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A Communication Framework for Extended Enterprise Performance Measurement

Paul Folan, Paul Higgins, Jim Browne

Computer Integrated Manufacturing Research Unit (CIMRU), National University of Ireland, Galway, Ireland

Tel.: +353-91-750-414;

Fax: +353-91-562-894.

paul.folan@nuigalway.ie

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Abstract

Inter-organisational performance measurement communication is a neglected facet of the performance measurement literature. Performance Measurement (PM) is undergoing a transformation in today's business environment, consistent with the development of inter-organisational paradigms, such as the Virtual Enterprise, Extended Enterprise (EE), and Supply Chain Management. In this paper the communication issue is discussed using an Extended Enterprise mindset, and the concepts behind a communication framework are presented. This utilises the concept of an Extended Enterprise host—the member of the Extended Enterprise with responsibilities for formulating, detailing, and distributing information concerning the Extended Enterprise performance measurement system to other Extended Enterprise nodes. The framework design is based upon standardised intranets located at each partner in the Extended Enterprise; this provides the necessary elements to enable different organisations in the EE to maintain PM databases locally, while ensuring the existence of a centrally located database maintained by the EE host. A case study is presented that focuses upon the implementation of the Extended Enterprise performance measurement system at the Extended Enterprise host.

Keywords: Performance Measurement; Extended Enterprise; Communication; Extranet

1. Introduction

Performance Measurement (PM) is undergoing a transformation in today's business environment. Inter-organisational paradigms, such as the Virtual Enterprise (Chalmeta and Grangel 2005), the Extended Enterprise (EE) (Folan and Browne 2005, Bititci *et al.* 2005),

and Supply Chain Management (van Hoek 1998, Beamon 1999, Brewer and Speh 2000, Dreyer 2000, Basu 2001, Gunasekaran *et al.* 2001, Chan and Qi 2003), have been the focus of recent research initiatives in PM. The situation that is used as a basis for this inter-organisational PM research is that of efficient communication and integration existing *between* enterprise nodes; that is, that an effective communication medium, common to all partners, exists which allows for effective transmission, analysis and usage of performance measures and their results. This, however, is not the case: PM communication at the inter-organisational level has been relatively neglected in the literature. There are serious consequences to this neglect if it continues; efforts to embed the concept of PM within the framework of inter-organisational paradigms will suffer if the basis for this instalment is absent. Currently, there has been little effort to provide this basis in the form of a flexible, dynamic, PM communication medium that allows enterprise nodes to interact and communicate successfully.

The EU funded MOMENT (Mobile Extended Manufacturing ENTerprise) project (GRD1-2001-40488) has, as part of its objectives: (1) the development of a conceptual framework to allow for the rapid transferral of processes and knowledge in the EE; (2) the development of approaches for the utilisation of performance measurement in EEs; and (3) the development of a software toolkit to support strategic decision-making in EEs. These objectives clearly relate to the problem investigated in this paper. There is a requirement for a clearly defined, dynamic and flexible communication infrastructure that allows for rapid PM information and data transferral, which, as a result, allows for effective strategic thinking and decision-making at a holistic (EE) level, as opposed to the existing single enterprise level.

The paper discusses the problem of PM communication from the point of view of the EE as it has been developed in the MOMENT project. The specific work in the project that was most directly of relevance to this paper included the analysis of PM literature, projects and systems, and the generation of a basic set of approximately 120 measures deemed most suitable for EE PM. In the next section, the relevant background literature has been outlined in three areas: the concept of the EE is introduced and the effect this is having on the communication between EE nodes is analysed; this is followed by an examination of the inter-organisational PM literature for previous initiatives that attempt to supply the communication deficit; whilst the succeeding area presents new proposals to address the problem from the point of view of the EE. The third section of the paper analyses the development of communication in the MOMENT system of performance measurement, with a case study subsequently offered that outlines the software that enables the MOMENT PM communication framework to function. At the end, conclusions are presented that summarise the paper, including its limitations.

2. Background Literature

The background literature has been divided into three main sections: first, an analysis of the impact of communication upon the EE paradigm; then an examination of communication in inter-organisational PM; followed finally by a review of the effect upon communication by integrating PM under the umbrella of the EE paradigm.

2.1 Extended Enterprises and Communication

With the increasing focus upon core competences within the organisation, there has been a correspondingly increased amount of focus upon closer links with suppliers, and the

management of supplier relationships, with the suppliers effectively becoming an extension of the firm (Childe 1998). The traditional view of manufacturing companies with clear boundaries, limited relationships with other companies and a focus on internal efficiency and effectiveness is no longer adequate (Browne and Zhang 1999). The core concept of the EE is that the Extended Enterprise can no longer treat their suppliers and customers as *them*—they are all now part of a larger *us* (Browne *et al.* 1995). The concept of the EE arises partly from attempts of manufacturers, situated at geographically dispersed locations, to build formal partnerships to gain competitive advantage. The crux of this logic is to embrace external resources and services without owning them (Jagdev and Browne 1998). Whicker and Walton (1996) suggest that the EE concept differs from the Virtual Enterprise concept insomuch as it consists of a dominant trader that is associated with all, or some, of its suppliers; the boundary of any particular EE that an organisation belongs to can be defined by how far the influence of its internal value chain reaches throughout its suppliers and partners. It is probable and desirable that an organisation will belong to a number of EEs within different industry sectors (Clegg 2003).

Communication in the EE—that is, interaction between EE nodes in the form of sharing, requesting, and transferring data, information and knowledge—has long been characterised by a call for further exploitation of intranet and Internet systems (Browne 1996); although, as Cullen (2000) points out, the current use of competition law—in the EU at least—may actually be restricting the development and size of EE communication networks because they are underpinned by presumptions that strategic collaborations are anti-competitive. Overall, however, the issue is governed by the realisation that EEs in practice require re-integration of those areas that have been outsourced if they are to succeed: the EE is facilitated by the availability of new communications and information technology tools, plus the emergence of

global telecomputing, intranets and the Internet (Jagdev and Thoben 2001, Browne 1996). Inter-organisational networking evolves from intensive information system integration; the EE is a paradigm that reflects the extent to which the information systems of the collaborating enterprises are integrated with one another and the way they actually communicate and collaborate with one another (Jagdev and Thoben 2001).

2.2 Inter-Organisational Performance Measurement Literature and Communication

Inter-organisational PM communication is a relatively neglected facet of the PM literature. Holmberg (2000) has suggested the use of a systems thinking approach to overcome communication issues; a postulation upheld by the research of Blackhouse and Burns (1999) who emphasise that communication methods to ensure measure visibility at the level of the EE requires further investigation; while Bititci *et al.* (2003) stipulate that the flow of individual EE node performance management information (such as performance objectives and targets) via a specialised 'meta-manage' process should be considered. Kleijnen and Smits (2003) suggest that communication and co-ordination within the supply chain should be applied in such a manner so as to overcome the obstacles created by an independent 'Balanced Scorecard' development process; and Chalmeta and Grangel (2005) have tackled virtual enterprise PM system development via a computer infrastructure based upon an extranet-based design.

Recently, Folan and Browne (2005) have introduced an EE PM system concept which attempts to tackle communication problems by the introduction of what is termed an "EE host". The EE host is introduced as a part of a system developed around an Extended Enterprise Balanced Scorecard (see Figure 1); with the EE host being the member of the EE

with responsibilities for formulating, detailing and distributing information concerning the EE direction and requirements to the other nodes of the EE; and for controlling the aggregated EE-perspective of the EE Balanced Scorecard.

