The Model of Automated Risk Trigger Status Change Detection Embedded Into Enterprise Wide Alert System

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Abstract

The last financial crisis triggered a large research effort in hope to find out why otherwise robust Risk Management systems failed to alert the enterprises of upcoming serious financial consequences. One of the reasons was sheer amount of data that couldn't be handled effectively. A detailed Operational Risk Registry contains anywhere from few hundred up to few thousand identified risks. Each risk seldom has only one trigger, raising the number of monitoring points to quantities which overwhelm the scope of regular risk audits and render the whole system inefficient. If a new risk threatening development is emerging, an automated system would be needed to react in time. But such a system is challenged by the fact that the monitoring ratios using financial data are tainted by time distortion as financial data lags behind the actual event. Nonfinancial trigger attributes lack common denominator to aggregate the status of the trigger.

This paper proposes a ratio based trigger monitoring model where each trigger may be based on different unit of measure and data collected from both financial and operational nonfinancial segments, rendering automated data collection plausible. The model further introduces trigger's time behavior into monitoring process, where linear progress is only a special case. Multiple triggers are easily aggregated as ratios are the common denominator.

Finally, this model is integrated into the model of Multidimensional Preemptive Coordination, which propagates the risk status change alert both horizontally and vertically across all of the enterprise, focusing on interested shareholders.

Keywords: *Automatic risk monitoring, ERM, Risk Management*

Track: *Governance*

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1. Introduction

Enterprise Risk Management (ERM) took first steps in financial and insurance institutions. As the significance of risk management increased, numerous risk management frameworks were designed. The primary goal of risk assessment in financial institutions was to reserve the funds to compensate the losses in case the risk became an actual event. Different approaches were designed to monitor and mitigate the risks, but most of them were on strategic level and periodic monitoring audits with yes/no answers in interviews were sufficient to manage the risks.

When ERM was introduced to nonfinancial corporations, it became evident that a large amount of risks emerge from everyday business operations and it was decided that steps could be taken to avoid or alleviate the risks if they were monitored better. This led to Risk Registers with large number of risks which made them difficult to manage.

The last financial crisis showed that implemented risk management frameworks performed poorly. Chartis research (Chartis, 2009) states that traditional governance, risk and compliance (GRC) procedures failed to alert the financial institutions of risks that led to the financial crisis, resulting in costly and fines and penalties. Financial consequences were significant in general business to.

Risk evaluation in general businesses was based on financial data. This, however, showed some important anomalies, as financial data lags behind real events and makes proactive action almost impossible. A global study (Oracle, 2011) of 1500 organizations revealed that on average, financial data used for decision-making is 4.2 month old, although 28% of the managers do not even know the age of the data they use. The study further shows that it takes 1.7 months for finance managers to be made aware of company or market changes and 16% are never officially informed at all.

Scheele and Haftor (2015) introduce the concept of Cognitive Time Distortion in economy and conclude that even moderate cognitive time distortions cause substantial deviation in budgeted profit as well as it proves to be a mechanism to large delays. The lever effect due to the time perception is an ever present distortion of a true economic outcome.

Poor monitoring of emerging risks is one of the four fatal risk management conditions mentioned in Gallagher report (Gallagher, 2013). Gallagher Think Tank concludes that risks cannot be monitored effectively by a single Chief Risk Officer or a selected team. Risks should be managed at a proper altitude in the hierarchy of the enterprise. Monitoring operational risks should be enforced by clear formulation of requests for action, and milestone checking upon execution. Results of the monitoring procedures should be recorded, as well as lack of them. This means that the monitoring process should be integrated into everyday operational procedures.

