figure 1: Visualization of Input Data and Event Log Data of an Invoice

Invoice number 003
Supplier: AT&T
Posting date: Feb 10th 2010
120 USD
Description: internet services Jan 2010
‘Signature of John’
‘Signature of Pete’

Invoice number 003
Supplier: AT&T
Posting date: Feb 10th 2010
120 USD
Description: internet services Jan 2010
‘Signature of John’
‘Signature of Pete’

PLUS

- ‘Create Invoice’
  Timestamp: Feb 12th 2010; 08:23 AM
  Originator: Mike
  Fields: supplier: AT&T, posting date: 02-10-2010, value: 100 USD,
  Description: internet services Jan 2010

- ‘Change’
  Timestamp: Feb 12th 2010; 08:43 AM
  Originator: John
  Field changed: Value
  Value old: 100 USD
  Value new: 120 USD

- ‘Sign’
  Timestamp: Feb 12th 2010; 08:44 AM
  Originator: John
PREDICTIVE AUDIT: TRANSACTION STATUS PREDICTION
Predictive Audit

• A predictive audit could help auditors and management to block a problem before it spreads.
• It is better to look forward than just look back at the historical information
• Continuous audit is used to monitor present transactions
• Can we use CA to predict the future?
  – Audit by exception
  – Alarm and warning system
## Results and analysis

- Models comparison of cost-sensitive approach
- 

<table>
<thead>
<tr>
<th>Model/Measurements</th>
<th>Accuracy</th>
<th>False negative rate</th>
<th>False positive rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>J48</td>
<td>0.64</td>
<td>0.48</td>
<td>0.35</td>
</tr>
<tr>
<td>Logistic regression</td>
<td>0.70</td>
<td>0.50</td>
<td>0.28</td>
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<tr>
<td>Support vector machine</td>
<td>0.79</td>
<td>0.63</td>
<td>0.18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accuracy</th>
<th>False negative rate</th>
<th>False positive rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.53</td>
<td>0.36</td>
<td>0.48</td>
</tr>
<tr>
<td>0.57</td>
<td>0.39</td>
<td>0.44</td>
</tr>
<tr>
<td>0.73</td>
<td>0.56</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Conclusion

• Predictive audit lets auditors monitor and audit controls in a preventive basis.
• The result of prediction model could alert auditors for suspicious transactions.
Rule based selection
Data Description

• Summary statistics
  – 16 transitory accounts
  – 17 variables
  – 418,971 transactions

• Data cleaning
  – 418,971: Source data
  – 50: wrong entries (due to wrong data extraction)
  – 18,504: out of date bounds (01/15/08 ~ 11/19/08, 310 days)
  – 400,417: Final data set
Level 2 Screening

All transactions

Selecting days by sum screening

Selecting transactions of the days by TR Screening

Selecting transactions by TR Screening

Alarmed transactions

2-stage screening

1-stage screening

Union of two screenings
The P-Rule

- Skewed (skewness > 1)
  - Y
  - Peaked (Kurtosis > 1)
    - N
    - Peaked (Kurtosis > 1)
      - N
      - Lowest Bound (e.g., P90)
    - Y
    - Normal Bound (e.g., P95)
  - N
  - Highest Bound (e.g., P99)

or
Suggested for further examination

Duplicates: 99 cases (214 obs)

Branch >= 2:
106 branches
(1,936 obs)
Continuous Monitoring Of Business Process Controls At

Professor Alexander Kogan
Rutgers Business School
Pilot Implementation Of CMBPC Systems By Siemens IT Internal Audit

- CARLab approached by Siemens IT internal audit to explore use of CA methodology to streamline audit of SAP system controls at Siemens USA
- Siemens uniquely SAP enabled with 60+ applications in the USA alone
- IT internal audit examines sites on a 2 year cycle: labor intensive, costly
- Internal Audit needed to find resources to take on 404 implementation without increase in headcount
Architecture Of The Generic CMBPC System
Audit Data Standards & Apps

AICPA’s Assurance Services Executive Committee – June 2011
Relationship Between Audit Apps and Common Data

- Production data
- Activity logs
- Cloud/data providers
- Data access
  - Common Data Repository
  - Black box log
- Audit apps (based on assertions)
  - Query
  - Data matching
  - Platform developers

ERP vendors

Platform developers

Classify

Query

Ratio

Data acquisition

Cloud/data providers

Dashboard

Data matching

Black box log

Activity logs
Dimensions of data/procedures

• **Method**
  – Data generation
  – Audit procedure

• **Timing**
  – Data generation
  – Data frequency
  – Audit frequency

• **Location**
  – Data storage/access
  – Audit steps
DASHBOARDS,
VISUALIZATION, KPI’S, KRI’S,
CONTROL PANELS
# Inventory dashboard 1

<table>
<thead>
<tr>
<th>Region</th>
<th>Jan-10</th>
<th>Feb-10</th>
<th>Mar-10</th>
<th>Apr-10</th>
<th>May-10</th>
<th>Jun-10</th>
<th>Jul-10</th>
<th>Aug-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEEMEA</td>
<td>$8,323,072</td>
<td>$8,674,514</td>
<td>$8,313,362</td>
<td>$8,964,535</td>
<td>$7,824,240</td>
<td>$7,089,338</td>
<td>$8,533,321</td>
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<tr>
<td>Targowek Plant</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>Household Care</td>
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<tr>
<td>Baby Care</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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<tr>
<td>P&amp;G Plant</td>
<td>-</td>
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</tr>
</tbody>
</table>

## Key Metrics
- **Inventory Value**
- **Net Inv Adj**
- **Abs Inv Adj**
- **Scrap**
- **Nor**
- **Blocked Invoices $**

### Notes
- Use "Select Region" dropdown to select the region.
- Use "Select Plant" dropdown to select site.
- Use "Show/Hide Detail" to show actual values.

### Links
- IC Web - CSA Location
## Control dashboard

![Excel sheet showing control dashboard](image)

<table>
<thead>
<tr>
<th>Plant Code - Plant Name</th>
<th>Dec-10</th>
<th>Nov-10</th>
<th>Oct-10</th>
<th>Sep-10</th>
<th>Aug-10</th>
<th>Jul-10</th>
<th>Jun-10</th>
<th>May-10</th>
<th>Apr-10</th>
</tr>
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<tbody>
<tr>
<td>0011 - 6TH OCT-BABYCARE PLANT-PGEGYPT</td>
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<tr>
<td>0016 - MASON-TIDE DRY CLEANERS-AGILE</td>
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<tr>
<td>0018 - ACU PHARMA &amp; CHEMIE-APLDA-PGIO</td>
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<tr>
<td>0025 - QUALITY ASSOCIATES-IOWA-PGD</td>
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<td>0041 - PENTAIR RES FIL-MILWAUKEE-PWP</td>
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</tbody>
</table>

Select a KPI to view in the table
Add the KPI to the Values
Ensure Value Field Settings is set to Summarize by SUM (not Count)

- [Site Detail](#)
- [Monthly Pivot](#)
CONCLUSION
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