Insert Figure 1 here…

The recommended EE host is a first-tier supplier of the EE (not an O.E.M.)—a choice dictated by the need to avoid coercive practices in the EE from the introduction of a large-scale PM system that crosses a number of company boundaries. This choice is depicted in Figure 2, where the EE host resides at the first tier level and, through the use of an EE PM communication system, it 1) provides EE PM information feed-forward to other EE nodes; and 2) deals with the EE PM feedback from these EE nodes.

Insert Figure 2 here…

The core of the software solution described in a later section lies in the interaction of the EE Balanced Scorecard with a procedural framework that outlines the process towards the selection and implementation of performance measures, to enable the development of a system of measures that are of relevance at both the intra-organisational and inter-organisational levels. When the EE Balanced Scorecard is used at each node of the EE, a set of relationships is developed between "node X" (any node in the EE) and *all* of the other nodes in the EE. Measures, meanwhile, are developed by a two-phase procedural PM framework: the first section prescribes measures suitable for the supplier-, internal-, and customer-perspectives; and the second section selects aggregated measures for the EE-perspective.

Thus, Folan and Brownes' (2005) solution is to appoint an EE host with powers to control the EE PM system put in place; the solution assumes both that sufficient trust has been built up between EE nodes to perform this operation, and that the EE is sufficiently developed to allow EE nodes to choose an EE host. However, by expanding the concept of PM to the EE scope we are crossing company boundaries, and attempting to introduce specific initiatives across a range of firms that may be geographically, as well as culturally, diverse. This situation, if not managed properly, may give rise to a number of specific problems. Lohman *et al.* (2004), for example, specify:

- Decentralised reporting leading to inconsistencies;
- Deficient insight in cohesion between measures;
- Uncertainty about what to measure;
- Poor communication between reporters and users;
- Dispersed information technology infrastructure.

Clearly, the key question to solve is: how do we develop an EE PM communication system to regulate the EE at the high EE-level, and at the local, node level? Presently, the literature offers very little in the way of answers to this question. This issue will be addressed in the next section with the development of an extranet devoted to PM, thus enabling efficient and controlled communication between EE nodes.

2.3 Communication for Performance Measurement in the Extended Enterprise

2.3.1 Developing a communication medium

There are some options available to companies who wish to develop a PM-oriented communication medium. The first may be considered a relatively cheap, manual operation that probably reflects the current experience of many companies in the field—that is, a *linking* technique, whereby the resources of existing databases of measurement information are pooled to form a coherent whole. This linking technique, based upon existing organisational systems and in-house technologies—Enterprise Resource Management systems, Material Requirements Planning systems, Product Data Management systems, and existing intranet solutions etc.—where valuable performance measurement information is located, may be *linked* together in order to form a PM-dedicated network. By extending this thinking to all nodes in the EE, an EE PM-dedicated communication infrastructure may be made available. There are a number of drawbacks to this approach however:

- The linking procedures between different databases may be difficult, if not impossible to perform due to incompatibilities in technology platforms—many lower-tier suppliers may be using simple Excel spreadsheets or simple pencil-and-paper procedures to monitor their measures, and so a linked network of this kind would not be able to link effectively with them;
- Data, arising from different sorts of systems, would mean that the information developed from it would be of an *ad hoc* nature and would require considerable administrative responsibility to standardise it and make it intelligible to all participants;

- Absence of a coherent interface to the linked EE PM system—the system may in reality only be used by a small number of IT-expert personnel;
- Attempting to link various intra-organisational systems in such a manner would be costly, labour-intensive, time consuming and require continual monitoring in order to successfully generate relevant PM information that, once generated, may only be viewed by a small proportion of the relevant population within the EE.

A more standardised technology platform that is user-friendly and cost-efficient is the second option. The technologies underlining the concepts of the *Internet*, *Intranet* and *Extranet* can be used to meet these demands; they can offer the most cost-efficient platform independent and multimedia capable approach to building partnerships and EEs (Browne 1996). The all-pervasive Internet software—based upon HTML (HyperText Markup Language) and XML (eXtensible Markup Language)—and the wide availability of Internet connectivity that is needed to support it, make it a more optimal choice for supporting the EE PM system, as opposed to a concept such as EDI (Electronic Data Interchange), which is limited by the existence of two widely used EDI standards: UN/EDIFACT and ANSI X. 12 (Damsgaard and Truex 2000).

2.3.2 Internet, intranet and extranets

The three concepts of the Internet, intranet and extranet are closely linked together, and are based upon the same underlining Internet technology, which has developed in an evolutionary process that is currently ongoing in its development. The Internet is probably the largest intellectual resource in the world (Addyman 1994), and its use has been noticeable in online commerce (Serve *et al*. 2002), e-learning (Graf 2002), e-collaboration (Bafoutsou and

Mentzas 2002) and supply chain strategy formulation (Cagliano *et al.* 2003). Intranets are private-computing networks, internal to an organisation, allowing access only to authorised users (Pakstas 1999).

Extranets may be said to be a middle ground between intranets and the Internet; they are not wide open like the Internet concept, nor are they restricted to internal use only like intranets (Pakstas 1999). Essentially, extranets are a network that links business partners to one another over the Internet (Vlosky et al. 2000); that is, a collaborative network—based upon Internet technology—is developed that allows a business to link itself to its suppliers, customers, or other businesses that share common goals (Pakstas 1999).

Riggins and Rhee (1998) specify two types of extranet: the *Intronet*—constructed by the extranet host to allow certain external trading partners controlled access to the firm's internal intranet to gain access to certain proprietary information; and the *Supranet*—a consortium sponsored, multi-application network created to allow members of the consortium to seamlessly exchange various types of information. The Supranet firewall surrounds the entire group of trading partners and allows for new work relationships between parties within and across these separate firms. Alternatively, Au *et al.* (2001) suggest two different extranet types: *User-to-Intranet*; and *Intranet-to-Intranet*, which is divided into three sorts:

- One to One—two intranets integrated together; requires considerable trust and the highest level of security planning;
- One to Many—a central intranet is connected with multiple intranets individually;
- Many to Many—multiple intranets are interconnected together over the public Internet—ideal for Extended or Virtual Enterprise formations.

The following section focuses on applying some of the concepts already outlined to develop the EE PM communication system for the MOMENT project, and subsequently a specific model of the PM toolkit is offered and explained.

3. Communication in the MOMENT system of performance measurement

3.1 Extranet communication in MOMENT

The MOMENT communication system for performance measurement of EEs may be considered as an extranet upon the two levels stipulated by Riggins and Rhee (1998) and Au *et al.* (2001). As illustrated in Figure 3, the Supranet boundary firewall encompasses all of the participating EE nodes, while the Intronet boundary firewall is constructed around the part of each EE node's intranet that is to be made available to the EE PM system. The Supranet boundary prohibits external access to the EE PM system extranet from unauthorised users lying outside in the open Internet; while the Intronet boundary prohibits access by members of the extranet to areas of the individual node's intranet that may be security-sensitive. Also, the figure shows how each EE node will be equipped with an intranet built upon their individual EE Balanced Scorecard of performance measures.

Insert Figure 3 here…

Illustrated in Figure 4 is the Intranet-to-Intranet (Many to Many) concept of Au *et al.* (2001). Whilst the previous situation outlining the Supranet and Intronet boundaries is relevant, participating EE nodes are encouraged to interconnect their intranets with other extranet partners—including and beyond their immediate trading partners—in the EE. If EE nodes are not willing to interconnect their intranets beyond with the EE host, then a situation whereby

one EE node wishing to access another EE node's intranet through the EE host may often arise. This situation is not ideal; increasing the amount of "traffic" through the EE host's intranet may make it congested and cumbersome to operate, slowing down the whole EE PM system. Further, this puts additional administrative strain upon the EE host: questions such as "should access be granted or not?" and "what parts of the EE node's intranet should be made available?" may have to be answered.