2. ERM in construction companies

Most authors describe the risks in construction companies on a strategic level. Sigmund and Radujković (2012) divide the Risk Breakdown Structure (RBS) in construction companies relative to projects, as projects are the core business in construction. They divide the RBS into two broad categories: external and internal to the project. External sources of risks are legal, political, economic, social and natural. Internal sources are management risks, design and documentation, human factor, delivery and logistic and contractual. Each source is further divided into four subcategories giving altogether about forty risks. The risk status monitoring relies on periodic evaluations an audit yes/no questions which suffices for such a broad assessment. The last financial crisis showed such a granular monitoring is insufficient to protect the company from losses. The risk assessment needs to be taken to an operational level such that possible threats can be detected and preventive actions taken.

The health of construction projects is monitored today with Earned Value Management procedures described in PMI Book of Knowledge - ANSI (2004). The value of current work is compared with the value planned work and their variances expressed in the Cost Performance Index (CPI) and Schedule Performance Index (SPI)

However, Lipke (2011) showed that traditional EVM performance indicators, CPI and SPI fail in projects that are late, which happens in almost 80% of cases. At the completion of a project which is behind schedule, Schedule Variance (SV) is equal to zero, and the Schedule Performance Index (SPI) equals unity. We know the project completed late, yet the indicator values say the project has had perfect schedule performance. He introduced the concept of Earned Schedule to compensate for late projects anomalies.

Operational Risk monitoring is can be related to performance measurement. Deviation from key performance indicators unconditionally influence key risk indicators. The research "Seizing opportunity: Linking risk and performance" (Atkinson, 2008) clearly identifies "inadequate risk assessment practices" as the most important shortcoming in corporate performance management. One of the most significant risks in construction projects is the one of schedule and cost overrun. Bernold et al.(2010) state that Supply chain is one of the critical factors of project performance on different levels. Their discussion clearly describes the complexities of detecting changes in risk status.

Any measuring system is, by nature, oriented to past, so data should be collected as early as possible so trends can be detected. The proactive Supply Chain Management was introduced in Toyota where trends in quality became indicators of trouble on the production line. They found out that preventing poor quality was cheaper than fixing poor quality. There is no single list of measures that would describe all the possible risks that may interrupt the supply process. Bernold *et al.* offer three perspectives of the Supply Chain Management:

a) Purchasing perspective relates to procurement activities for equipment and resources that are either used to build the project or are built or embedded into the site
b) Construction site operation perspective addresses deliveries for everyday site operation.
c) post-project repairs and warranties perspective covers the last part of the project life cycle

They describe eight different performance measures important to the purchasing perspective that are related to suppliers: response time, trust, financial stability, adherence to specification, capacity, payment terms, logistics and bid price. Longer response times of a supplier would indicate possible problems in project schedule and clearly elevate the risk of delay. Automatic detection of changes in response time is relatively easy, though it mandates data access from two different corporate data sources: the Procurement department, from where the order issue date would be accessed and the Inventory system, which would render delivery date from the Receipt Note. Monitoring the difference between those two dates on order per order inside a defined time interval would give indication of deterioration of response time. This means that the two systems would need to be integrated, that the content of the Receipt Note can be loaded from the issued order and the link between the two established.

But how would one measure trust? Bernold *et al.* describe elements of trust in relation to a supplier as standing by quoted prices, product quality, completeness of shipments and eleven more measures. Past dealings evidently mean assigning a score to the supplier in each project, based on above measures. Score downgrade over time would indicate an increase of risk in contracting the same supplier. This particular measure would use similar data sources, namely Procurement and Inventory, but matching the issued order to the supplier's invoice would be needed to test adherence to quoted prices. The supplier's invoice is held in Accounting, in the Accounts Payable system, which means that another IT subsystem would need to be accessed.

The risk of delay in the supply chain for a particular construction project is of paramount importance to the project manager and any changes to its status should be immediately communicated to the shareholders, so that appropriate preventing or mitigating actions could be taken.

3. The model of automated change detection

Jung and Sookyong (2010) describe an automated progress management framework in construction. They cite most of the previous work, but there have been scarce success in automating the process as the main efforts were directed to data acquisition technologies (DATs). Automation in measurement was achieved with use of automated monitoring technologies like RFID, GPS, 3D-scanners, etc. These methods have very limited scope, they may be efficient in measuring the amount of work done in earth removal on a construction site, but are useless in detecting changes in risk indicators in normal business processes.