Insert Figure 4 here…

EE nodes can only be *encouraged* and not *coerced* into participating in this exercise of interconnecting with other EE nodes. As Gulledge (2003)) suggests, supply chain integration is impossible to achieve through coercion; some subset of suppliers will participate in order to preserve a valuable business relationship, but marginal suppliers will not participate.

3.2 Summary of the Extanet infrastructure

An adapted information system infrastructure designed to support Virtual Enterprises (Park and Favrel 1999) is illustrated in Figure 5; this diagram shows the underlining relationship between the intranet, extranet and Internet with regard to their integration and connectivity. Notice how the intranet is the closest system available to the individual user (in terms of databases and processes available etc.); once a firewall has been bypassed, the user may pass into the extranet where the databases and web applications of other nodes may be available to use. Finally, through another firewall and beyond the extranet, lies the open Internet. In terms of the EE PM system dashboard, each EE node will have its own intranet containing the performance measures selected for each of the four perspectives of the EE Balanced

Scorecard. Lying outside the intranet firewall are the other EE nodes participating in the EE PM system. At this point, the EE node is connected to the EE host through the extranet, and may be connected with other EE nodes. Finally, outside the Extranet firewall lies the open Internet.

Insert Figure 5 here…

In order to meet the user requirements of each EE node participating in the EE PM system, a communication medium was developed as part of the MOMENT project that operated as a series of EE Balanced Scorecard intranets that were incorporated together to form the basic EE PM extranet. The overall goal was to produce an intranet that was logical, consistent and functional; a flexible navigation solution using web-based software that is easily customisable to suit new adaptations is intended.

3.3 MOMENT performance measurement toolkit

A conceptual model for the intranet / extranet system is illustrated in Figure 6. A web-based user interface is the layer of the system that is presented to the individual user; this is based upon a database-secured security layer that allows for full audit and tracking possibilities for any interactions with the data in the EE PM system itself. Underneath the security layer is the objects and management layer; this contains a series of objects that handle various aspects of the system functionality including: data editing, reporting and import/export facilities. The data access layer lies beneath this, and controls the interactions of various users with the data contained in the database via user role-based control. Underlining the whole information system model is the operating system. The system allows for three types of users:

- Administrator—maintains complete control of the EE PM system extranet; primarily located in the EE host where monitoring and control of the EE PM system extranet as a whole is performed;
- Editor—maintains control of individual intranets in the EE PM system; primarily located in each individual EE node where duties include: updating measure selections for the node, ensuring that measures are frequently measured, EE node intranet security is maintained etc.; has only limited administrative powers;
- User—little or no control over the EE PM system or individual intranets within the system itself; users are located in all of the EE nodes that wish to use the EE PM system; they are the lifeblood of the EE PM system, i.e. they supply measures, targets, and other raw data to the system.

Insert Figure 6 here…

The system design was developed using web-based technologies and an object oriented design approach that is client platform and client browser independent. The system database was designed using Microsoft SQL Server 2000 in order to generate a flexible model of a "content free" information management system that provides extensibility to incorporate future modifications easily and with minimal programming effort. Examples of the use of this system are outlined in the following case study, where the corresponding dashboard graphical user interface for each intranet is developed and analysed.

4. Case Study

4.1 Company application

The identity of the company discussed in this case study, plus its associated EE partners, has been protected. The company—which, in this case study acts as the EE host of the EE—is a first-tier supplier of component products to leading automotive companies in the European automotive industry. Products are manufactured by the company to suit the requirements of three main customers, at seven separate locations in Europe; while the company has eleven suppliers, mainly based in Europe, that supply nineteen distinct components to the company. The company has its main manufacturing plant in Europe, and a duplicate plant in North America to service their American market. This research is based upon collaboration with the European manufacturing plant, which is interested, as far as possible, in duplicating its European EE set-up in North America—hence its interest in EE PM, especially with efforts that will enable efficient and flexible communication. The next section examines the systems of information presently available in the company, and the need to customise these for the extranet design as applied to the company; while the succeeding section outlines the dashboard—the standardised front-end of the extranet design. Finally, security issues are examined.

4.2 Customisation of existing systems

Currently the company services its different requirements with a set of IT systems that, in one way or another, are all connected to the web; these systems include: an ERP system for bills of materials, production plans and control, inventory, invoicing, accounting etc.; an EDI

system for the direct electronic transmission of structured commercial documents between trading partners; a software package for process visualisation that allows for frequent measurement of the company's automated equipment; a system for the control and monitoring of tool and spare parts databases, and ordering and handling from equipment and tool suppliers; a maintenance system, including an equipment database, which allows for the continuous improvement of maintenance in the company; and an in-house intranet specifically tailored to the company's needs. Some of these systems maintain overlapping jurisdictions which means that they may need to be only partially customised to the EE PM system extranet. Other systems present data upon issues that may lie beyond the domain of EE PM as envisaged here; however for the development of a dedicated EE PM system extranet at the company, a complete evaluation of these systems and their ability to be customised to suit the needs of PM in the company, needs to be performed. Once performed, the parts of the systems required are selected for participation in the extranet solution.

4.3 Dashboard infrastructure

The dashboard for the EE PM system extranet is now outlined; note that although the dashboard is analysed here from the point of view of the focal company, the same standardised dashboard will be used at each node of the EE. The dashboard represents the front-end of each EE node's respective EE PM intranet, which, when integrated with the intranets at other EE nodes, produces the EE PM extranet. The system allows users to "drill-down" into the EE PM dashboard to examine individual elements of the system; performance measures, for example, may be analysed in detail and edited, so that additions or corrections may be saved for individual EE nodes; however, holistic, EE-wide chages may only be performed on the extranet dashboard by the EE host—thus control over the functionality and

general characteristics of the EE PM solution is maintained. The performance measures for the EE PM system dashboard are freely available to all members of the EE consortium that have access to the extranet, and they are arranged in the dashboard by name and formula. Each user, through the procedures described in (Folan and Browne, 2005)) are expected to select their own performance measures. The performance measures that the user has authority over appear upon the homepage once the user logs in; thus, the homepage itself acts as an effective scorecard detailing all of the relevant measures that concern a particular user.

A core element of the EE PM system dashboard is the ability of the web-based user interface to maintain and visualise performance measures at different stages and in different views; this enhances the functionality of the EE PM system dashboard, with regard to its monitoring capabilities. The initial entry point into the dashboard is via a password-protected, log-in screen which requires each participating EE node to log into their EE PM system intranet before commencing a session. A personalised and secured data driven menu system is located inside the intranet and, when the user logs in, the personalised "home page" for each EE node—with tables that they own or provide data for—is presented to the viewer; this is depicted in Figure 7. There are four main segments to the home page depicted in the figure; these are:

1. Hierarchical menu tree;
2. Horizontal toolbar;
3. Main window; and
4. Main window detail box.

Insert Figure 7 here…

The home page displays the tables of information that are required from that EE node on the one web page, thus reducing the amount of "searching" that the user may have to perform; this home page functionality is a standard element of the extranet design. The following sections further outline the main segments of the homepage.

4.3.1 Hierarchical menu tree

The hierarchical menu tree (see 1 in Figure 7) is the chief navigational instrument for the EE PM extranet; by clicking upon each module in the menu tree, the user may access any part of the extranet system. The hierarchical menu tree contains a number of other toolkits, besides PM, including industrialisation, supplier selection, transport, and localisation guides to enable the user to obtain a comprehensive view of EE operations. In terms of PM, the hierarchical menu tree contains three main modules, which are depicted as folders in Figure 7; these are:

- Process Model—the "process model" module enables the user to characterise the key Actors, Products and Processes associated with the EE PM system. Once actors have been defined, they may be linked or grouped to allow the user to visualise their nodal partners as an EE. Graphical displays are also possible with the EE Dashboard link, which enables the user to depict its EE partners as suppliers, transporters, warehouses, manufacturers, and customers. A basic example of this functionality appears in Figure 8; the nodes, and links between the nodes, provide dynamic information to the user when the browser is passed over it, or when the user clicks upon either nodes or links.

Insert Figure 8 here…

- Reports—the "reports" module holds the performance measure results for the EE node in question; results may be reported on all active performance measures (i.e. performance measures that are in use). The user can set up a number of different views, but this is dependent on the individual node's PM requirements; for example, in Figure 7, the user currently maintains seven viewpoints, enabling reports upon measures labelled "Red" (i.e. measures that are currently under-reported), and "Green" (i.e. measures receiving frequent reporting levels) at the EE, supply chain and project levels. The project link enables the user to specify groups of measures that must be considered together in a project setting when reporting is performed; this link is useful for internal project-based initiatives involving teams of individuals.

  As has been stated above, users may set up any number of views for the reports module—including comprehensive, high-level views accessible by top management only; and lower-level views, specifically tailored to the requirements of individual users.

- PM tools—the "PM tools" module holds three distinct toolkits for PM system development: PM external assessment, Performance measure suggestor, and PM self assessment. These toolkits are software versions of the tools outlined in Folan *et al*. (2005) and Folan and Browne (2005), and as such are beyond the scope of this paper; the interested reader is referred to these sources for the methodology behind the toolkits. Graphically, the assessments appear as in Figure 9: the user is obliged to provide answers for each question to enable the calculation of a weighted "score" at the end for each assessment. A similar procedure must be followed in the performance measure suggestor: the user checks the generic competitive priorities that they are interested in (e.g. cost, time, quality etc.), and the system generates a suggested list of

suitable measures based upon the combination of competitive priority and EE perspectives.

Insert Figure 9 here…

4.3.2 Horizontal toolbar

The horizontal toolbar (see 2 in Figure 7) provides the user with tools to enable efficient interaction with the EE PM extranet. Besides buttons with obvious functionality—such as Print, Home and Log Out in Figure 7—the toolbar allows users to view, edit, delete, attach and save items to and from the EE PM system. The attach button, for example, allows users to affix pertinent documentation to individual measures; the edit button allows textual changes to the measures—particularly their wording in the extranet; while delete allows the user to remove superfluous information or measures from the system.

4.3.3 Main window

The main window (see 3 in Figure 7) is the key viewing pane for the EE PM extranet; when different modules are selected in the hierarchical menu tree, or different functions are clicked on the horizontal toolbar, the changes become apparent in the main window. In Figure 10, for example, the detailed view of the performance measure "transporter's precision" is presented: note how the main window holds all of the relevant data concerning the measure, including its description, frequency of measurement, owner, provider and results. The main window acts as the interactive pane for the EE PM extranet: additions, adjustments and changes all take place within its compass.

Insert Figure 10 here…

Further, the main window hosts the development of filtered lists and display charts; the key aspect of this side of the main window is the provision of charts and easy access to numerical results for any of the performance measures, or groups of performance measures. Figure 11, for example, depicts the output from a typical use of the performance measure suggestor; charts may be displayed differently as bar, column, pie or radar graphs, at the overall, group or individual question level—the main window changes the graph when prompted to do so by the user.

Insert Figure 11 here…

4.3.4 Main window detail box

The main window detail box (see 4 in Figure 7) provides the relevant orientation details to the user to enable them to navigate through the EE PM extranet in as effective a manner as possible. The main window detail box consists of pieces of relevant data that appear in the main window above graphs, lists of data, charts etc. The details displayed include information upon (see Figure 12): the title of the main window display; the record type currently being displayed in the window; whether filters of a specific sort have been applied to the main window; and the current view (if more than one) that is on display. The main window detail box also allows the user to decide whether to view cumbersome items, such as long lists of measures, on one web page, or to divide it up into easier viewing sizes by spreading the list across a number of pages; this is performed by clicking the "All" button on or off.

Insert Figure 12 here…

In order for the EE PM system dashboard to operate in a protected environment, the next section looks at security features of the EE PM system extranet.

4.4 Security Issues

Issues of security include those that have already been mentioned, such as firewalls and user authentication. The user authentication method used in the intranet / extranet is the standard "log-in" method requiring a user name and password; this security mechanism requires no special hardware to implement, and can be set up for members of each EE node in the extranet itself. The issue of implementing firewalls is a matter that requires agreement throughout the EE upon the setting-up of the extranet and individual intranets, so is, to some extent, a customisable feature of the EE PM system dashboard. However, a standard level of security at both the intranet and extranet level should be insisted upon, in order to avoid breaches of security whereby "hackers" pass from one intranet system to the other. The three levels of firewall (i.e. Supranet, Intronet and intranet) envisaged for the case study have already been outlined in section 3 above; at the time of writing, these precautions are still in the discussion phase in the case study.

5. Conclusions

Research in PM will increasingly include studies of the impact of the supply chain, Virtual Enterprise and EE paradigms upon the communication methodologies adopted by companies and their inter-organisational partners. For the most part, this as yet has been neglected in the

literature; recent inter-organisational PM studies have either left communication problems unanswered, or assumed away existence. The current paper recognises this lacuna in the literature, and attempts to formulate a solution—based upon the EE host concept of Folan and Browne (2005)—for the EE perspective; in the process of which, it further validates Chalmeta and Grangels' (2005) extranet design solution for the Virtual Enterprise.

The approach outlined in the paper is that of an extranet design based upon standardised intranets located at each EE partner in the EE. The concept is one of duplicating and providing external access capabilities for the individual EE partners' intranets. As the EE may consist of a number of different types of nodes—for example, SMEs on the one hand, and large multi-national enterprises and OEMs on the other—the extranet must be customised to fit the particular EE. Since the intranet is to be duplicated for each individual node of the EE, the dashboard of the extranet has been standardised, enabling the user to gain access to required information without undue concern about the differences in interfaces (Sridhar 1998). One of the major advantages of duplicating the intranet concept across the extranet is that the user need not have a detailed knowledge of the database management system used at each node; the user may assume that the extranet is comprised of virtually the same database systems as those that are found in the user's own intranet. Although the EE PM system dashboard must be customised to fit the EE it is intended for, the availability of several web-to-database connectivity tools provide seamless access to data residing in a variety of databases (Sridhar 1998); this means that the EE PM system can, at independent intranets, evolve to include new, different databases of information if required.

The case study described is that of a company operating as the EE host of the EE PM system. To examine in more detail the impact of EE communication *between* the EE nodes involved, an extended analysis of EE PM system implementations at a number of EE nodes (in different

supply chain tiers) would be required. Customisation issues would differ from EE node to EE node, and could not be generically depicted in this case study. At the time of writing, the company are beginning to extend their EE PM system beyond their intranet into the extranet domain, so these aspects of the EE PM system cannot presently be empirically tested.