It would be expected to use RFID technologies to track production data in the Concrete Manufacturing Plant, but those technologies would be quite useless in detecting increase in concrete manufacturing demand that might overwhelm the production and cause the delay in concrete delivery and hence increase the risk of schedule delay. For this particular risk, we would have to monitor the quantities in Requests for Production and compare those with the maximum production throughput. But this is only one monitoring point that might increase the risk of delivery delay. If we monitor the demanded quantities for production, we have to compare them with quantities of components in the inventory. If the demand increase is not compensated with appropriate increase in inventory stock, the delay in production might still occur and the risk of delivery delay should change status.

There may be numerous events that may trigger operational risk status change which means that numerous events need to be monitored. Bernold & AbouRizk (2010) mention up to fifteen measuring points for a single key performance indicator. The values that are used to detect a change that might lead to risk status change are gathered from different places of the corporate knowledge base. However, the important part is to understand that those values come from standard business processes, where data is already gathered in everyday work, but is trapped in various applications that do not communicate between them.

If the corporate risk assessment renders a few dozen risks, then traditional periodic risk audit might be sufficient. If the Risk Register contains few thousand risks and each risk is driven by multiple triggers, there might be tens of thousands monitoring points. Human monitoring of such a number of events is futile, so an automated monitoring system is mandatory.

A project manager clearly is not the owner of the risk of delivery delay in the concrete Manufacturing Plant, but he is undoubtedly a shareholder. If the risk of delivery delay increases, he should be notified of the danger of schedule delay in his project. Such an event is utterly unimportant to a fellow project manager whose project does not have any activities involving pouring concrete. The risk owner is not the only shareholder inside the Manufacturing Plant. A number of his subordinates might be involved in mitigating the situation. But Supply Chain Manager should also be alerted of possible change of the situation. This means that for each event that might trigger a risk status change, a different group of people should be notified. In practice this is difficult, because each one of them is in different business unit. The solution is to gather the group into a closed corporate social network where they would be alerted about a particular problem and immediately discuss and coordinate the mitigating actions.

The automated status change detection system should have at least three components:

a. Trigger definition with metrics and attributes that would tell the monitoring process where to get the current and reference data, how to calculate its value, how often the trigger need to be evaluated and how to decide whether further action is needed
b. Automatic monitoring process which would periodically visit each trigger, calculate its value and decide if the risk status needs to be updated
c. An enterprise wide alert infrastructure which would know who to notify if a risk status change occurs, assist coordination about this particular event and avoid data overload to each participant with a focused horizon of visibility to problems in his domain.

3.1 Trigger definition: metrics and attributes

A risk is expressed as a number (the risk assessment phase defines different status thresholds) which is calculated from multiple measures that are given a weight to be used in aggregation and eventually trigger the status of the risk. A measure is expressed as a fraction, a ratio, where the numerator describes the actual data and the denominator the reference. A trigger should have at least the following attributes:

a. Name and description
b. Data source
c. Measurement frequency
d. Computation method
e. Thresholds
f. Trigger type
g. Aggregate weight

The measures used to monitor a particular risk vary with different situations, from company to company. New measures might be needed to cover the emerging situations. The ability to introduce new measures into the risk monitoring process mandates the ability to define the measure metrics attributes.

Attribute dependencies are shown on Figure 1. The trigger should contain all the attributes necessary to detect the change, instruct the monitoring process where to find the data, how to evaluate it, how often, and once that the change is recognized as mandatory, how will the risk status change.

The values to monitor will be selected by professionals at the proper corporate altitude, and they should be able to fine tune the trigger using elements that will most effectively detect risk situations. They should be able to introduce new measures as new developments emerge. As the measures are attached to the Risk Request for Action, they are focused on only those risk monitoring measures that are in their horizon of visibility.