One of the main assumptions taken as a starting point in this paper is the role of the EE host. Sufficient trust must exist between EE nodes so that an EE host may be appointed: this requires a mindset upon the part of the nodes to allow them to view the value chain holistically; in order that an EE node may be selected as host, they must move beyond a viewpoint which enables them to see only their own needs and requirements, to a situation whereby the *health* of the whole EE is prerequisite, so that the selection of the most appropriate host node may follow. In the future, the concept of the EE PM concept may lie in being an outsourced entity owned by all nodes of the EE; as the number of EE nodes participating in the PM system grows, the time available to the EE host for concentrating on overall performance management of the EE PM system may become too costly and complicated. A decision to outsource the EE PM concept to a service provider, with a subsequent return to a focus upon internal PM—albeit with regular feeds of PM information to the service provider—may be the result.

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Figures

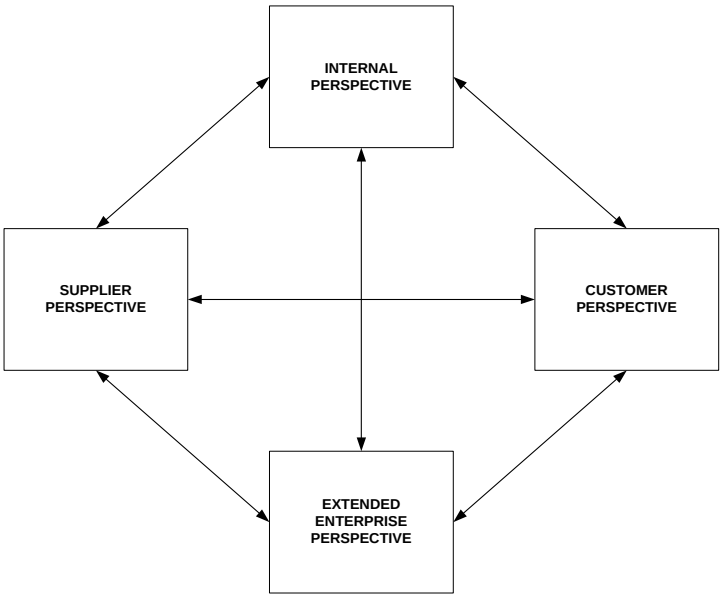

Figure 1: EE Balanced Scorecard (Folan and Browne 2005)

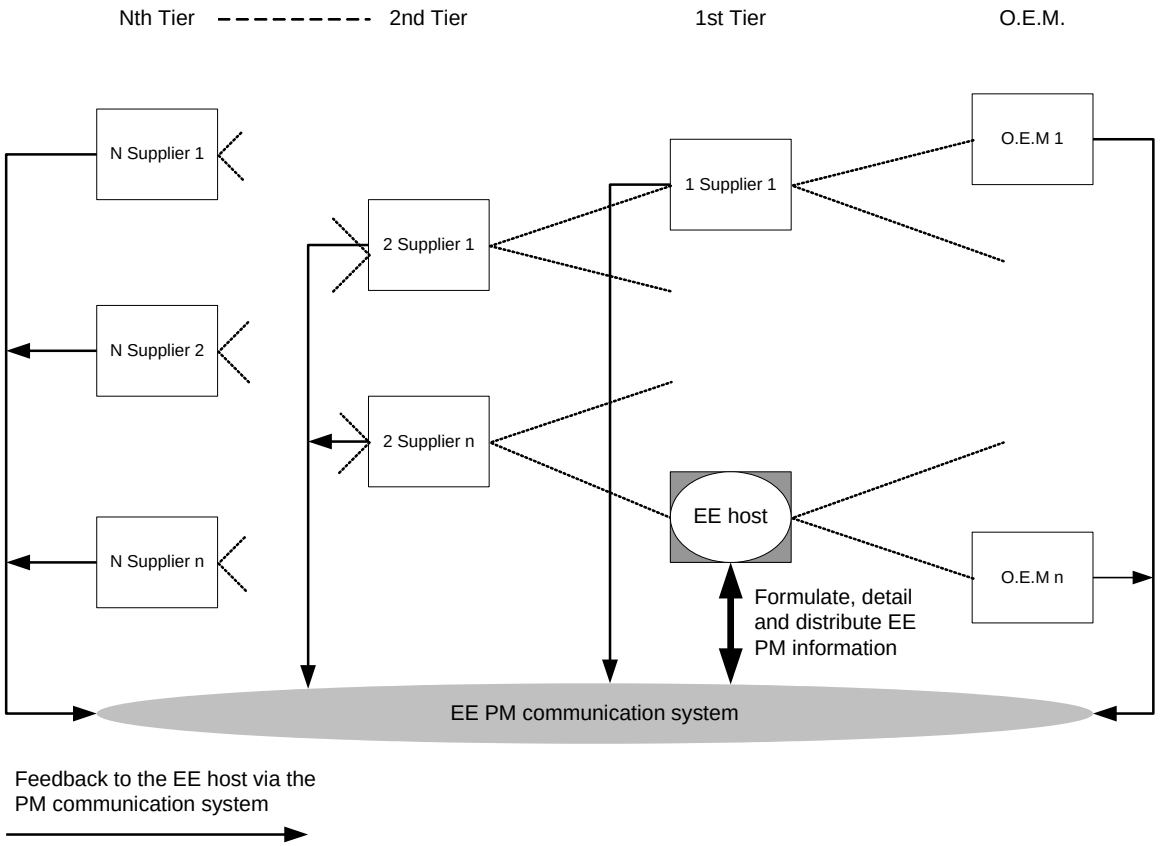

Figure 2: The EE host

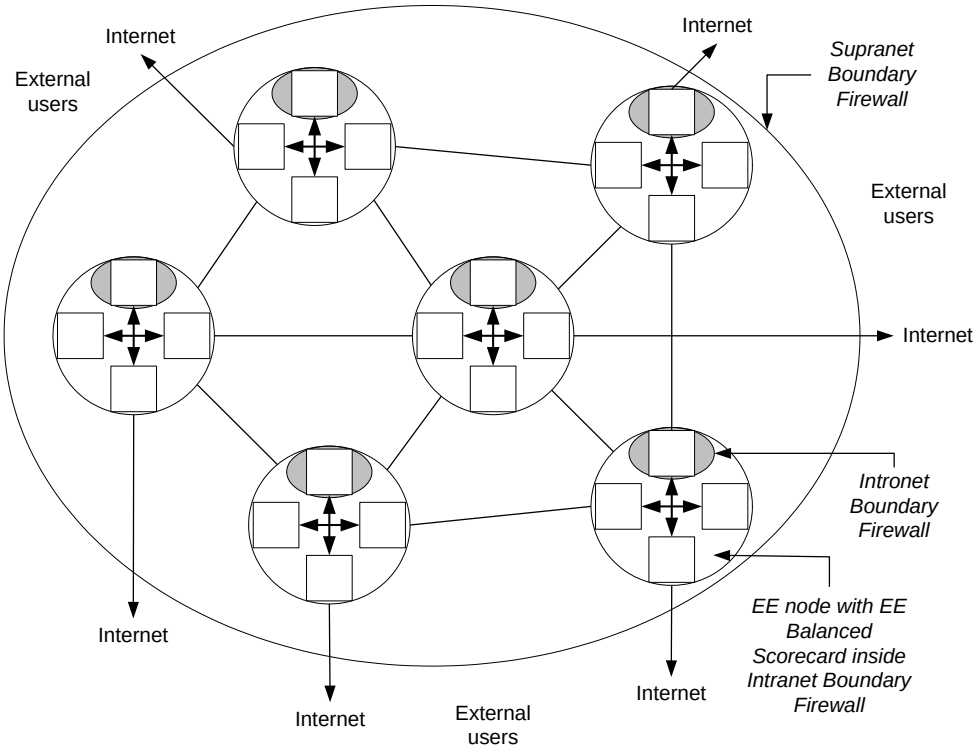

Figure 3: Supranet, Intronet, and Intranet in the MOMENT EE PM system

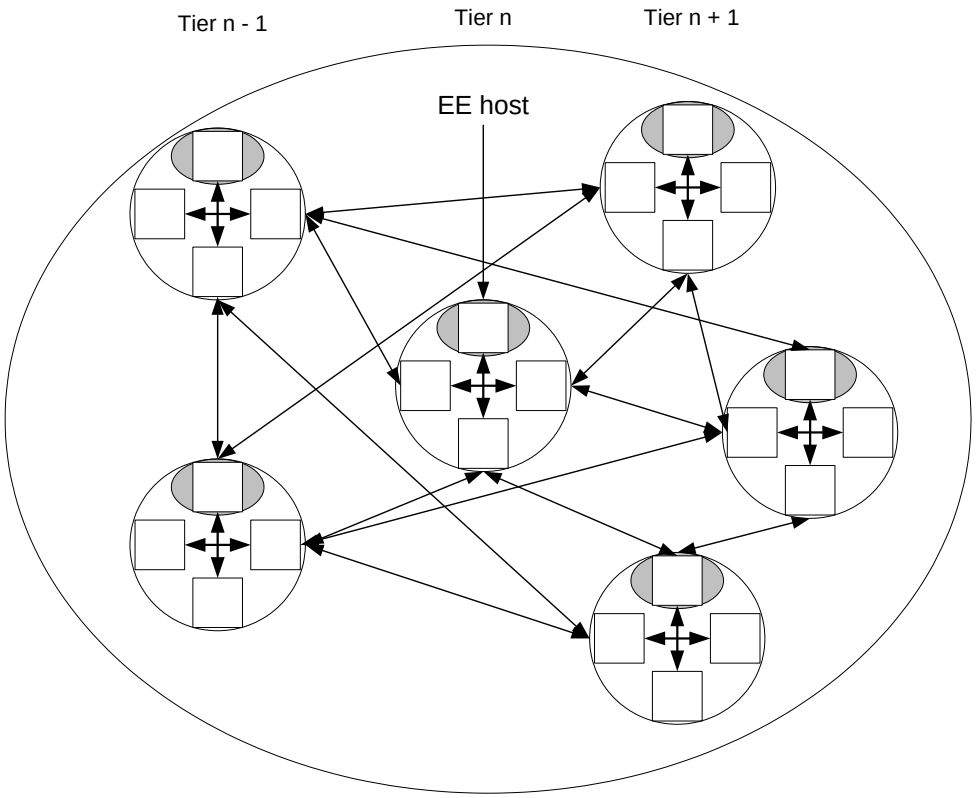

Figure 4: Interconnections between intranets in the MOMENT EE PM system

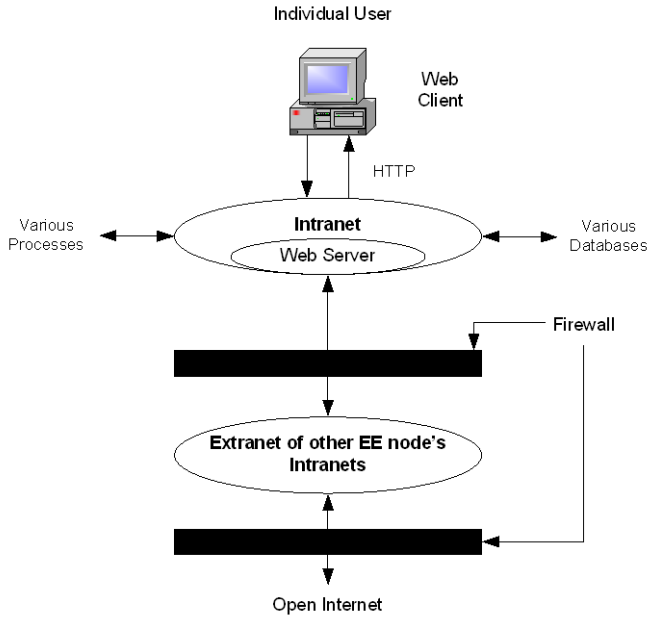

Figure 5: Information system infrastructure (adapted from Park and Favrel (1999))