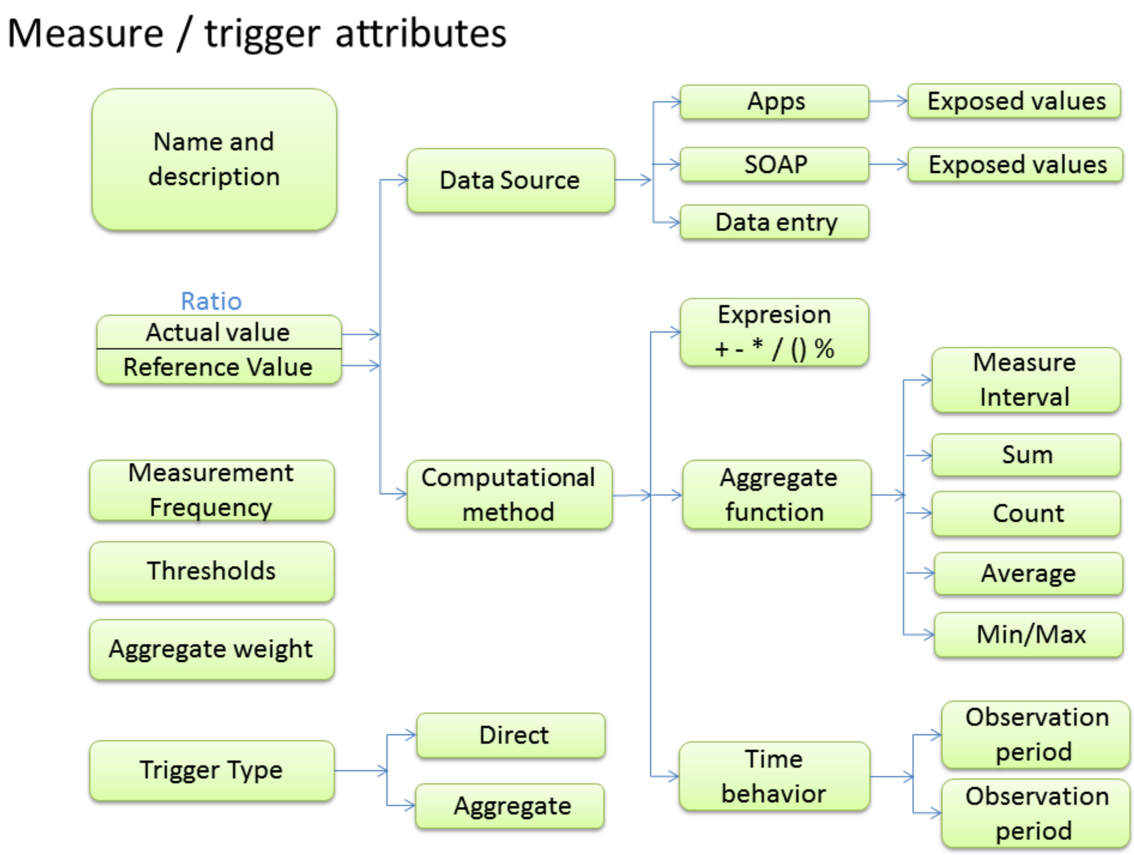

Figure 1: Trigger attributes

If automation in the monitoring process is to be achieved, data has to be sampled from an existing IT application that performs everyday data collection from a business process. This mandates that the Data Source for the measure be selectable. In construction companies, data sources should be the following IT subsystems (in no particular order):

a) Purchasing
b) Inventory Management
c) Invoicing
d) Site daily reporting
e) Accounting
f) Transport Management
g) Estimating
h) Equipment management
i) Internal Repair Workshop
j) Concrete/Asphalt Production plant
k) Project schedule

Each subsystem exposes particular data to the monitoring process. For example, the General Ledger might expose an account balance or its debit accrued value to be used as numerator in the measure ratio, so that the monitoring process can periodically access it and test against same period last year as the denominator. The Concrete Production Plant may expose daily concrete quantities delivered to a particular project. The Site daily reporting may expose the number of workers present daily on site. Selecting the data source allows the measure designer to design a measure that would be most significant for a particular risk.

Another Data Source is the SOAP services available over internet which will become significant in the years to come. Login credentials and internet address will need to be available in the trigger so that monitoring process can access the data as needed.

Data Entry always has to be available, but we are not talking true automation in this case. It might be viable only in case when no software application is available to follow the business process.

Current value and reference value are compared in a ratio. Both the numerator and the denominator have to be evaluated periodically so that changes in ratio can be detected and possible risk status updated. The monitoring process needs to know when a particular measure must be evaluated, so a start date and frequency of evaluation has to be specified. The Measurement Frequency may be any number of days, weeks, months or years.

When the measure is due to be evaluated, the monitoring process has to know how to compute the ratio. Both numerator and denominator must have a Computation Method definition. The monitoring process should support at least the following methods:

1) A simple expression like sum, difference, division or multiplication of exposed Data Source values
2) An aggregate value of exposed Data Source values in which case the Measuring Interval should be specified.
3) Deviation of expected value over a period of time

The aggregate value over the period should support at least the following functions:

1) sum of the exposed Data Source value over Measure Interval, like the accrued quantities of supplied concrete in a week.
2) occurrence count of exposed Data Source element inside the Measure Interval, like the number of concrete pump trips in a week
3) calculated average of exposed Data Source value
4) minimum or maximum value of exposed Data Source element

Business activities are seldom performed with constant intensity. Sales of any product are different in spring than in summer. Construction activities are more intense during summer then during winter. Monitoring the behavior of an exposed Data Source element over time period can disclose important trending information that is otherwise undetectable with simple ratio of two values. This applies both for financial and nonfinancial measures.

Belak (2011) mentions such a procedure in evaluating the risk of fraudulent documentation or “creative accounting”. He distinguishes three analytical procedures in forensic accounting investigation: preparatory or indirect, independent or direct and final. Preparatory or indirect procedures are the ones that show trending. This is done by comparing current account values to some reference value, like the values from a previous period. The sales in September can be compared with last year September sales. Current values can be compared against the budget, projections of plans, or industry averages. The financial data can further be compared to operational quantities rendering a number of indicators to detect deviations from expected results.

These procedures suggest that another type of procedure should be introduced into risk monitoring process if the reference value is not constant. If the reference value is some kind of curve (which in most cases is true), the process should detect how well the current values follow the behavior of the reference curve in the selected Observation Period. This is easily achieved with appropriate statistical procedures like least squares method. Better trending indication is can be obtained by calculating the tangent at selected point in time. Large angle difference between the reference curve and actual values would indicate an unexpected drop in performance (or rise of resource consumption) that, although still inside permitted values, could lead to later catastrophic consequences. Such an indication most certainly deserves to change the status of cost overrun risk or schedule delay risk, so it can be looked into properly. If sales values were collected monthly, there are twelve points of reference, which would be to granular to exploit this feature, but most information systems today can easily provide weekly data that would supply 54 points in a time analysis. In construction projects, weekly reporting is common today, while Daily Site Log provides details on a daily basis giving 364 points of reference for trending. It is logical that in this case, trend monitoring would need to be implemented on activity by activity basis, but that is how daily site reporting in modern systems is actually done today. The resource consumption logged in the Daily Site Log is tied to a particular schedule activity so that it can easily be compared to the planned resource consumption. A moderately complex construction project might have several thousand activities, each one possibly multiple trigger measures. It is obviously physically impossible to monitor such an amount of data by hand, which is why an Automated Risk Trigger Status Change Detection model is introduces in this paper.