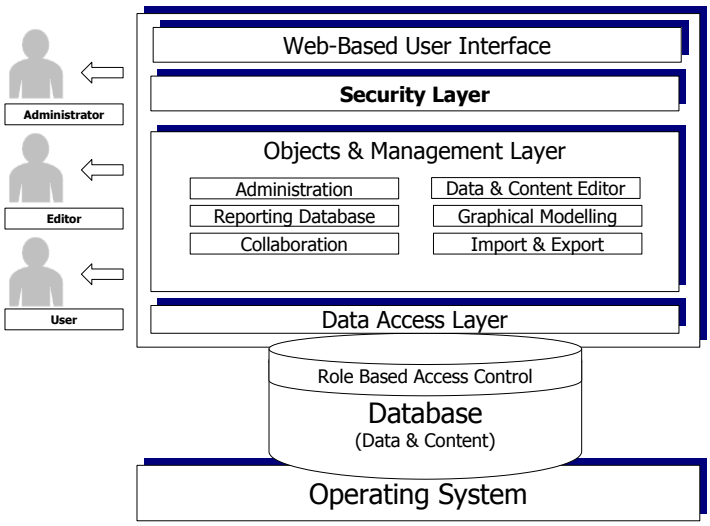

Figure 6: Conceptual model for the intranet / extranet system

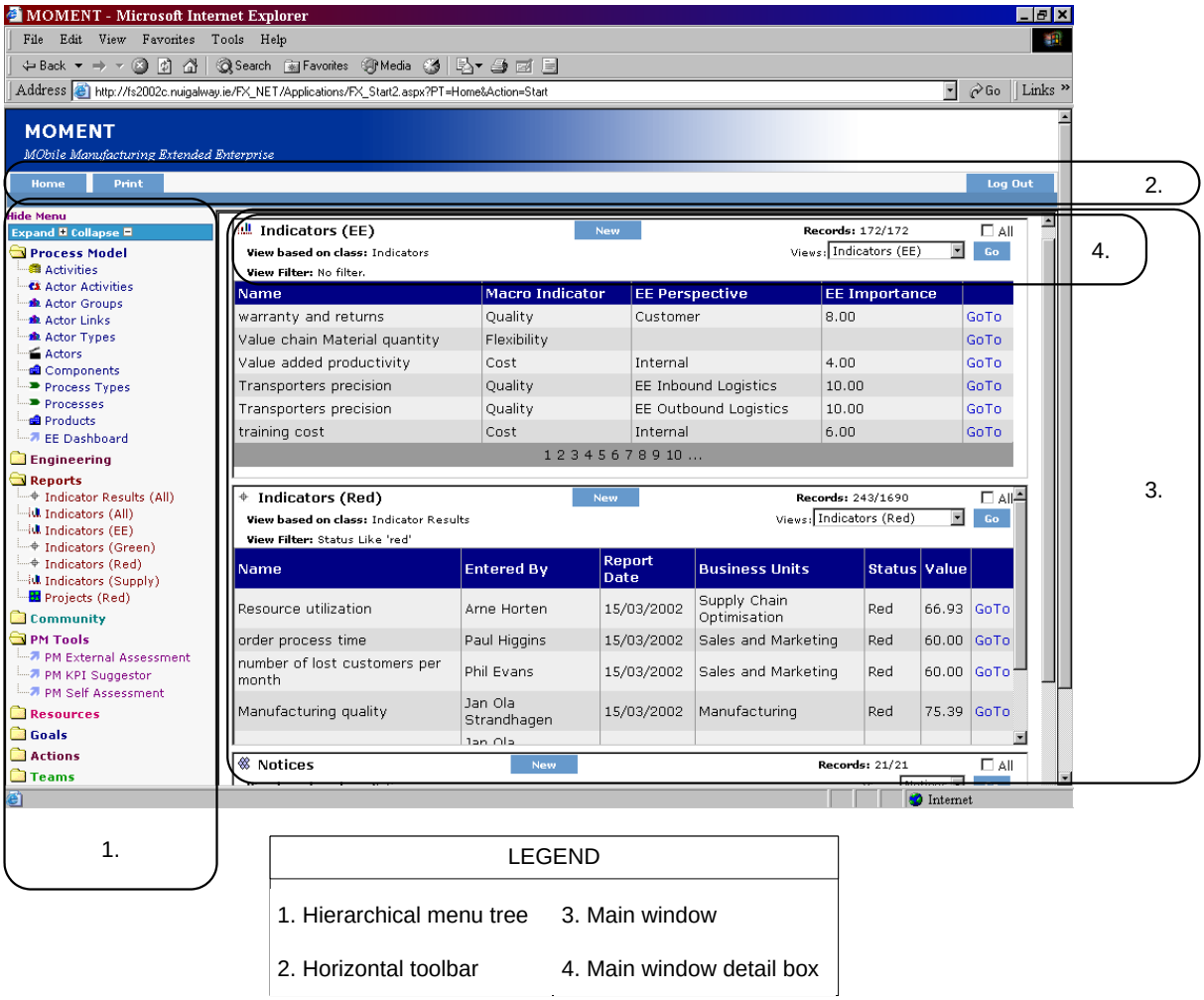

Figure 7: Personalised home page of the EE PM system extranet

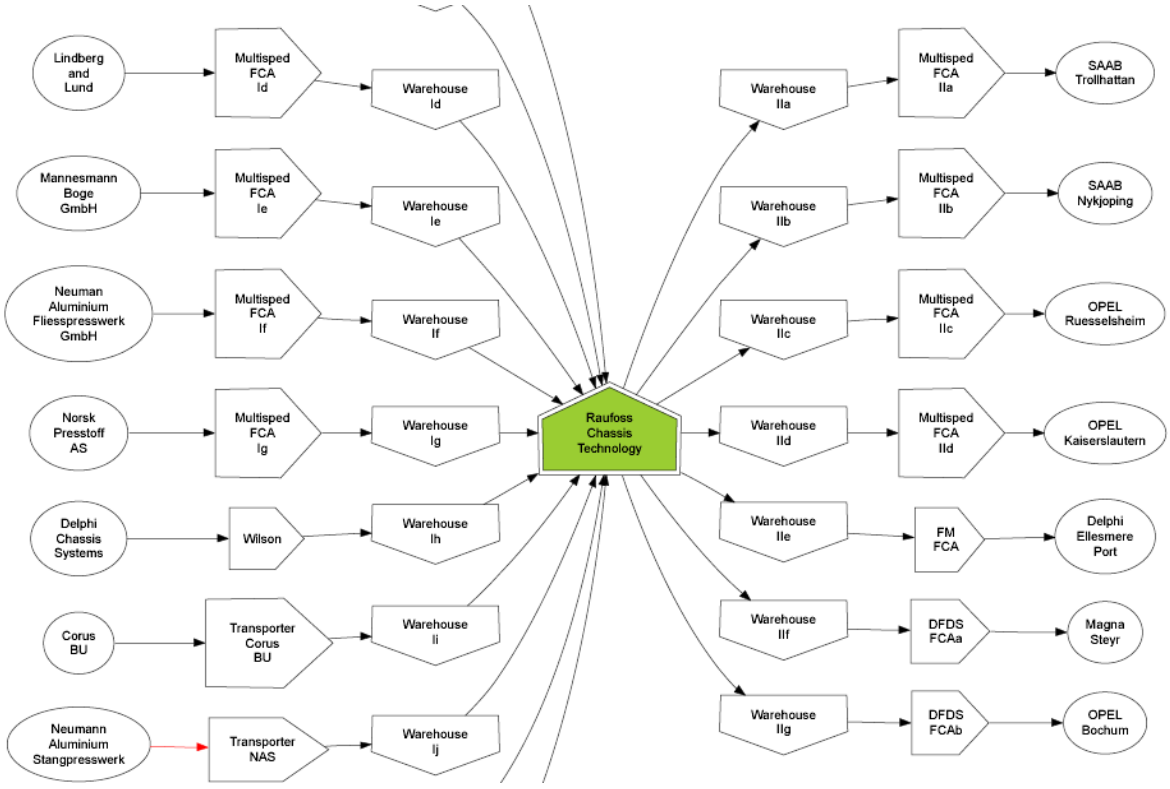

Figure 8: Graphical display of the EE

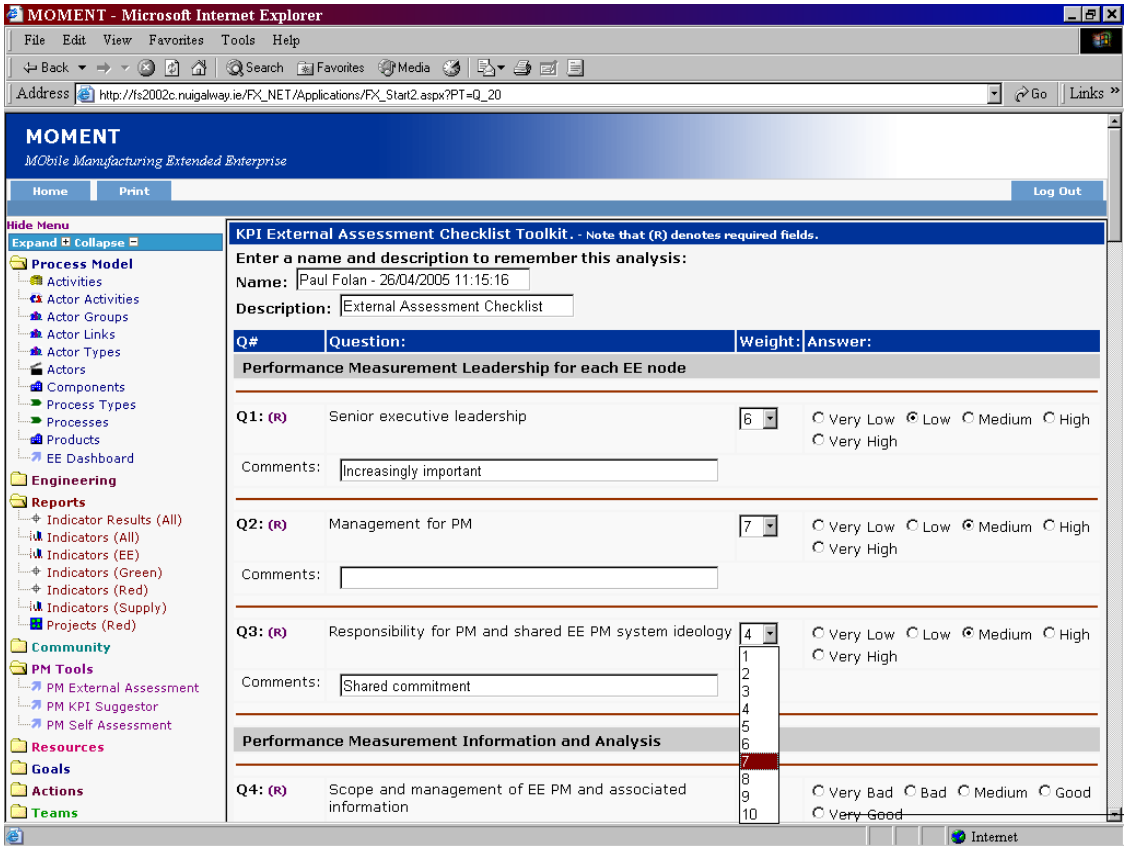