Time behavior is extremely important in construction projects. Each project has a Critical Path, a sequence of activities where a delay in any activity would precipitate the delay of the entire project with serious financial consequences. Having a trending insight into possible deterioration of activity cost or performance, although resource consumption is still within permissible limits, would allow preventive action. The pouring concrete activity in one 10 floors building and another 20 floors building would certainly have different values, but the shape of the activity intensity curve would follow the same form. Sudden deviation in intensity slope would mandate further investigation. The reference data points for time behavior curve of any activity is already present in a modern IT system via experience previous similar activities that were recorded in the Daily Site Log.

The measure has a lower and upper limit Thresholds. It states the boundaries that, if crossed, would mandate risk status update. The action triggered by exceeding boundaries can be of two types: direct or aggregate. The sudden drop in measured performance that would elevate the risk of schedule delay is an example of direct Trigger Type. If the tangent angle at this observation point exceeds the defined Threshold, we would want to elevate the risk status immediately, regardless of the status of other measures that might be tied to the risk. We would immediately want to propagate the notification to all the risk shareholders. If the measure is not of such urgent importance, it has to be considered together with other measures. In this case each measure does not necessarily have the same importance and its influence to the status of the risk is determined by the Aggregate Weight. The sum of weights of all the measures is 100 and their values are aggregated weighted to be compared to the risk status change threshold. If the aggregate value crosses the thresholds defined in the risk, risk status changes and a notification is generated and propagated to the risk shareholders across the enterprise via enterprise alert infrastructure.

3.2 Automated monitoring process

The monitoring process will periodically check whether a particular measure is due to be recalculated. If those conditions are met, current values of the exposed Data Source elements will be retrieved and measure ratio recalculated. If Measure Thresholds are reached, risk status upgrade will be evaluated. If the measure Trigger Type is direct, the status will be updated immediately. If it is of aggregate type, all the measures linked to the risk will be evaluated before the aggregated ratio is compared to the risk thresholds.

There is no point to change the status of one of few thousands risks if it stays hidden among the Operational Risk Registry forest. The risk owner must be notified of risk status change. However, the risk owner is not the only risk shareholder. Risk shareholders reside in different corporate departments, at different risk altitudes. When the monitoring process changes the risk status, it also logs the change in the Risk Request for Action (RRFA) that assigned the risk to his owner.

The monitored triggers are attached to the same Risk Request for Action. Thus the monitoring process knows which risk status needs to be updated. The RRFA becomes the integration point of the automated change detection. On one side the RRFA has a connection with the Risk Registry and on the other with the triggers. As the RRFA is a standard Request for Action with triggers and Risk Registry element attached to it, it is part of the Multidimensional Preemptive Coordination infrastructure. The log entry made by the monitoring process is automatically entered into an enterprise wide communication and notification infrastructure that propagates the change horizontally and vertically to the pertinent risk shareholders.

3.3 Enterprise wide alert infrastructure: Multidimensional Preemptive Coordination

The model of Multidimensional Preemptive Coordination was first described by Bacun (2013) with the extension to include participants external to the enterprise in a safe and secure way (Bacun 2014). In its most simple form, a Sender issues a Request for Action (RFA) to the recipient who logs the task progress in the task History log. Both Sender and Receiver can post to the History log, making it a billboard where problems, progress and actions taken are discussed. Neither can change the log entries, but both can change the RFA status signaling the other party of new developments. New statuses or approaching or missed deadlines are forced into the focus of both participants. Missed deadlines or mandatory status changes are forced into focus of the upper level of both participants, so that important status changes are propagated vertically across the enterprise and cannot go unnoticed. The RFA owner, the Sender, can invite other parties to the discussion, even parties external to the enterprise (like subcontractors, suppliers, etc.) if additional help is needed from professionals in other corporate departments. They also can post to the History log, and will also be notified of new developments. Thus a selected group of corporate professionals participate in a focused effort to solve a business problem. Their upper level management is also notified of important developments. The History log becomes a closed corporate social network where handpicked professionals discuss solutions and progress as the discussion is visible only to the invitees. Any participant can initiate a sub-request, focusing another group of professionals on a particular aspect of the original problem. Each participant has the horizon of visibility limited to the altitude he has been invited to, avoiding data overload.

Each participant participates in multiple problem discussions, multiple corporate social networks, and the model of Multidimensional Preemptive Coordination presents him with selected developments and status changes only from the discussion he is part of, avoiding data overload. This enables an automatic alert system across all of the enterprise, as participant in a particular Request for Action come from different corporate departments and different management altitudes.

The integration of the risk assessment process and enterprise Risk Registry design was described by Bacun (Oct 2015). The Board issues the initial Request for Risk Registry design to the Chief Risk Officer (CFO) who consequently issues sub-requests to each risk owner or owner of a group of risks. The risk owner would gather a group of people at the operational level, who are most competent to enumerate and asses the risks reaching any depth that he thinks appropriate. The resulting hierarchical risk breakdown structure seldom follows the Organizational Breakdown Structure of the enterprise. It selects the most pertinent professionals to asses *a* particular risk, because each risk is dealt at the altitude it can be assessed best. Mitigating procedures and monitoring procedures are designed at operational level. Such Request for Action become risk related, and their status automatically reflects the status of the risk because risk attributes and thresholds are embedded into the RFA.

Everyday business activities are main source of Operational Risks. An example of integration of everyday activities in a construction project was described by Bacun (Apr 2015). The risk of construction cost overrun is considered as one of the most important (Banaitiene, 2012), classified as high and frequent. The most common cause of construction cost overruns are delays in construction activities (Flyvbjerg, 2004) and the consequent average cost overrun is 32% of the project budget. The activities that are on the critical path of the schedule, may delay the whole project, so it is understandable the importance that the project manager would assign to this risk.

The delay may be caused by external factors like weather or shortage of personnel on site, but it can also be caused by delays in delivery of the concrete. The causes for such delay reside inside the enterprise, but are still out of reach of the project manager. It is evident that the project manager is a risk shareholder of the delay risk in the supply of concrete from Concrete Manufacturing Plant. So an activity in the Manufacturing Plant, namely a Request to supply the concrete to the project is an ordinary everyday business activity.