Figure 9: Assessments template

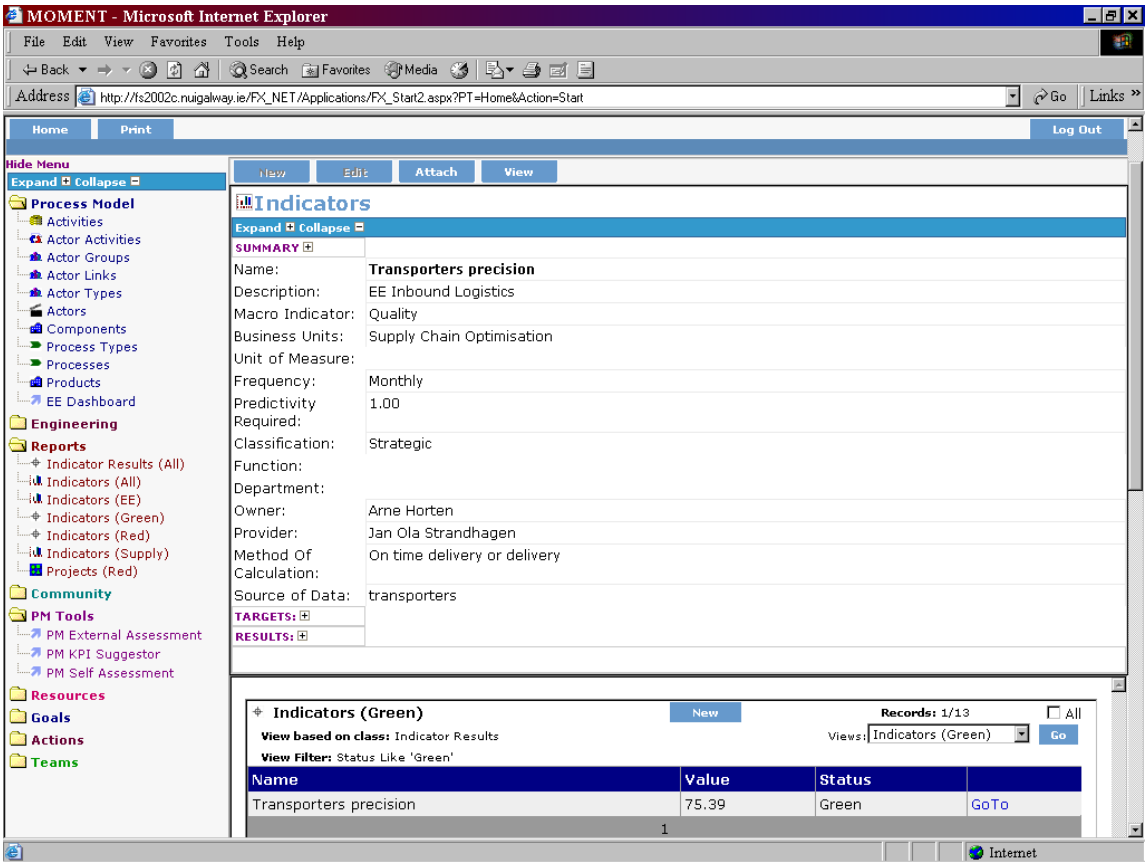

Figure 10: Transporter's precision

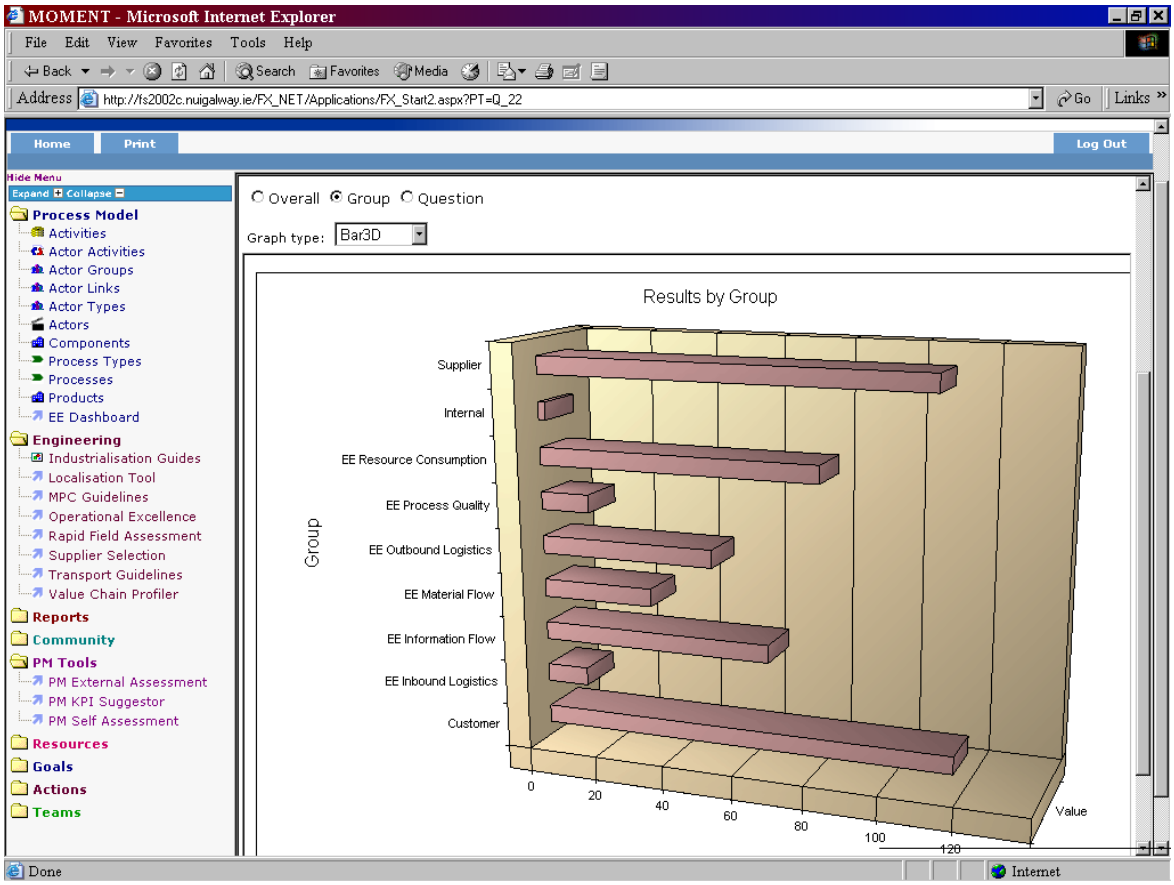

Figure 11: Chart example for the PM suggestor toolkit using the value of the competitive priorities (x-axis) versus the relevant EE perspectives (y-axis)

Figure 12: Main window detail box