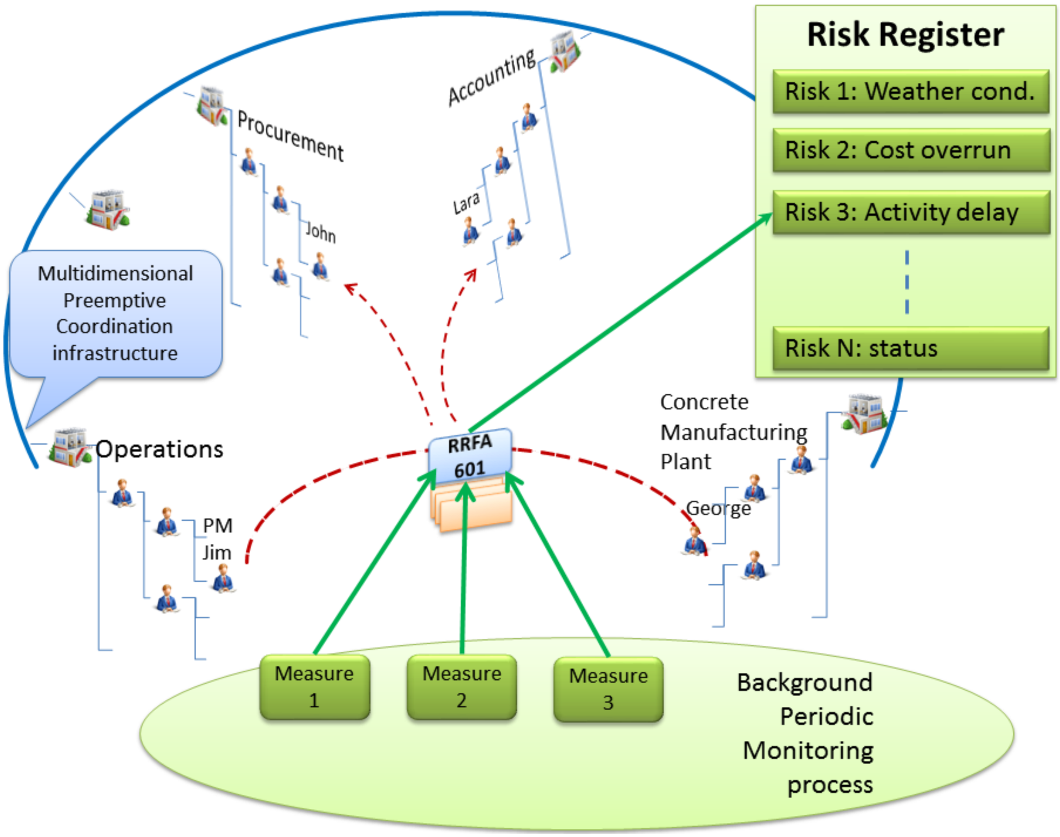

Figure 2: Integration of triggers into alert infrastructure

The Risk Request for Action, which names the Manufacturing Plant manager as the owner of the delay risk to the project has a number of sub-requests, one of them being the above Request to supply the concrete to the project. Both requests become a single corporate social network enabling risk management into everyday business operations. The project manager will be an invitee into the risk monitoring request and will be notified immediately if risk status changes. A Risk Request for Action can be linked to any number of sub-risk requests.

Each Risk Request for Action can have to any number of Risk Measures attached to it. The monitoring procedure described in this paper periodically tests (daily, weekly, etc.) whether a measure is due to be evaluated and accordingly updates the status of the risk. The procedure is a system process, so it can post to the history log of the current RFA. It is actually just another invitee to the current Request for Action. If the proper conditions are met, and the risk status is updated, the monitoring procedure makes a log entry into the request that owns the measure. The notification is forced into focus of any invitee to the request, managing automatic propagation of alerts both horizontally and vertically across the enterprise. The integration of multiple triggers into the enterprise wide alert infrastructure is shown in Figure 2.

The managers at the upper levels can decide the depth of the notifications that will show on their corporate social topic wall so they can easily avoid data overload. The default depth is one level deep, which gives the status of the requests the participant himself issued, but he can drill further to any depth. However, if higher level decided that a particular notification is mandatory, this overrides an individual setting and the participant cannot avoid to be notified.

Several tens of thousands measures can be tested automatically. The model allows for easy extension. The measures are designed at the operational altitude, by professionals who now best what are the relevant measures that need to be monitored. All the participants would not be overwhelmed with data, as the notifications are generated only when proper conditions are met. The conditions can be easily changed or new measures introduced, so emerging developments are easily attacked. The Risk Breakdown Structure can be changed without operational consequences, because the request owner, the Sender, can change the recipient. This allows for changes in business processes and makes Risk Registry design a continuous process.

4. Conclusion

The performance of existing Enterprise Risk Management Systems was poor in past years. Gallagher (2013) report finds several reasons that led to such a situation. The risks were managed by a single Risk Officer or a team instead of professionals at proper corporate altitude. Risk monitoring was not performed with enough detail to provide any useful information for proactive mitigation. Detailed Risk Registers led to several thousand risks assessed, which rendered futile the traditional risk monitoring audits.

This paper describes an automatic risk monitoring model. A risk may have any number of triggers attached to it. New triggers are easily designed by professionals at appropriate corporate attitude, so emerging risks are easily integrated into the system. Each trigger may be evaluated with different frequency. Monitoring data is collected from existing IT subsystems so there is no extra load to the participants. If trigger thresholds are reached, the monitoring process decides whether the risk status should be elevated. The triggers are integrated into the model of Multidimensional Preemptive Coordination which propagates alerts both horizontally and vertically across the enterprise. The alerts are tailored for each risk shareholder avoiding data overload.

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